File Copy

Application for

POWER PLANT SITE CERTIFICATION

to

Florida Department of Pollution Control

Arvah B. Hopkins Generating Station
City of Tallahassee, Florida

CITY of TALLAHASSEE
FLORIDA

REYNOLDS, SMITH AND HILLS · ARCHITECTS · ENGINEERS · PLANNERS, INCORPORATED
IN ASSOCIATION WITH
ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.

February 15, 1974

Mr. Hamilton S. Oven, Jr.
Deputy Executive Director
STATE OF FLORIDA
Department of Pollution Control
2562 Executive Center Circle, East
Montgomery Building
Tallahassee, Florida 32301

Dear Mr. Oven:

Enclosed please find our application for certification of an expansion in steam electric generating facilities at the Arvah B. Hopkins Generating Station. We respectfully request that this application be given official status as soon as possible.

Additional field investigations will be conducted in August 1974 for a summer biological assessment of the site. Upon completion of such an investigation this data will be submitted to your office. We sincerely hope that certification can be attained by November of this year. This would enable us to maintain our present schedule for the construction of the Hopkins Unit No. 2, the first of the two units included in our application.

Included with this application is the required fee of twenty-five thousand dollars ($25,000).

We offer our assistance and cooperation in attaining any additional information that would be essential to the evaluation of our application.

Sincerely,

ARVAH B. HOPKINS GENERATING STATION

C. H. Corn

C. H. Corn, Superintendent
Electric Production Department
City of Tallahassee

cm
cc: Mr. A. B. Hopkins
Mr. Bryan Henry

REYNOLDS, SMITH AND HILLS

ARCHITECTS · ENGINEERS · PLANNERS

INCORPORATED

February 15, 1974

Hamilton S. Oven, Jr.
Deputy Executive Director
Florida Department of Pollution Control
2562 Executive Center Circle East
Montgomery Building
Tallahassee, Florida 32301

Subject: Hopkins Station Certification

Dear Mr. Oven:

This application was compiled for the City of Tallahassee under the guidelines for application for electrical power plant site certification adopted by the Florida Pollution Control Board in January 1974.

The application was prepared by Reynolds, Smith and Hills Architects-Engineers-Planners, Incorporated and Environmental Science and Engineering, Inc.

An application fee of $25,000 is also being submitted at this time. We request that your earliest review of the application be to determine the sufficiency of the information supplied.

This document represents an initial submittal, with an addendum planned for September 1974 containing information based on field data to be collected during a summer sampling period. This sampling period will duplicate the efforts of the December sampling period, except that fisheries samples will be collected in addition to other biological samples.

If, upon review of this initial submittal, the Department finds the application to be sufficient for purposes of certification, we request that the certification process be completed without the summer addendum. This would greatly facilitate scheduling construction of the proposed Unit 2. At present, the planned date to start construction for Unit 2 is January 1975.

Very truly yours,

Malcolm Steeves

W. M. Steeves, P.E., Manager
Associate Vice President
Environmental Engineering Division

WMS:slg
Encl.

TABLE OF CONTENTS

SECTION NO.			PAGE NO.
1	APPLICANT INFORMATION		1-1
2	THE SITE		2-1
	2.1	SITE LOCATION	2-1
	2.2	REGIONAL DEMOGRAPHY, LAND AND WATER USE	2-1
	2.3	REGIONAL HISTORIC LANDMARKS	2-3
	2.4	GEOLOGY	2-3
		2.4.1 Area Geology	2-3
		2.4.2 Site Geology	2-4
	2.5	HYDROLOGY	2-7
		2.5.1 Surface Water	2-7
		2.5.2 Groundwater	2-23
	2.6	SITE METEOROLOGY	2-28
	2.7	ECOLOGY	2-32
		2.7.1 Terrestrial Ecology	2-32
		2.7.2 Aquatic System	2-51
	2.8	AMBIENT AIR QUALITY	2-67
	2.9	OTHER ENVIRONMENTAL FEATURES	2-68
3	THE PLANT		3-1
	3.1	PLANT APPEARANCE	3-1
	3.2	FUELS	3-1
		3.2.1 Fuel Consumption	3-2

TABLE OF CONTENTS (Continued)

SECTION NO.			PAGE NO.
	3.2.2	Fuel Analysis, Storage and Transportation	3-2
3.3	PLANT WATER USE		3-7
	3.3.1	Cooling System Demand	3-7
	3.3.2	Demineralizer	3-9
	3.3.3	Sanitary Systems	3-10
	3.3.4	Miscellaneous	3-10
	3.3.5	Plant Shutdown Flows	3-11
	3.3.6	Emergency Shutdown Periods	3-11
	3.3.7	Water Analysis	3-11
3.4	HEAT DISSIPATION SYSTEM		3-12
	3.4.1	Cooling Tower Design	3-12
	3.4.2	Circulating Water Chemical Treatment	3-13
	3.4.3	Monitoring	3-14
	3.4.4	Alternate Heat Dissipation Systems	3-15
3.5	CHEMICAL AND BIOCIDE WASTES		3-18
	3.5.1	Waste Treatment	3-19
	3.5.2	Cooling Tower Blowdown Discharge	3-19
	3.5.3	Boiler Blowdown	3-20
	3.5.4	Ion Exchange Regeneration Wastes	3-21
	3.5.5	Discharge from Miscellaneous Plant Systems	3-22
✓3.6	AIR EMISSIONS		3-22
	3.6.1	Stack Effluents	3-22
	3.6.2	Cooling Tower Drift	3-25
3.7	SANITARY AND OTHER WASTE SYSTEMS		3-25
	3.7.1	Sanitary and Chemical Laboratory Wastes	3-25

TABLE OF CONTENTS (Continued)

SECTION NO.			PAGE NO.
		3.7.2 Solid Waste	3-27
	3.8	ASSOCIATED TRANSMISSION FACILITIES	3-27
4		ENVIRONMENTAL EFFECTS OF PLANT CONSTRUCTION	4-1
	4.1	LAND CLEARING	4-1
	4.2	WATER USE DURING CONSTRUCTION	4-1
	4.3	WASTE GENERATION AND DISPOSAL ASSOCIATED WITH CONSTRUCTION	4-2
	4.4	EFFECTS ON AIR QUALITY DURING CONSTRUCTION	4-3
	4.5	NOISE LEVELS DURING CONSTRUCTION	4-3
		4.5.1 Ambient Sound Survey	4-3
		4.5.2 Effects of Construction	4-5
5		ENVIRONMENTAL EFFECTS OF PLANT OPERATION	5-1
	5.1	EFFECTS OF OPERATION OF HEAT DISSIPATION SYSTEM	5-1
		5.1.1 Blowdown Characteristics	5-1
		5.1.2 Possible Effects	5-3
	5.2	EFFECTS OF CHEMICAL AND BIOCIDE DISCHARGES	5-5
		5.2.1 Water Quality Effects	5-5
	5.3	EFFECTS OF SANITARY AND OTHER WASTE DISCHARGE	5-19

TABLE OF CONTENTS (Continued)

SECTION NO.				PAGE NO.
	5.4	EFFECTS OF AIR EMISSIONS		5-19
		5.4.1	Results of the Air Quality Impact Evaluation	5-19
		5.4.2	Discussion	5-22
		5.4.3	Fogging Potential Impact Evaluation	5-23
		5.4.4	Conclusions	5-28
		5.4.5	Environmental Impact of Air Emissions on Terrestrial Communities	5-28
	5.5	EFFECTS OF OPERATION AND MAINTENANCE OF THE ASSOCIATED TRANSMISSION SYSTEM		5-29
	5.6	OTHER EFFECTS		5-29
	5.7	RESOURCES COMMITTED		5-29
6	ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS			6-1
	6.1	SURFACE WATERS		6-1
	6.2	PHYSICAL AND CHEMICAL PARAMETERS		6-1
		6.2.1	Water Collection	6-1
		6.2.2	Analytical Procedures	6-2
		6.2.3	Scheduled Sampling Program	6-2
	6.3	ECOLOGICAL PARAMETERS		6-4
		6.3.1	Terrestrial Methods	6-4
		6.3.2	Aquatic Parameters	6-5
	6.4	AIR		6-9
		6.4.1	Introduction	6-9

TABLE OF CONTENTS (Continued)

SECTION NO.			PAGE NO.
	6.4.2	Applicable Regulatory Standards	6-9
	6.4.3	Description of Models	6-10
	6.4.4	Calibration of Models	6-12
BIBLIOGRAPHY			B-1

LIST OF TABLES

TABLE NO.		PAGE NO.
II-1	Reports of Flow Records for Ochlockonee River	2-11
II-2	Flow Characteristics of the Ochlockonee River Near Havana (1926-1971)	2-12
II-3	Flow Characteristics of the Ochlockonee River Near Bloxham (1926-1971)	2-13
II-4	Low and High Flow Frequency Data, Ochlockonee River Near Havana and Bloxham	2-14
II-5	Plant Discharge as Percent of River Flow at Point of Discharge for Selected Low Flow Frequencies	2-22
II-6	Diurnal and Monthly Temperature and Precipitation Means and Extremes Over the 30-Year Period 1941-1970	2-29
II-7	Frequency of Occurrence of Wind Direction and Stability Class, 1972 Tallahassee Municipal Airport	2-30
II-8	Relative Frequency of Occurrence of Wind Direction and Stability Class, 1972 Tallahassee Municipal Airport	2-31
II-9	Frequency of Occurrence of Wind Direction and Wind Speed Classes, Tallahassee, 1972	2-33
II-10	Plant Species Found Inhabiting 1.5 Radius of A. B. Hopkins Generating Station	2-36
II-11	A List of Animal Species Expected or Observed During the January 1974 Field Survey of the A. B. Hopkins Station	2-39
II-12	Relative Importance of Tree Species in Upland and Lowland Habitats With 1.5 Mile Radius of the A. B. Hopkins Generating Station	2-44

LIST OF TABLES (Continued)

TABLE NO.		PAGE NO.
II-13	Observed or Expected Commercially and/or Recreationally Valuable Animal Species and Their Preferred Habitats	2-47
II-14	Threatened Species which Might Occur on Habitats Within a 1.5 Mile Radius of the A. B. Hopkins Station	2-50
II-15	Phytoplankton Data from Samples Obtained in the Vicinity of the A. B. Hopkins Generating Station	2-54
II-16	Periphyton Data from Samples Obtained in the Vicinity of the A. B. Hopkins Generating Station	2-57
II-17	Summary of Periphyton and Phytoplankton Data Obtained in the Vicinity of the A. B. Hopkins Generating Station	2-59
II-18	Benthic Macroinvertebrates Collected During the Winter Survey for the A. B. Hopkins Generating Station	2-61
II-19	Diversity Indices of the Benthos Samples Collected During the Winter Survey	2-64
II-20	Macroinvertebrate Densities Collected During the Winter Survey	2-65
III-1	Projected Fuel Consumption	3-3
III-2	Water Usage Rates	3-8
III-3	Plant Discharge Volume Composition	3-18
III-4	Fuel Composition	3-23
III-5	Laboratory Water Analysis	3-26

LIST OF TABLES (Continued)

TABLE NO.		PAGE NO.
IV-1	Summary of Existing Ambient Noise Levels at the Site	4-4
V-1	Time that 1972 Wet-Bulb Temperature Represents Violation of Thermal Limitations	5-2
V-2	Water Quality Data	5-4
V-3	Toxicity Levels of Various Species of Phytoplankton and Periphyton Collected During the Winter Survey	5-14
V-4	Toxicity Levels of Various Species of Macroinvertebrates and Fish Collected During the Winter Survey	5-16
V-5	Tolerance Levels of Various Species of Macroinvertebrates and Fish Collected During the Winter Survey	5-17
V-6	Parameters Affected by the A. B. Hopkins Generating Station Cooling Tower Blowdown and Comparison to Ambient Levels	5-18
V-7	Ground-Level Concentrations of Sulfur Dioxide and Total Suspended Particulate Matter at the Points of Maximum Contribution from the A. B. Hopkins Units 2 and 3	5-21
V-8	Probability of Fog Formation During Periods of Various Weather Conditions	5-27
VI-1	Procedures Used for Water Analysis	6-3
VI-2	Parameters, Stations and Sampling Frequencies for the A. B. Hopkins Station Preconstruction Aquatic Assessment	6-6

LIST OF TABLES (Continued)

TABLE NO.		PAGE NO.
VI-3	Florida Department of Pollution Control Ambient Air Quality Standards for Sulfur Dioxide and Total Suspended Particulate Matter ($\mu g/m^3$)	6-10

LIST OF EXHIBITS

EXHIBIT NO.		FOLLOWS PAGE NO.
II-1	Site Location	2-1
II-2	Plant Site - Arvah B. Hopkins Generating Station	2-1
II-3	Population Distribution and Land Use Analysis	2-1
II-4	Zoning	2-1
II-5	Soils Map	2-4
II-6	Stratigraphic Nomenclature for Geologic Formations in Leon County	2-7
II-7	Stratigraphic Nomenclature for Geologic Formations Recorded at the Site	2-7
II-8	High Flow Frequency - Ochlockonee River at Havana	2-11
II-9	High Flow Frequency - Ochlockonee River at Bloxham	2-11
II-10	Low Flow Frequency - Ochlockonee River at Havana	2-11
II-11	Low Flow Frequency - Ochlockonee River at Bloxham	2-11
II-12	Location of Surface Water Sampling Stations	2-15
II-13	Temperature Variation at Sampling Stations	2-17
II-14	Distance-Drawdown Curves	2-27
II-15	Time - Drawdown Curves	2-27
II-16	Map of Generalized Vegetation Associations Within a 1.5 Mile Radius of the A. B. Hopkins Generating Station	2-32

LIST OF EXHIBITS (Continued)

EXHIBIT NO.		FOLLOWS PAGE NO.
II-17	Aquatic Sampling Stations	2-51
II-18	A Simplified Flow Diagram of Energy Flow for Aquatic Habitats Present in the Vicinity of the A. B. Hopkins Generating Station	2-52
II-19	Shannon-Weaver Species Diversity Indices (Base e) for Periphytic Diatoms Collected at Nine Stations in the Vicinity of the A. B. Hopkins Generating Station	2-53
II-20	Phytoplankton Species Diversity Indices Calculated for Six Sites in the Vicinity of the A. B. Hopkins Generating Station	2-56
II-21	Densities/m^2 of Pollution Tolerant and Intolerant Macroinvertebrates Collected During the Survey	2-67
III-1	Plant Layout - Arvah B. Hopkins Generating Station	3-1
III-2	Fuel Oil Transportation Systems	3-4
III-3	Plant Water Use Flow Diagram	3-7
IV-1	Sampling Points for Ambient Sound Survey	4-3
V-1	Blowdown Temperature - 10°F Approach Tower	5-1
V-2	Blowdown Temperature - 6°F Approach Tower	5-1
V-3	Wet-Bulb Temperature - 1972	5-1
V-4	Schematic Diagram of Approximated Flow Rates in the A. B. Hopkins Outfall Creek	5-5
V-5	Ground-Level Concentrations of Total Suspended Particulate Matter Near the Site of the A. B. Hopkins Generating Station	5-19

LIST OF EXHIBITS (Continued)

EXHIBIT NO.		FOLLOWS PAGE NO.
V-6	Expected Ground-Level Concentrations of Total Suspended Particulate Matter Near the Site of the A. B. Hopkins Generating Station with Existing Sources Emitting at Maximum Permissible Levels for 1975	5-19
V-7	Expected Contribution of the Proposed A. B. Hopkins Units 2 and 3 to Ground-Level Concentrations of Sulfur Dioxide Near the Hopkins Site, 1975	5-20
V-8	Expected Contribution of the Proposed A. B. Hopkins Units 2 and 3 to Ground-Level Concentrations of Total Suspended Particulate Matter Near the Hopkins Site, 1975	5-20
V-9	Expected Ground-Level Concentrations of Sulfur Dioxide Near the Site of the A. B. Hopkins Generating Station, with Existing Sources and Hopkins Units 2 and 3 Emitting at Maximum Permissible Levels for 1975	5-20
V-10	Expected Ground-Level Concentrations of Total Suspended Particulate Matter Near the Site, with Existing Sources and Proposed Hopkins Units 2 and 3 Emitting at Maximum Permissible Levels for 1975	5-20
V-11	Location of Points of Maximum Incremental Impact of Hopkins Units 2 and 3 on Short-Term Pollutant Concentrations	5-20
V-12	Regions of Fogging Potential Classification in the United States	5-24
V-13	Plot of Saturation Deficit Versus Temperature	5-25
VI-1	Annual Wind Rose for Tallahassee for 1972, Including all Stabilities	6-12

SECTION 1

SECTION 1 - APPLICANT INFORMATION

APPLICANT NAME:	Arvah B. Hopkins Generating Station City of Tallahassee, Florida
REPRESENTATIVE:	C. H. Corn, Power Production Superintendent
ADDRESS:	Route 4, Box 450, Tallahassee, Florida 32301
OFFICIAL REPRESENTATIVE RESPONSIBLE FOR OBTAINING CERTIFICATION:	W. M. Steeves, P.E. Associate Vice President Reynolds, Smith and Hills Architects-Engineers-Planners, Incorporated P. O. Box 4850 Jacksonville, Florida 32201
SITE LOCATION:	Leon County
NEAREST INCORPORATED CITY:	Tallahassee
SITE COORDINATES:	Latitude 84° 21'-00" Longitude - 30° 27'-08" UTM - 749,510 m East 3,371,230 m North
NAME PLATE GENERATING CAPACITY:	Existing: Unit 1 - 80 MW Proposed: Unit 2 - 238 MW Unit 3 - 238 MW

SECTION 2

SECTION 2 - THE SITE

2.1 SITE LOCATION

The Arvah B. Hopkins Generating Station is located in Leon County approximately four miles west of the City of Tallahassee. (See Exhibit II-1) The site is situated on State Road 260, between U. S. 90 and State Road 20. A main branch of the Seaboard Coast Line Railroad borders the site on the east. The Ochlockonee River and Lake Talquin, a man-made lake created by erection of a dam on the Ochlockonee, are the only major bodies of water in the vicinity of the site. (See Exhibit II-2)

The Hopkins Station together with the Sam O. Purdom Generating Station, located on the St. Marks River south of Tallahassee, comprise the Electric Power Production Department of the City of Tallahassee. The Hopkins Station first began generating electrical power in 1971 with a base-load unit of 80 MW. This 80 MW unit, hereafter referred to as Unit 1, is a conventional fossil fueled steam generating plant, with an associated closed-loop cooling system utilizing mechanical draft wet cooling towers.

2.2 REGIONAL DEMOGRAPHY, LAND AND WATER USAGE

The population distribution within a five-mile radius of the Hopkins site is depicted in Exhibits II-3 and II-4. As indicated, this area represents portions of both Leon and Gadsden Counties. The only major population center in close proximity to the plant area is the City of Tallahassee, which had a 1970 census population of 71,897.

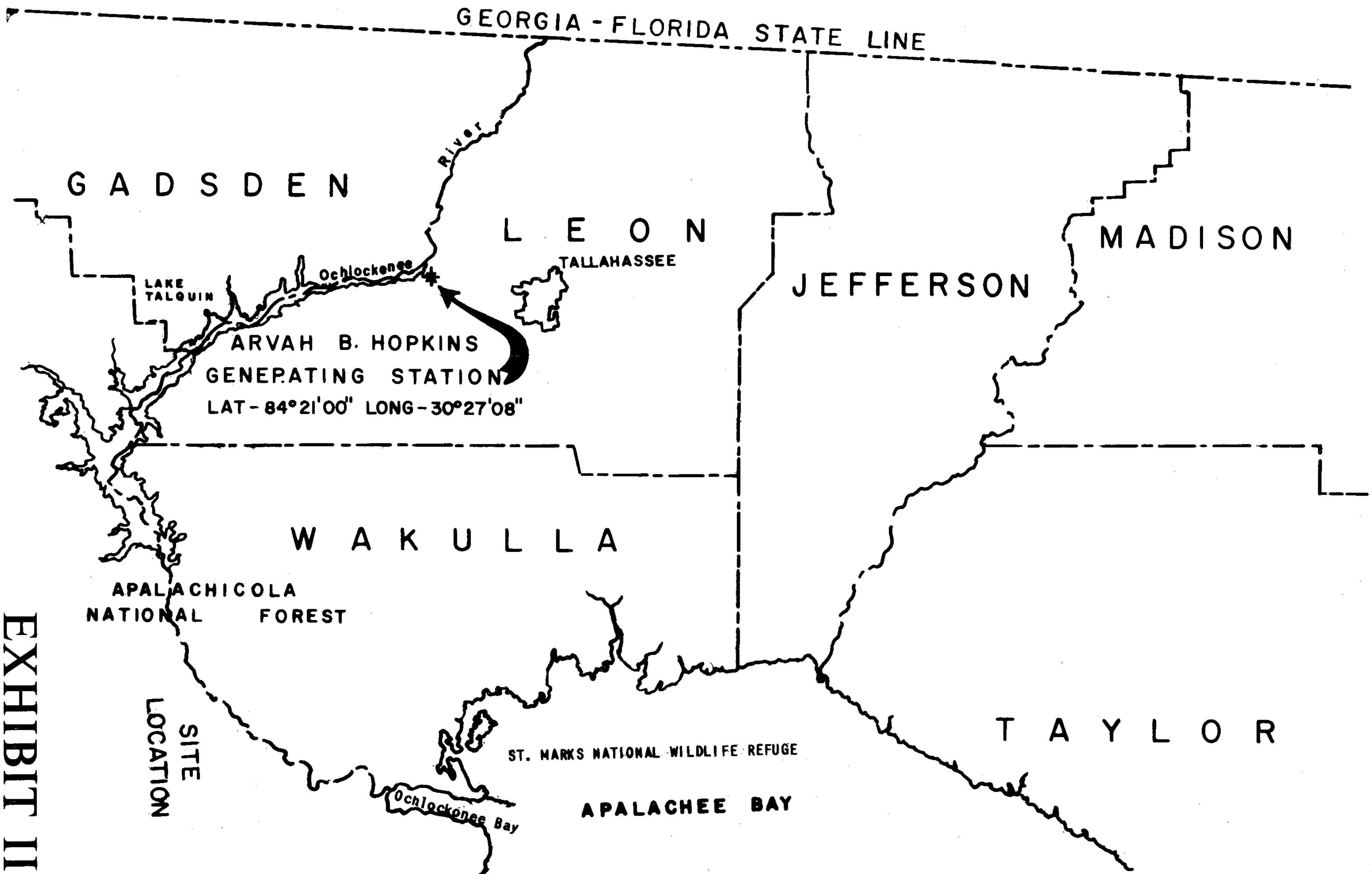
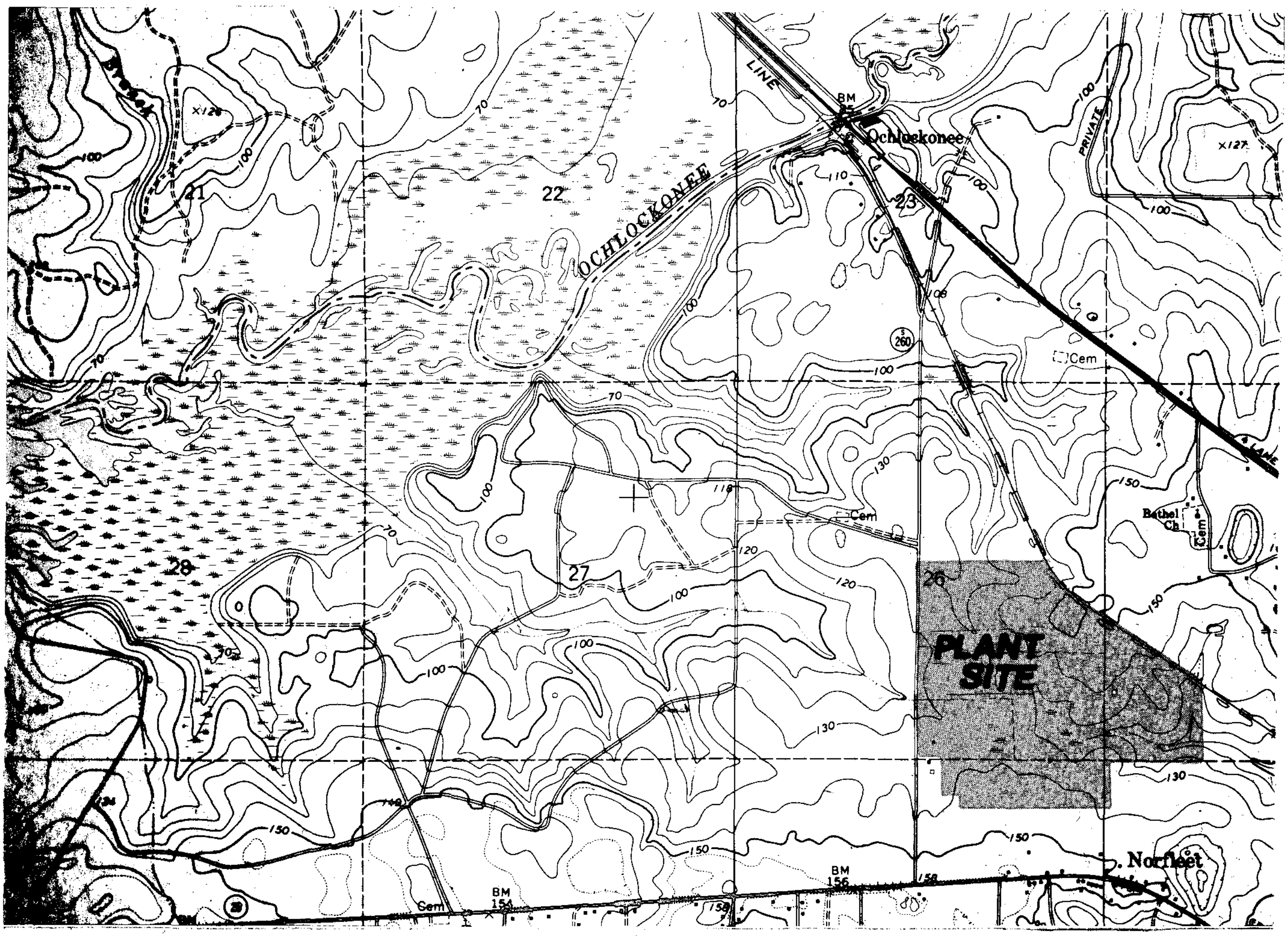


EXHIBIT II-1

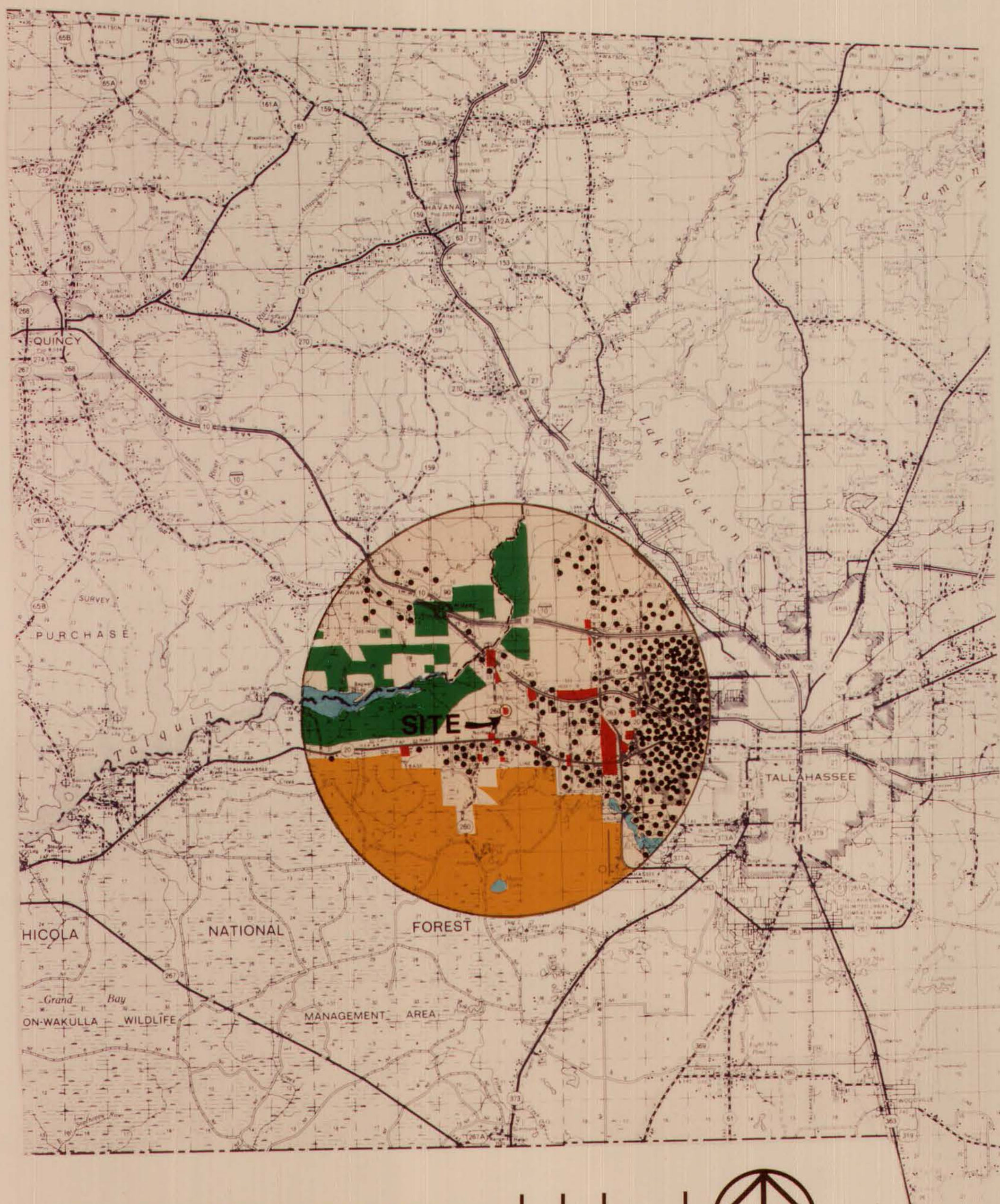
SITE LOCATION



PLANT SITE
ARVAH B. HOPKINS GENERATING STATION

EXHIBIT II-2

POPULATION DISTRIBUTION & LAND USE ANALYSIS



LEON-GADSDEN COUNTIES

0 1 2 MILES 4

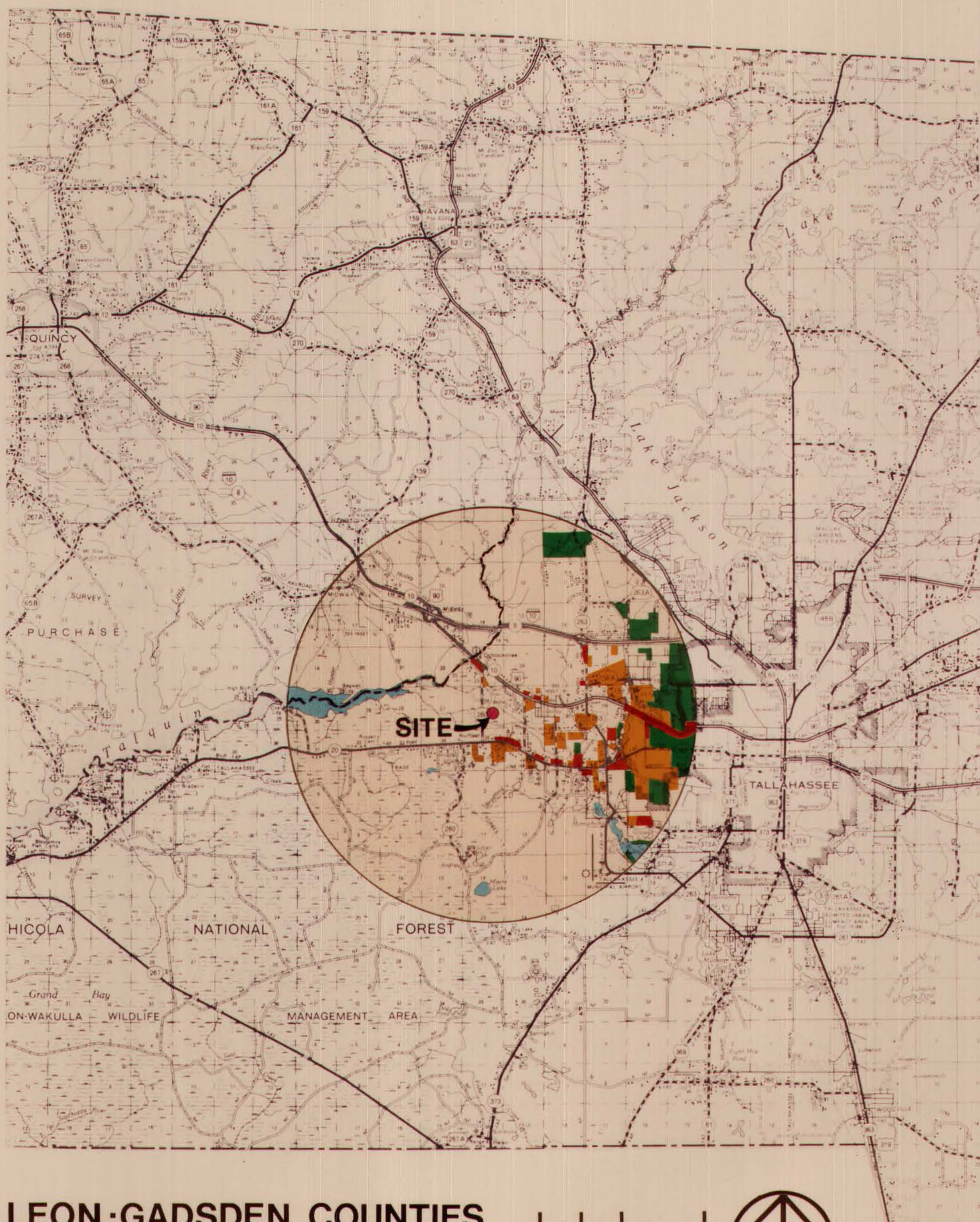
- PRIVATE INTEREST
- GOVERNMENT INTEREST
- COMMERCIAL INTEREST
- UNDEVELOPED

ONE DOT REPRESENTS 50 PERSONS

SOURCE: REYNOLDS, SMITH & HILLS
DATE: DECEMBER, 1973

EXHIBIT II-3

ZONING



LEON·GADSDEN COUNTIES

0 1 2 MILES 4

- AGRICULTURAL / OPEN RURAL
- RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL

SOURCE: REYNOLDS, SMITH & HILLS

DATE: DECEMBER, 1973

EXHIBIT II-4

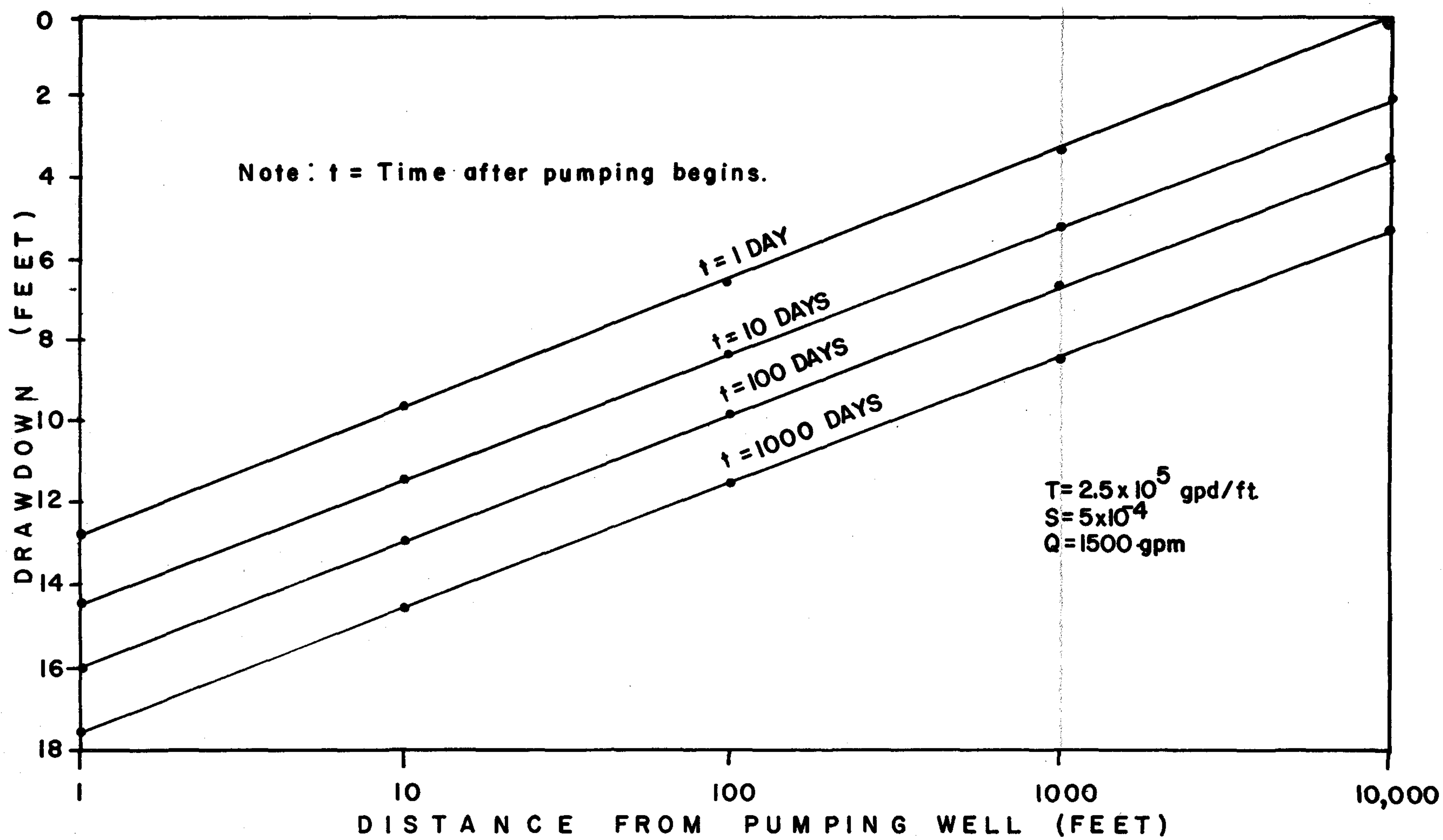
The population analysis was made of this area utilizing data from the 1970 census and the two electric authorities serving this area, City of Tallahassee Electric Utilities Department and Talquin Electric Cooperative of Quincy, Florida. The data from the electric companies was used by applying persons per household, as determined from the 1970 census, to the total number of active residential electric meters in the area.

The major concentration of population is located in the eastern portion of the study area, within the Tallahassee city limit. The residential areas are comprised of single family dwellings, mobile homes, duplexes, and milti-family apartment complexes. Using the aforementioned data for population analysis, the results show that there were approximately 24,000 people in the five-mile radius at the time of the analysis.

A substantial portion of the study area is represented by the Apalachicola National Forest, managed by the U. S. Forest Service, and much of the study area is presently undeveloped and sparsely populated. As shown on Exhibit II-4, most of the area is zoned AG (agriculture/open rural) with small parcels of commercial, industrial, and residential.

There is very little industrial development around the study area and the trend is to industrial parks which serve as commercial, light industrial parks, and distribution centers for goods and services. The major growth trend of Leon County is to the north-east of Tallahassee which is not represented in this study area.

The population analysis indicates that less than 2,000 people reside within two miles of the plant area. In an area one-half mile from the plant there are only two



DISTANCE — DRAWDOWN (THEORETICAL)

EXHIBIT II-14

residences. One of these dwellings is owned by the City of Tallahassee, and is actually within the site property lines.

The major existing wells (over 50 gpm) which are a part of the Tallahassee municipal water supply are located outside the five-mile radius of the study area. At present, there are no major industrial wells inside the study area besides the wells existing at the site. A small number of small service wells (averaging 35 gpm yield) are located within the study area and are maintained by the City of Tallahassee. These wells will be phased out of service as master water and sewer plans of the city are implemented.

2.3 REGIONAL HISTORIC LANDMARKS

This application will not address the possible points of historical interest, due to the fact that no additional land will be purchased for the proposed facilities. The use of the existing site will not be changed and any of the effects to points of historical significance will remain the same.

2.4 GEOLOGY

2.4.1 Area Geology

The Arvah B. Hopkins Generating Station is located in an area known as the Okefenokee Dunes as part of Apalachicola Coastal Lowlands (Hendry and Sproul, 1966).

The Apalachicola Coastal Lowlands are characterized by essentially flat, sandy surfaces marked by shallow, poorly defined creeks. The area is underlain by sand and clay deposits up to 80 feet thick. The water table is very close to the surface, and during rainy seasons much of the area is swampy.

Across the northern edge of the Apalachicola Coastal Lowlands, just south of and essentially paralleling State Highway 20, is a low southward-facing escarpment (Cody Scarp) that occurs at 140-150 feet elevation. (Bulletin No. 47, Geology and Ground-water Resources of Leon County, Florida Geological Survey, 1966.)

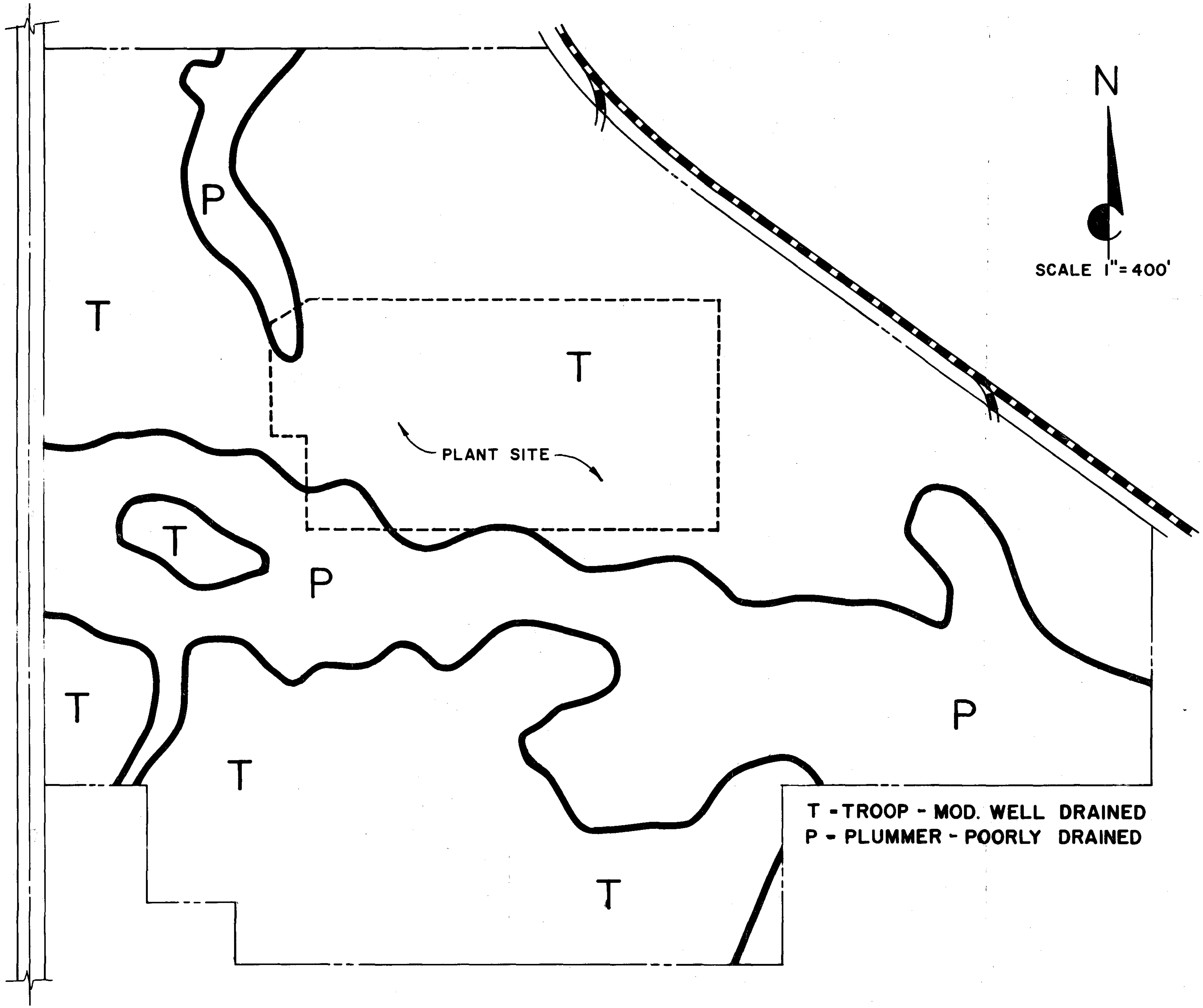
2.4.2 Site Geology

The generating plant is located just north of the Apalachicola lowlands on a ridge of loose, quartz sands. The ridge probably represents the dune area associated with the Okefenokee shoreline.

(a) Topography - General terrain of the area slopes in the east-west direction towards the Ochlockonee River valley lowlands. On site, the highest contour noted is 150 feet above mean sea level in the northeastern section and a low of 130 feet above mean sea level along the western boundary. Elevation of the creek bed located just west of State Road 260 is about 120 feet above mean sea level. The elevation of the Ochlockonee River bank is approximately 70 feet above mean sea level.

(b) Soils - Information obtained from United States Department of Agriculture - Soil Conservation Service, indicates that soils located on site fall within two associations - Troop and Plummer (see Exhibit II-5).

Following is a brief explanation of the associations.



SOILS MAP

EXHIBIT II-5

(1) Troop Association - Troop association is comprised of Blanton and Klej series. These are deep, moderately to somewhat poorly-drained, strongly acid soils. They are representative of nearly level to strongly sloping terraces, developed from thick beds of unconsolidated acid sands and are underlain by sandy clay loam and sandy clay.

The surface layers are dark-gray to grayish-brown sand to loamy sand surface layers four to 14 inches thick. No "B" horizon has developed and the surface layers grade with a "C" horizon of fine, coarse to loamy sands. The "C" horizon generally extends to a depth of 42 inches, but in some cases a "D" horizon is found at depths of 30 to 42 inches.

Native vegetation supported by this association is thin stands of longleaf and slash pines, myrtle, gallberry, various oaks, and wire grass.

These soils have rapid permeability, which may be restricted in places due to high water table conditions. They have low fertility and are not loamy enough for good tilth.

(2) Plummer Association - Plummer association is comprised of Leon, Plummer, and Rutledge series. These are deep, somewhat poorly-drained, strongly acid to very strongly acid soils, occurring on uplands in nearly level areas, formed from moderately thick beds of acid sand and loamy sand. They are underlain by finer textured sediments.

Leon and Plummer series have a gray to dark-gray fine sand to sand surface layer three to seven inches thick. The surface soil grades to a subsurface layer to light-gray sand, six to 12 inches thick. At deeper depths, the soil has a dark-brown layer weakly cemented and stained by organic matter.

Rutledge soils have a black fine sand surface soil high in organic matter. The surface layers are eight to 18 inches thick and grade to a gray to white fine sand subsoil.

The native vegetation for the association consists of turkey oaks, runner oaks, sparse stands of longleaf and slash pines, palmetto, wire grass, blackgum, gallberry, and water loving grasses.

The surface runoff is low because of the flat topography and plant nutrients leach rapidly. These soils are excessively wet and consequently their natural fertility is low.

(c) Stratigraphy - The State of Florida is uniquely distinct both in geographic position within the North American continent and in its outline. It lies at the extreme southeastern corner of the continent and projects seaward as an elongated peninsula. This peninsula is the emerged portion of a greater mass of sediment known as the Floridan Plateau. Leon County is located along the north central border of the Floridan Plateau.

In Leon County there are about 4,500 feet of Mesozoic clastics and carbonates, and the Tertiary beds are represented by 2,500 feet of carbonates, sands, and clays, The Quaternary beds are composed of sands and some sandy clays, and are less than 100 feet thick.

The general stratigraphy of the county is shown in Exhibit II-6. Boring logs recorded by Ardaman & Associates (September, 1968) for the site show the substrata that belongs predominantly to the Quaternary and Tertiary Periods. Dark brown and gray fine sand make up the top soil. This strata is underlain by brown fine sand, clayey fine sand, sandy clay, montmorillonite clay. Traces of limestone seams associated with calcareous clay matrix were located at 100 feet msl.

From boring records, a generalized stratigraphic nomenclature for geologic formations recorded at site was made (Exhibit II-7).

2.5 HYDROLOGY

2.5.1 Surface Water

Leon County is characterized by many solutional depressions that usually contain water as small ponds or lakes. Commonly, there are small streams of relatively short length that empty into these ponds and lakes. These small streams have dendritic patterns, and their upper reaches may be dry except during and for a short period following the rainy season.

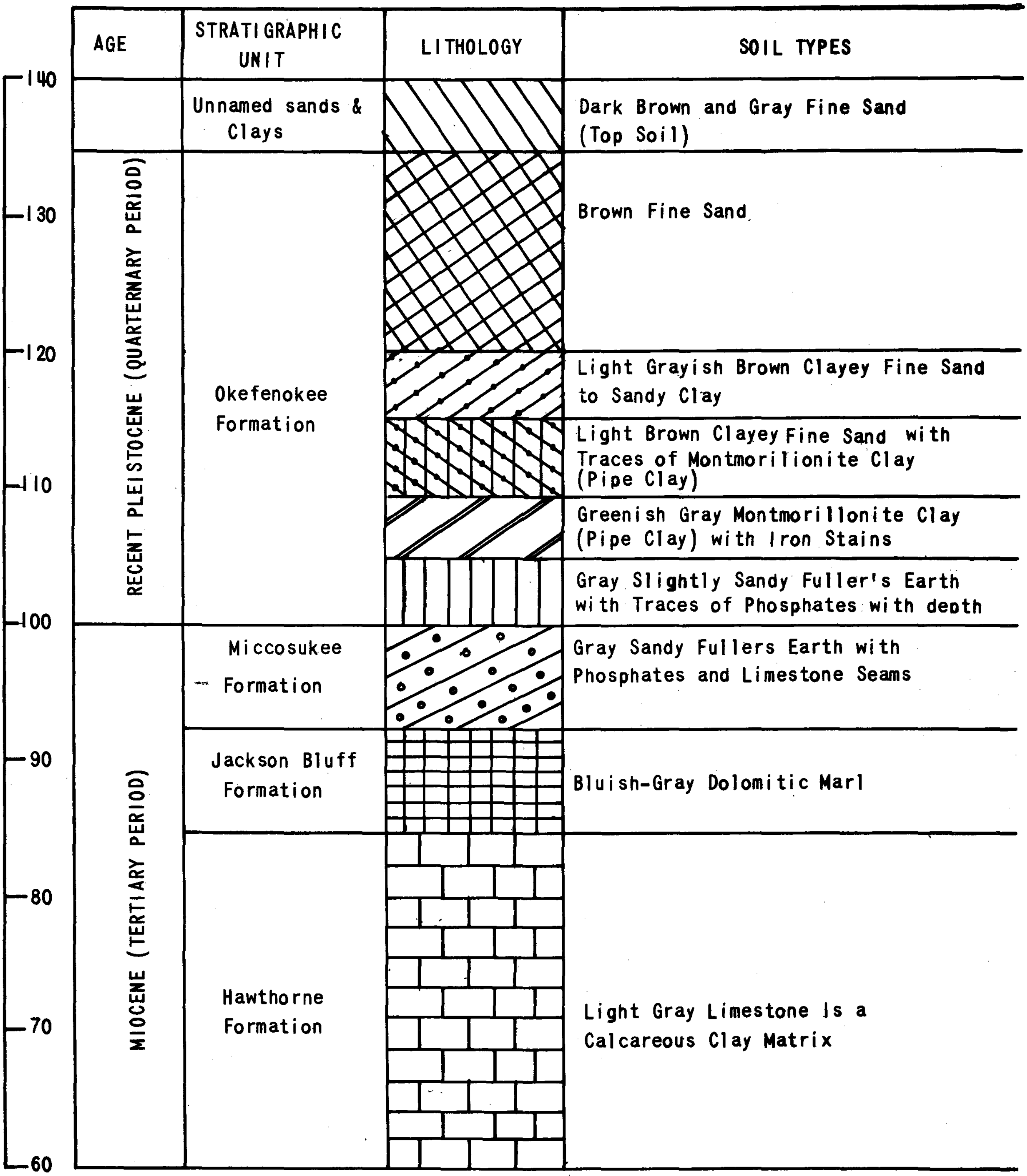
The Arvah B. Hopkins Generating Station is in close proximity to many bodies of water. The two most important of which are the Ochlockonee River and Lake Talquin. In the vicinity of the generating station, the Ochlockonee River runs generally from the northeast to the southwest and is approximately 6,500 feet northwest of the plant site at the closest point. The east most portion of Lake Talquin lies approximately 13,000 feet west of the plant site.

STRATIGRAPHIC NOMENCLATURE FOR GEOLOGIC FORMATIONS IN LEON COUNTY

PERIOD	SERIES		STAGE/AGE	FORMATION.
Quaternary	Recent-Pleistocene			Unnamed Sands and Clays.
				Pamlico Dunes.
				Wicomico Formation.
				Okefenokee Formation.
Tertiary	Miocene		Chotawhatchee Stage	Miccosukee Formation.
				Jackson Bluff Formation
			Alum Bluff Stage	Hawthorn Formation.
			Tampa Stage	St. Marks Formation
	Oligocene			Suwannee Formation
	Eocene	Upper	Jackson Age	Ocala Group.
		Middle	Claiborne Age	Avon Park Limestone.
				Tallahassee Limestone.
		Lower	Wilcox Age	Undifferentiated Beds.
		Paleocene	Midwage Age	Undifferentiated Beds.
Cretaceous	Gulf			Beds of Tayor Age.
				Austin Chalk.
				Atkinson Formation.
	Comanche		Undifferentiated Beds of Lower Cretaceous Age, Composed of Red, Waxy Shales, Nodular Limestones and Sandstones.	
Triassic	Upper		Newark Age	Beds of Red, Micaceous Shales and Poorly Sorted Sandstones and Diabase Intrusives.

EXHIBIT II-6

STRATIGRAPHIC NOMENCLATURE FOR GEOLOGIC FORMATIONS
RECORDED AT SITE 1



1. BORING RECORDS SUPPLIED BY ARDAMAN & ASSOCIATES

EXHIBIT II-7

The generating station discharges its heated effluent into the Ochlockonee River by way of a small stream that flows generally in the northwest direction as shown in Exhibit II-12. This is a natural stream and is joined by another small stream about one-third of the way down its reach toward the river.

Both Lake Talquin and the Ochlockonee River are Class III waters and are subject to the controls of the State of Florida as set forth in Chapter 17-3, "Pollution of Waters," of the Florida Administrative Code. The usage of these waters under this classification is for recreation and propagation and management of fish and wildlife.

Historic information on Lake Talquin and the Ochlockonee River is available from the United States Geological Survey (USGS) and the State of Florida, Department of Natural Resources concerning water stage, flow and a limited amount of water quality.

A field investigation was conducted on January 16, 17, and 18, 1974 to collect data concerning stream flows and the diurnal variation of dissolved oxygen (DO) and temperature of the plant discharge stream and the Ochlockonee River.

(a) Ochlockonee River - The tributaries to the Ochlockonee River in the Lake Talquin area have trellis, rather than dendritic drainage patterns.

The Ochlockonee River is the largest river in the county. This river heads up in Georgia and flows southward to its junction with the Gulf of Mexico in southwestern Wakulla County. It forms a common boundary with Gadsden and Liberty Counties along the western side of Leon County. The stream is mature with numerous meanders and meander scars. Its gradient from the Georgia State Line to the southwestern tip of Leon County is 1.5 feet per mile.

The stream has been dammed just upstream of the State Highway 20 bridge for hydroelectrical facilities (no longer used). With the reach of the dammed portion (Lake Talquin), the stream valley is narrower and steeper than elsewhere along its course.

The Ochlockonee River has two United States Geological Survey (USGS) stream gaging stations. One station is upstream of the point of intersection of the plant discharge stream and the other downstream of this point.

The upstream station is referred to as Ochlockonee River near Havana, Florida, Station No. 02329000. This is a nonrecording gage from which values of stage are read daily. Water quality records are also available for this station for the period October 1962 to present. The drainage area for this station is approximately 1,140 square miles. The period of record is June 1926 to present and the average discharge for 44 years is 993 cfs. The extremes for the period of record are as follows: maximum discharge 55,900 cfs, April 14, 1948; maximum water level 94.44 feet msl; minimum discharge 17 cfs, October 23-28, November 1, 1954; minimum water level 70.11 feet msl, October 31, November 1, 3, 1968. The extremes in water quality for this period of record are as follows:

(1) Specific Conductance - maximum daily, 775 micromhos, November 15, 1962 - minimum daily, 16 micromhos, September 22, 23, 1968.

(2) pH (1966-70) - maximum daily, 7.9, November 24, 1967 - minimum daily, 5.7, September 23, 1969.

(3) Water Temperature - maximum daily, 29°C, August 11, 1963 and June 21, 1964 - minimum daily, 1°C, December 26, 1963.

Downstream station is referred to as Ochlockonee River near Bloxham, Florida, Station No. 02330000. This station has a water-stage recorder that gives continuous readings of the water stage. Water quality records for this station are not available on a regular basis but some miscellaneous analyses are available. This station has a drainage area of approximately 1,720 square miles. The period of record is from June 1926 to present and the average discharge for 28 years (1926-1954) is 1,614 cfs, unadjusted, and 16 years (1954-1970) 1,749 cfs, unadjusted. The extremes for the period of record are as follows: maximum discharge, 89,400 cfs, September 23, 1969; maximum water level, 57.33 feet msl. Minimum discharge since October 1954, 1.0 cfs, November 1, 2, 1957 caused by closure of breaks in embankment of Jackson Bluff Dam.

The sources of stream flow records for the Ochlockonee River are indicated in Table II-1.

TABLE II-1

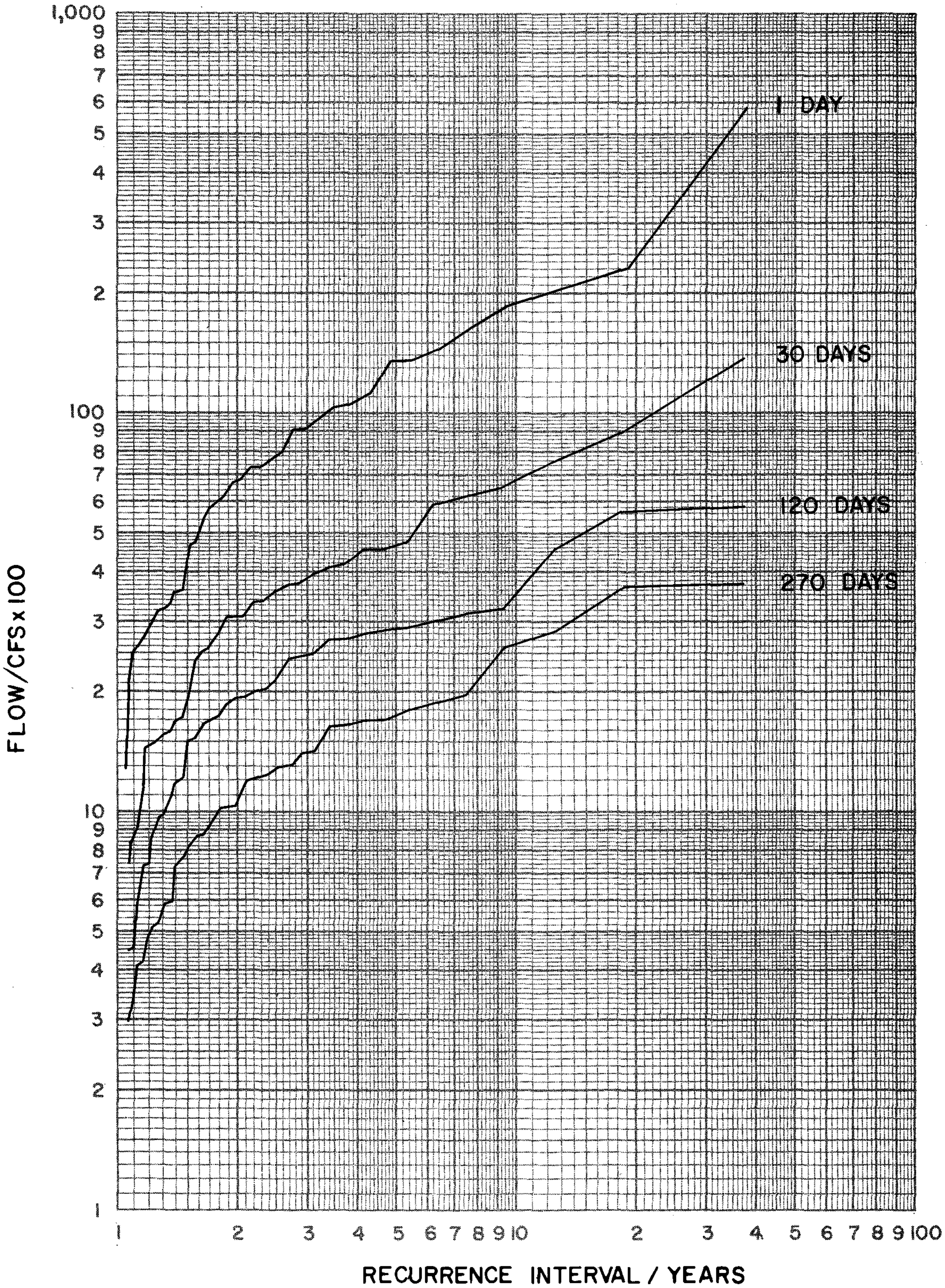
REPORTS OF FLOW RECORDS FOR OCHLOCKONEE RIVER

Period	Report	Title
1926-1930	WSP 1304	Compilation of Records of Surface Waters of the U.S.
1950-1960	WSP 1724	Compilation of Records of Surface Waters of the U.S.
1960-Present	State Reports	Water Resources Data for Florida - Part 1, Vol. 1

The flow characteristics of the Ochlockonee River near Havana and Bloxham were evaluated from the indicated flow records. These characteristics are shown in Tables II-2 and II-3.

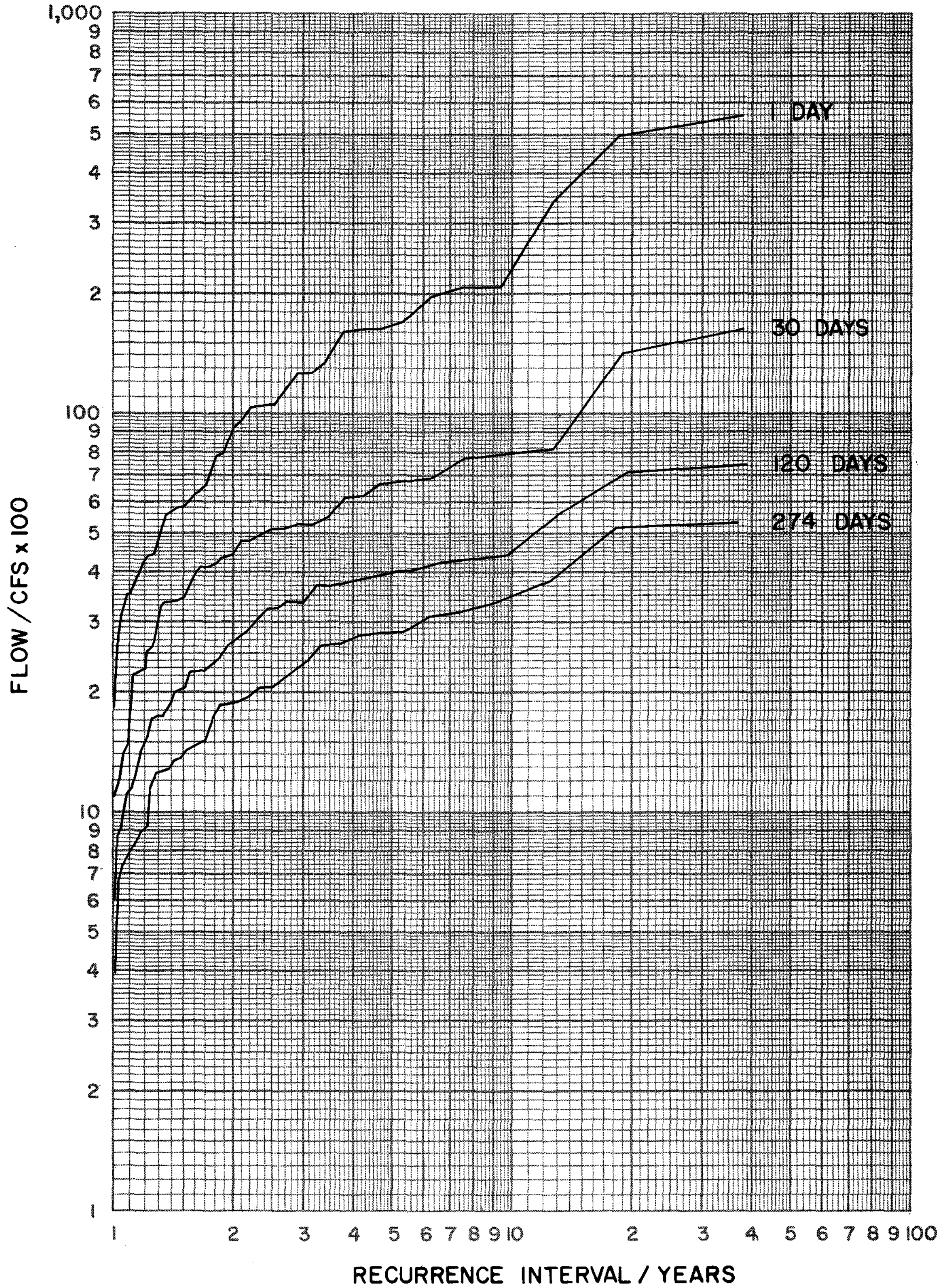
Low flow and high flow characteristics were analyzed from statistical summaries published in the 1971 report of the Florida Department of Natural Resources, "Selected Flow Characteristics for Florida Streams and Canals." Selected low and high flow frequency curves are plotted as shown in Exhibits II-8 thru II-11. A summary of the 5, 10, and 25-year frequency low and high flows for the Ochlockonee River near Havana and near Bloxham are given in Table II-4.

The data in Table II-4 indicates that on the average every 10 years, the lowest mean discharge for a period of 1, 30, 120, and 274 consecutive days at the Havana station would be 28.1, 32.0, 52.2, and 142 cubic feet per second. The comparable lowest mean discharge for the Ochlockonee River near Bloxham would be 1.9, 50.9, 138, and 418 cubic feet per second.



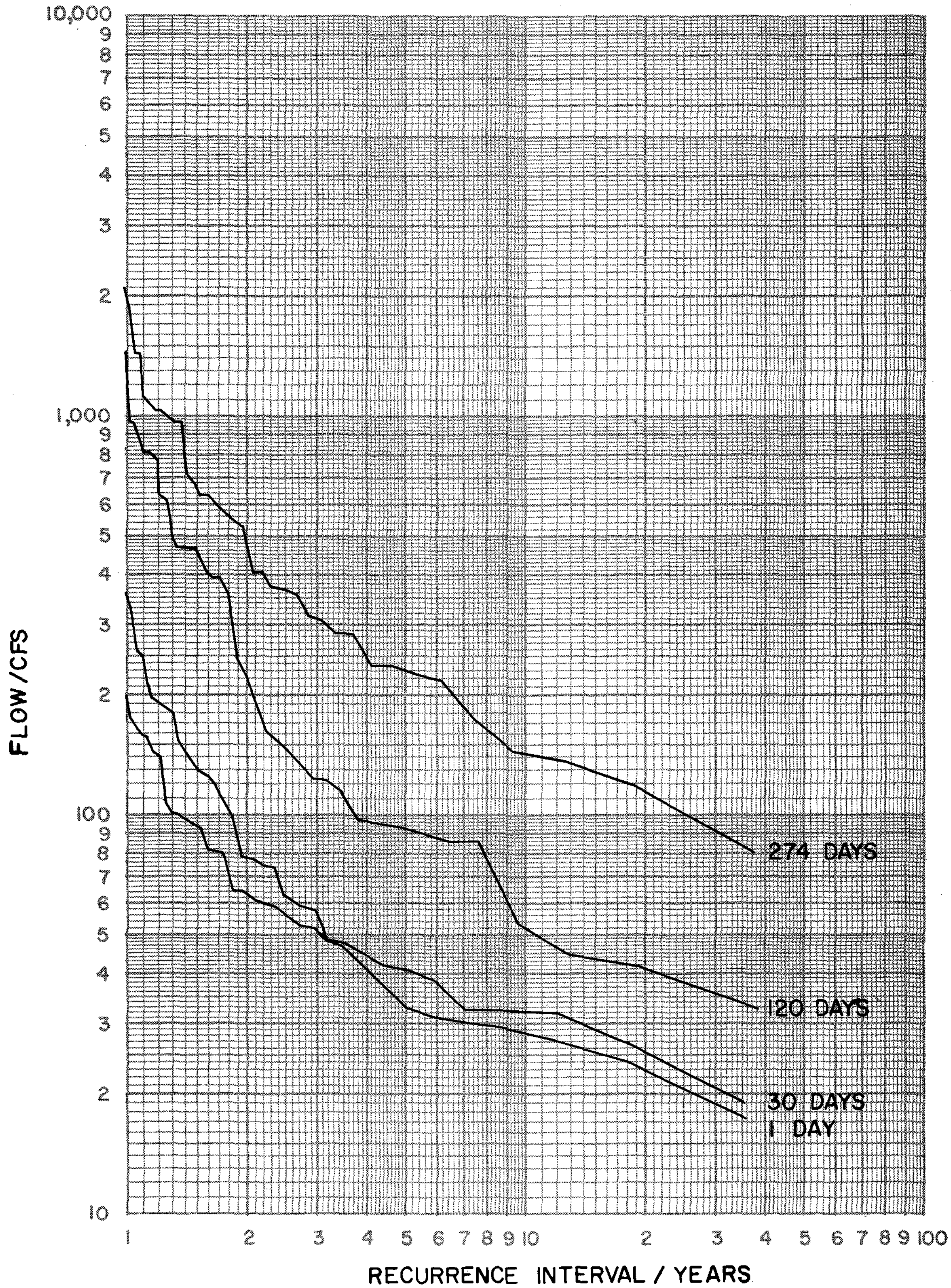
SELECTED
HIGH FLOW FREQUENCY CURVES
OCHLOCKONEE RIVER NEAR HAVANA
(02-3290.00)
1927 - 1965

EXHIBIT II-8



SELECTED
HIGH FLOW FREQUENCY CURVES
OCHLOCKONEE RIVER NEAR BLOXHAM, FLA.
(02-3300.00)
1927 - 1965

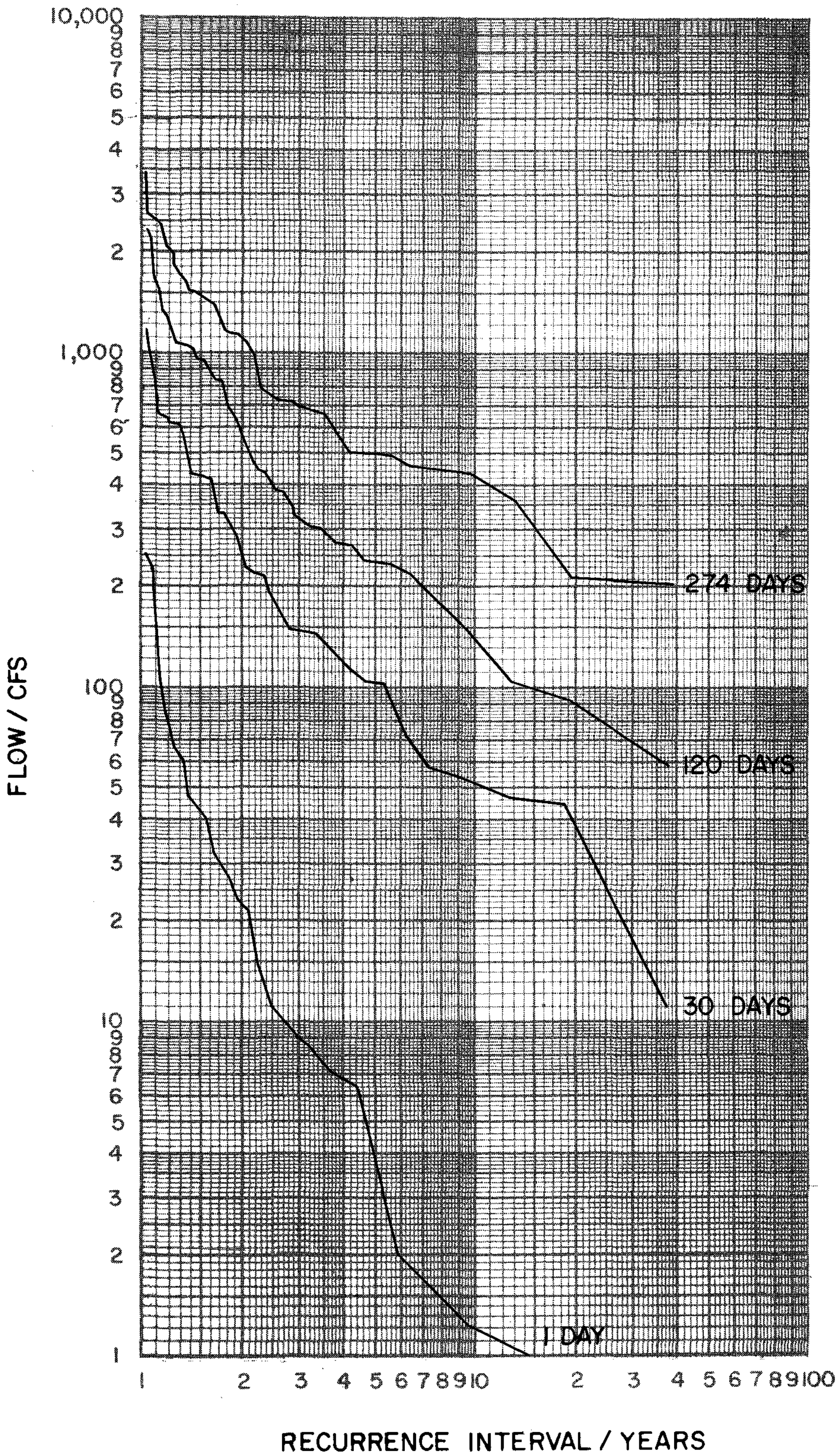
EXHIBIT II-9



SELECTED
LOW FLOW FREQUENCY CURVES

OCHLOCKONEE RIVER NEAR HAVANA
(02-3290.00)
1927 - 1964

EXHIBIT II-10



SELECTED
LOW FLOW FREQUENCY CURVES
OCHLOCKONEE RIVER NEAR BLOXHAM, FLA.
(02-3300.00)
1927 - 1964

EXHIBIT II-11

TABLE II-2

FLOW CHARACTERISTICS OF THE OCHLOCKONEE RIVER NEAR HAVANA (1926-1971)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Average Min. Flow (past 20 years) cfs	46.7	60.8	108	225	398	502	396	174	127	157	141	75.5
Average Flow (past 20 years) cfs	529	234	777	1254	1858	2354	1817	1171	694	806	754	495
Average Flow (record) cfs	508	365	716	1164	1593	2205	1897	913	574	729	912	689
Maximum Flow (record) cfs	2120	3594	6057	3657	6866	6444	9368	7282	2860	1970	6100	4279
Minimum Flow (record) cfs	22.0	26.5	37.0	65.5	116	167	173	61.0	85.0	114	58.0	26.0

TABLE II-3

FLOW CHARACTERISTICS OF THE OCHLOCKONEE RIVER NEAR BLOXHAM (1926-1971)

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Average Min. Flow (past 20 years) cfs	80.6	92.7	165	481	712	798	578	311	285	216	293	206
Average Flow (past 20 years) cfs	1003	538	1413	1841	2752	3198	2646	1282	1186	1334	1267	1401
Average Flow (record) cfs	1029	723	1264	1788	2381	3081	2885	1299	1108	1334	1599	1472
Maximum Flow (record) cfs	3792	4943	8913	4918	9203	8355	13240	4880	4470	2998	6840	7890
Minimum Flow (record) cfs	50.0	52.5	82.6	222	243	296	361	172	102	115	207	120

TABLE II-4

LOW AND HIGH FLOW FREQUENCY DATA
OCHLOCKONEE RIVER NEAR HAVANA AND BLOXHAM

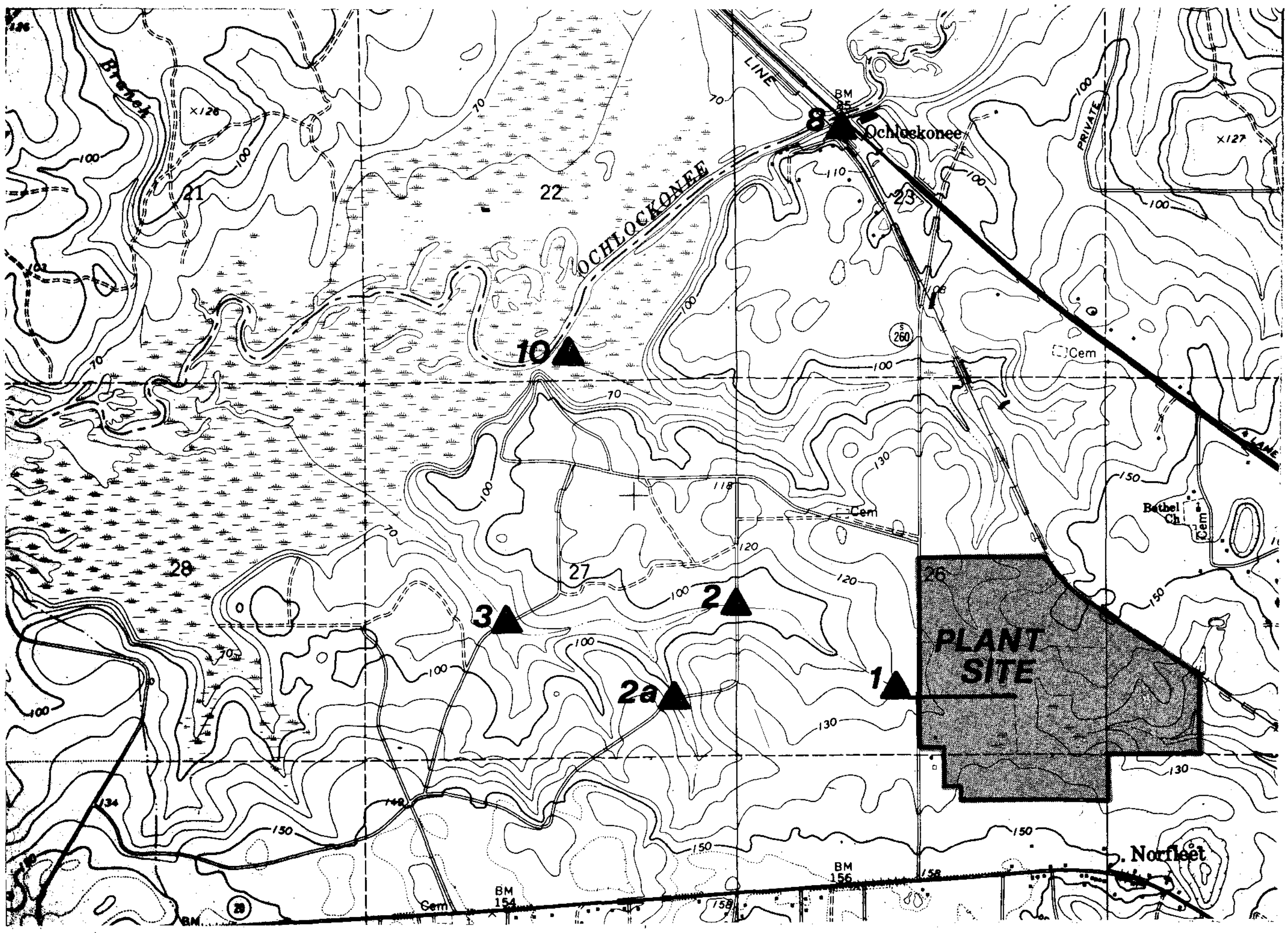
Frequency	Station	1-Day Flow(cfs)		30-Day Flow(cfs)		120-Day Flow(cfs)		274-Day Flow(cfs)	
		High	Low	High	Low	High	Low	High	Low
5	Havana	12,700	33.2	4,410	41.0	2,720	92.5	1,650	232
	Bloxham	16,300	3.6*	6,600	102	3,910	124	2,800	490
10	Havana	17,600	28.1	6,320	32.0	3,320	52.2	2,480	142
	Bloxham	20,600	1.9*	7,800	50.9	4,320	138	3,390	418
25	Havana	29,600	20.2	9,850	22.4	5,270	37.5	3,400	100
	Bloxham	51,500	0.0*	14,800	24.6	7,190	78.0	5,200	205

*Affected by dam just upstream.

(b) Lake Talquin - Lake Talquin is a man-made lake created by the Florida Power Corporation dam which is located on the Ochlockonee River at the junction of Gadsden, Leon and Liberty Counties. This locality is known as Jackson Bluff and is a famous upper Miocene shell locality. The lake is about 15 miles long and one-half to one mile wide. The water level, controlled by the dam, is about 69 feet in elevation. The valley that the lake occupies trends in an east-northeast to west-southwest direction, and the elevation of the bordering hills is up to 180 feet.

Lake Talquin is served by a nonrecording gage referred to as Lake Talquin near Bloxham, Station No. 02329900. The period of record for this gage is 1930 to present. The surface area of Lake Talquin is 6,850 acres (10.7 square miles) when the water level is 60 feet msl. The drainage area is approximately 1,720 square miles. The extremes for the period of record for Lake Talquin are as follows: maximum daily contents, 99,400 acre-feet, September 22, 1969 (elevation 71.16 ft. msl); maximum instantaneous elevation 71.60 ft. msl, September 22, 1969; minimum daily water level after January 1930, 48.70 feet msl, October 22, 23, 1957 (earth embankment breached). No water quality information is available on a regular basis.

(c) Field Investigation - January 16-18, 1974 - Exhibit II-12 shows the location of the sampling stations relative to the power generating plant. Station No. 1 was at the point where State Road 260 crosses the discharge stream from the power generating facility. This point is approximately 1,400 feet downstream of the origin of this stream. Dissolved oxygen (DO) and temperature measurements



LOCATION OF SURFACE WATER SAMPLING STATIONS

EXHIBIT II-12

were taken in the center of the stream, 20 feet downstream of the edge of the road. Discharge measurements were taken at two points: one, 20 feet upstream of the road, and the other, 100 feet downstream of the road. These two measurements were obtained because the downstream measurement included flow from small streams that ran parallel to the road, and therefore, did not represent the plant discharge. The upstream measurement did not include this additional flow and was therefore more truly representative of the plant discharge.

Station No. 2 was approximately 2,800 feet downstream of Station No. 1, at a point where the stream is crossed by an unimproved road. Dissolved oxygen (DO) and temperature measurements were made in the center of the stream directly beneath the log bridge. The discharge measurement was taken 20 feet upstream of the road crossing. Immediately upstream of Station No. 2 lies a body of water that is a result of a beaver dam.

Station No. 2a is on a small tributary stream. The sampling point was approximately 1,600 feet upstream of the intersection of these two streams where the small stream passes through a culvert under the unimproved road. Dissolved oxygen (DO) and temperature measurements were taken in the center of the stream 15 feet above the culvert entrance. The discharge measurement was taken at a point 50 feet upstream of the culvert entrance.

Station No. 3 was approximately 3,320 feet downstream of Station No. 2 at a point where the stream intersects an unimproved road. Dissolved oxygen (DO) and temperature measurements were taken in the center of the stream at the center of the bridge that crosses the stream. The discharge measurement was taken 30 feet upstream of the bridge.

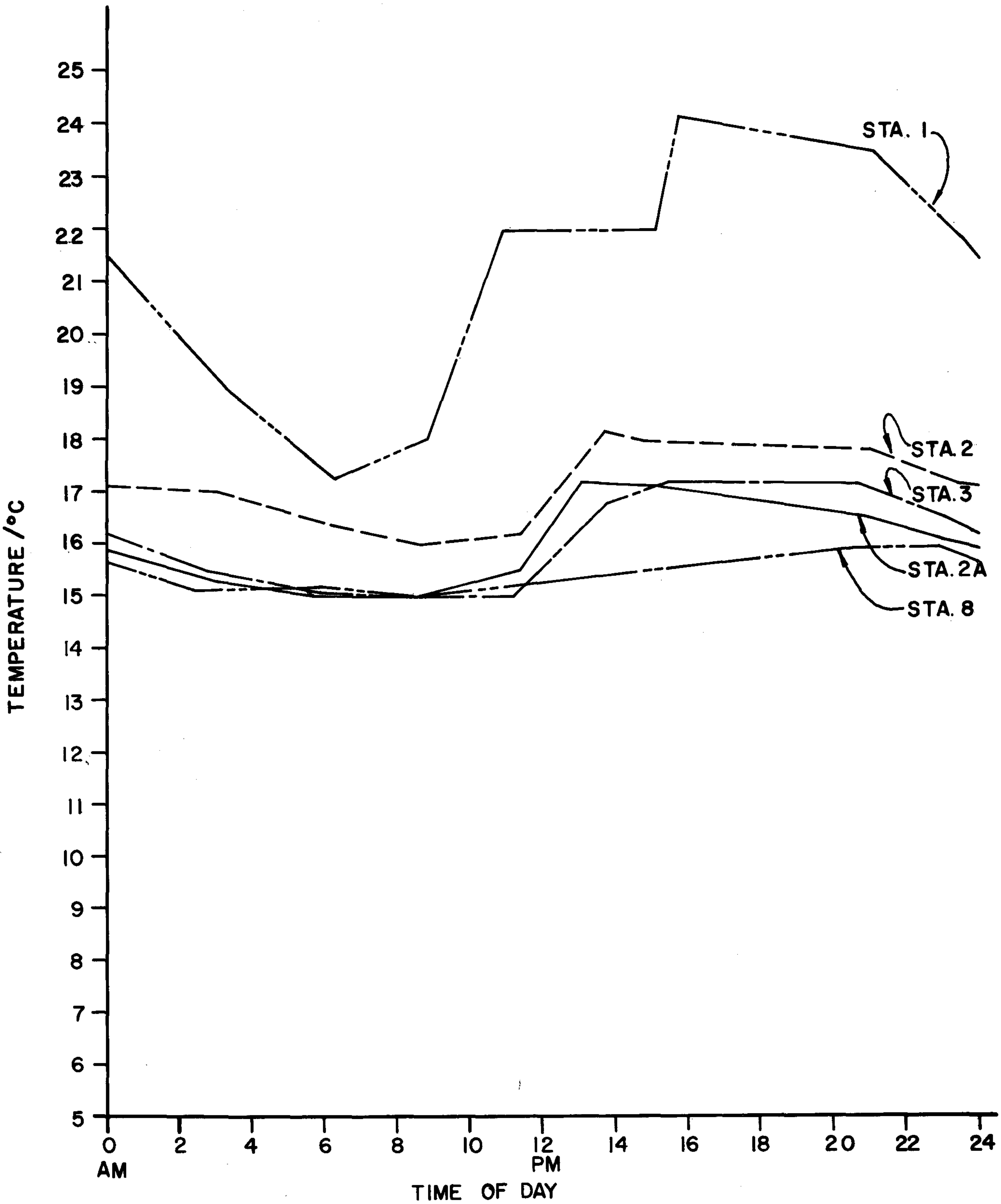
Station No. 8 was at the intersection of the Ochlockonee River and Highway 90. Dissolved oxygen (DO) and temperature measurements were taken from the upstream edge of the downstream highway bridge 95 feet from the left abutment of the bridge. The discharge measurement was taken from the downstream side of the upstream highway bridge.

Station No. 10 was located on a stream that flowed into the Ochlockonee River approximately 5,000 feet downstream of Station No. 8. Dissolved oxygen (DO), temperature and discharge measurements were taken 200 feet upstream of the mouth of this stream at the river.

(1) Dissolved Oxygen and Temperature - The measurement of dissolved oxygen and temperature was accomplished with a Yellow Springs Model 54 oxygen meter. This instrument made it possible to obtain on the spot values for both DO and temperature by merely placing the probe in stream after calabration. Air temperature measurements were also made using this instrument.

Measurements were taken every three hours over a 24-hour period from January 16 to January 17, 1974, at Stations No. 1, 2, 2a, 3, and 8. Each time the measurements were taken at the same location to insure uniform conditions at each sampling point.

Exhibit II-13 shows the temperatures recorded at each of the stations over a 24-hour period. Temperatures ranged from a maximum of 24.2°C



TEMPERATURE VARIATION
AT SAMPLING STATIONS
JAN. 16 17, 1974

EXHIBIT II-13

at Station No. 1, to a minimum of 15°C at Stations No. 2a, 3, and 8. As expected, the temperatures recorded at Station No. 8 were found to be consistently lower than the temperatures recorded at all of the other stations.

The largest temperature differential between adjacent stations was observed most often between Stations No. 1 and 2. The minimum temperature difference between these stations was 0.85°C observed at 6:18 a.m. and the maximum difference was 6.3°C observed at 3:45 p.m.

Diurnal variation of the temperature is clearly illustrated in Exhibit II-12. Generally, minimum temperatures occurred between 6:00 a.m. and 8:00 a.m., and maximum temperatures occurred between 1:00 p.m. and 4:00 p.m. This exhibit also shows the effects of dilution and the heat transfer on the plant discharge as it passes through the reaches of the stream and the relative temperature differential between the discharge stream and the receiving river.

Dissolved oxygen measurements revealed relatively high percentage of saturation. Generally, Stations No. 1 and 3 exhibited higher percentage of oxygen saturation than did the Ochlockonee River as measured at Station No. 8. The lowest percentage saturation was observed at Station No. 2 where the measurements were taken in the stream as it left a beaver pond. Here the water was between 44 and 66 percent saturated with oxygen. Station No. 2a exhibited the second lowest level of oxygen saturation.

(2) Measurement of Discharge - The discharge or rate of flow of a stream is the quantity of water flowing past a cross section of the stream in a

unit time. The unit in which discharge is expressed is cubic feet per second. The procedure for measuring the area of a cross section of a stream and the velocity of flow past the section is known as the velocity-area method of measuring discharge. The product obtained by multiplying the area of the cross section by the velocity constitutes a discharge measurement.

A velocity-area measurement of discharge in which the velocity is measured by an instrument known as a current meter is a current-meter measurement.

In making a current-meter measurement, the total area of the cross section at the place of measurement is divided into small or partial sections and the area and the mean velocity is determined separately for each partial section. The product of the mean velocity thus obtained and the area of the partial section is the discharge in that section. The sum of the discharges in all the partial sections is the discharge in the stream at the point of measurement.

The mean velocity for each partial section was determined by using the six-tenths method for streams with a depth less than 1.5 feet, and by the two-point method for depths greater than this. In the six-tenths depth method, an observation of velocity is made in each partial section at 0.6 of the depth below the surface. The velocity measured at this point is taken as the mean velocity for the section. In the two-point method of measuring velocities, observations are made in each section at 0.2 and 0.8 of the depth below the surface. The average of these two observations is taken as the mean velocity in the partial section.

Current meter measurements were made at Stations No. 1, 2, 2a, 3, and 8 using either the Pygmy or the Price current meter.

The Pygmy meter was used where velocities were below the range of the larger Price meter and where it was possible to make the measurement by wading the stream. In this case, the meter is mounted on a sounding rod that is used to determine the depth in each partial section. The Price meter was used only at Station No. 8 where because of the depth of the river, it was not feasible to use the wading apparatus. In this case, the meter was mounted on a sounding cable that has a weight attached to the lower end. The meter assembly was lowered into the water and depth and velocity measurement made in this manner.

Flows determined by discharge measurements made at the stations are listed below:

Station	Flow (cfs)
1 Upstream of SR 260	0.64
1 Downstream of SR 260	0.72
2	0.89
2a	0.20
3	1.46
8	833

At the time of measurement, the discharge from the plant was 0.42 cfs, meaning that the difference between this flow and the flow measured at Stations No. 1 and 2 was contributed by another source. As the days prior to and during the measurements were without precipitation, it could be assumed with some confidence that the additional flow was a result of groundwater seepage. In the case of Station No. 3, a portion of the additional flow is from the small stream that joins the discharge stream between Stations No. 2 and 3. The discharge from this stream was measured at Station No. 2a. Once again, in totaling the measured flows, it is obvious that a portion of the total flow is contributed by another source, presumably, groundwater.

At the time when the discharge measurements were taken the plant discharge was diluted 3.39 times by the time it had reached Station No. 3.

In comparing the flow measured at Station No. 8 with the flow measured at the USGS gaging station at Havana (02329000) for the same time period, it was found that the flows are very close to being the same. The USGS gage is of the nonrecording type from which values are obtained once daily. On January 16 and 17, 1974, the estimated average daily flows at this gage were 846 cfs and 816 cfs, respectively. The flow at Station No. 8 of 833 cfs was measured on the afternoon of January 16, 1974. This data indicates that the flows measured at the Havanna gaging station can be taken to be the same as the flows in the river at the point where the power plant discharge stream meets the river during periods which are without significant precipitation with reasonable accuracy.

With the river flowing at the rate of 833 cfs as it was on January 16, 1974, and the discharge from the power plant being 0.42 cfs (as it was at that time) the factor of dilution is 1973. Assuming the river to be flowing at the above mentioned rate and the power plant discharge increased to 2.686 cfs 1 unit because of the addition of Unit 2, the dilution factor would be 311.7. Once again, assuming the river to be flowing at the same rate and the power plant discharge to be flowing at the rate of 4.63 cfs as a result of the addition of both Units 2 and 3, the dilution factor would be 181.3.

In comparing the anticipated plant discharge for the addition of Units 2 and 3 and the values listed in Table II-4 (low and high flow frequency) for the USGS gaging station near Havana, it can be determined that on the average of once in five years for the period of one day, the plant discharge with Units 1 and 2 on line, and Units 1, 2, and 3 on line would make up 8.1 percent and 13.9 percent, respectively, of the total flow in the river at the discharge point. By the same principle, Table II-5 was computed for other selected low flow frequencies.

TABLE II-5

PLANT DISCHARGE AS PERCENT OF RIVER FLOW
AT POINT OF DISCHARGE
FOR SELECTED LOW FLOW FREQUENCIES

Frequency	Units Operation	Number of Consecutive Days: 1	30	120	274
5	1 and 2	8.1%	6.6%	2.9%	1.2 %
	1, 2 and 3	13.9%	11.3%	5.0%	2.0 %
10	1 and 2	9.6%	8.4%	5.1%	1.9 %
	1, 2 and 3	16.5%	14.5%	8.9%	3.3 %
25	1 and 2	13.3%	12.0%	7.2%	2.7 %
	1, 2 and 3	22.9%	20.7%	12.3%	4.63%

2.5.2 Groundwater

(a) Area Hydrogeologic Conditions and Analysis - The primary source of groundwater supplies in Leon County consists of a series of hydraulically connected limestones of Miocene through middle Eocene age collectively referred to as the Floridan aquifer. The overlying sections of silts, clays, and sands have been called the Floridan aquiclude, and over much of Leon County these beds confine the Floridan aquifer under artesian pressure. Some localized lenses within the aquiclude are capable of producing small yields of water, however, these aquifers represent a minor source of supply and are unlikely to be developed as sources of large quantities of water.

In Leon County, water producing wells penetrate as much as 600 feet of limestones and dolomites ranging in age from upper Eocene to middle Miocene. Water producing formations in Leon County include the Crystal River formation, the Suwannee limestone, the Tampa (St. Marks) formation and the Hawthorn formation. The Suwannee limestone is the section of the Floridan aquifer most commonly used as a groundwater supply in Leon County. This formation, however, is discontinuous in its ability to yield water, because most producing zones may be separated by less permeable zones of dolomite or dolomitized limestones. This formation also appears to be highly solutioned, and cavity zones most commonly appear near the top of the formation. Wells penetrating these zones of solutioning have been able to produce large quantities of water.

In the westernmost area of Leon County the St. Marks (Tampa) and Suwannee limestones probably exhibit less solution cavity activity. This is evidenced by well logs in the area which show a covering of impermeable sediments overlying the limestone, a high potentiometric surface in the area, and a generally lower yield in wells in the area.

The Crystal River is the oldest formation penetrated by wells in Leon County. Well logs indicate that the top of this formation may also be highly solutioned, and the top 50 to 60 feet of the formation is highly permeable. In the Tallahassee area, this formation characteristically shows a hard impermeable zone about 60 feet below the top of the formation. Those wells that have penetrated the Crystal River have been good producers, however, the Crystal River has not been extensively developed as a source of water because good quantities of water can usually be withdrawn at shallower depths.

The Floridan aquifer in Leon County exhibits both water table and artesian conditions. In the southeastern area of the county where the aquifer is covered by sands (Pleistocene and Recent deposits), the water is relatively unconfined and occurs under water table conditions. In other areas of the county, the aquifer is covered by less permeable beds which confine water in the Florida aquifer under artesian conditions.

In some areas, however, primarily in the St. Marks (Tampa) limestone, water may be confined in highly permeable zones within an otherwise impermeable rock unit. Wells placed in these areas have produced only when drilled well below the water table. In a few areas, water in wells has been observed to stand several feet above the regional water table. This may be explained by penetration of perched or permeable zones within a limestone unit that is above the regional potentiometric surface.

The potentiometric surface in Leon County shows a high in the southwest portion of the county. This high is probably the result of low transmissivities of the Floridan aquifer in the area. Water entering the aquifer in this area moves away slowly from the recharge area due to the low transmissivity, and therefore, local recharge, although limited by the cover of poorly permeable material maintains a water level of over 100 feet msl in the limestone. A trough exists in the potentiometric surface and trends to the north through the Tallahassee area. This trough is probably due to large quantities of spring discharge which occur in the area.

Recharge to the Floridan aquifer in Leon County is due primarily to the infiltration of rainwater in Leon and adjacent counties, and Georgia. In most of Leon County, the water table is perennially higher than the potentiometric surface and recharge is accomplished by downward percolation through the Miccosukee and Hawthorn formations. These sediments are, for the most part, absent in northern Leon County and rainwater has direct access to the aquifer, and probably represents the primary source of recharge. Another important source of recharge in Leon County is the numerous sinkholes throughout the region which transmit water directly to the aquifer.

The primary sources of discharge in Leon County are through evapotranspiration, spring discharge, and pumped wells. Water pumped from wells has been estimated at 12 mgd, of which approximately 9 mgd is in the Tallahassee area. Spring discharge, most of which is derived from the Floridan aquifer, has been estimated at more than 400 mgd primarily from springs in southern Leon and northern Wakulla Counties.

Productivity of the Floridan aquifer in Leon County shows wide variations. Generally, the highest yielding wells are those having the greatest length of uncased hole open to the aquifer or those that penetrate a solution cavity. Well yields are indicated to be the highest in the Tallahassee area, and lower yields are reported to the north and south of the area and the lowest yields are reported in western Leon County. It should be noted the reliability of pump tests that have been conducted are questionable because pumping times and stabilization times have not been recorded in test wells and most of the data has been derived from shallow domestic wells. It is probable that higher yields could be expected from deeper wells. The low yields found in the western part of the county are thought to be a result of the low transmissivity of the aquifer in that area.

One aquifer recovery test was made on the eastern edge of Lake Talquin (Well WLm-1S-4W-12-bc). The well was allowed to flow at a known rate for several days to allow water levels to stabilize. The flow was then stopped and the rate of recovery recorded. The data from this test and of another nearby test to the west of the lake gave transmissivity coefficients of 6,500 gpd per foot and 8,700 gpd per foot respectively, and the storage coefficient has been projected to be about 0.0001. The exact depth of these wells and the formations penetrated were not indicated in the literature, and it is felt that these extremely low transmissivities are representative of the water table aquifer rather than the Floridan aquifer.

(b) Groundwater Availability of the Site - Based on available aquifer constants reported in the literature and the results of two on-site pump tests, an analysis of groundwater development possibilities on the A. B. Hopkins site was performed. A storage coefficient of 0.0005 was utilized with the available pump test data, and a transmissivity of 250,000 gpd/ft of aquifer width was derived. It is felt that the values of transmissivity and storage coefficient are somehwat conservative but not unrealistic in light of aquifer constants reported in the literature.

To determine the effect of additional development of the carbonate aquifer on groundwater conditions in the vicinity of the site, a theoretical case was examined using a transmissivity and storage coefficient of 250,000 gpd/ft and 0.0005 respectively. Utilizing these parameters, it was possible to construct the theoretical distance-drawdown and time-drawdown graphs indicated in Exhibits II-14 and II-15. Construction of the distance-drawdown and time-drawdown graphs allows as estimate of the change in water levels at any point in the vicinity of a well for any time after pumping begins. The pumping rate was assumed to be 1,500 gpm; however, water level changes for other pumping rates may be obtained through multiplying the calculated drawdowns by the ratio of the desired pumping rate to 1,500 gpm.

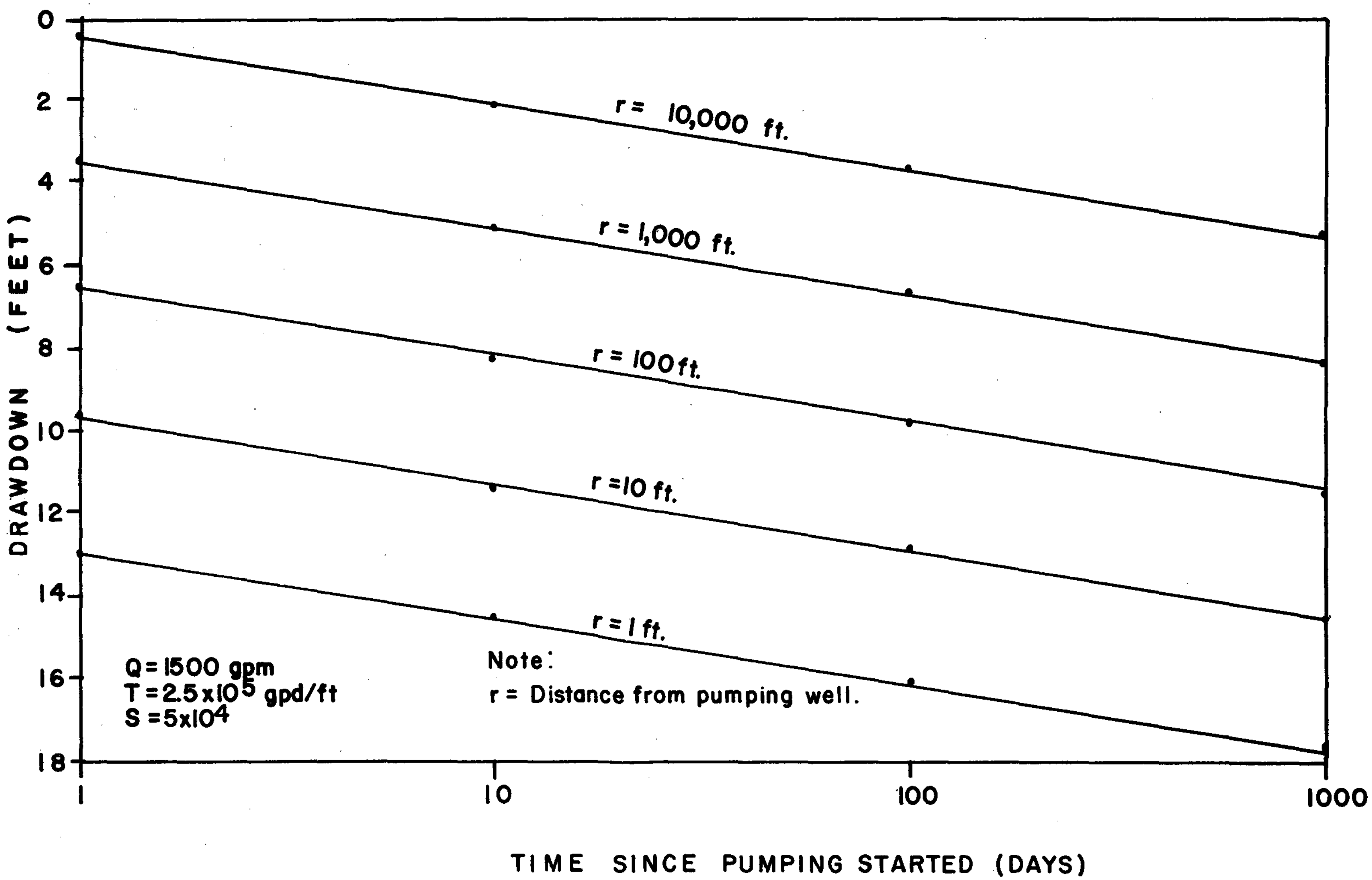
It can be seen from the theoretical distance-drawdown and time-drawdown curves that continuous pumping of the well for 100 days would result in a drawdown at the well of approximately 18 feet. Assuming two pumping wells were placed at diagonals of the property, continuous pumping of these wells for 100 days would result in a drawdown at each well of approximately 18 feet, and an additional 6 feet of drawdown at each well due to interference, for a composite drawdown effect at the well of approximately 24 feet. If it is assumed that the existing on-site wells will also pump continuously at their present rate, the drawdown effect of the present wells on the hypothetical wells will be approximately two feet. Therefore, the resultant composite theoretical drawdown in two wells placed at diagonals of the property would be approximately 26 feet after 100 days of continuous pumping.

It can be seen that in order to limit drawdown effect of on-site wells to 30 feet or less, that pumping wells for Unit 3 should be located a distance of at least 10,000 feet from pumping wells for Unit 2. Therefore, it appears from the preceding theoretical analysis that an additional 3,000 gpm required for Unit 2 may be developed on the A. B. Hopkins site without serious dewatering of the Floridan aquifer. It is felt that the present withdrawal of 857 gpm combined with an additional withdrawal of 3,000 gpm can safely be developed on the A. B. Hopkins site, for a maximum allowable withdrawal of 3,800 - 3,900 gpm at this particular site before dewatering of the aquifer occurs.

2.6 SITE METEOROLOGY

The Hopkins Generating Station location is approximately 20 miles from the Gulf of Mexico. The Tallahassee area has a mild, moist climate with the yearly average temperature being 68°. Table II-6 summarizes the average diurnal means and extremes of temperature by month for 1972. The average yearly rainfall in the area is about 57 inches (Table II-6). In 65 years of reported monthly precipitation data, for only six months did Tallahassee receive less than 1/10 inches of rain, and for these instances during the same period the two-month total was less than 1-inch.

The frequency and relative frequency of occurrence of joint wind directions and stability categories are shown in Tables II-7 and II-8, respectively, for 1972.



TIME-DRAWDOWN (THEORETICAL)

EXHIBIT II-15

TABLE II-6

DIURNAL AND MONTHLY TEMPERATURE[a] AND PRECIPITATION[a] MEANS AND EXTREMES OVER THE 30-YEAR PERIOD - 1941-1970[b]

	Temperature					Precipitation
Month	Daily Maximum	Daily Minimum	Monthly Average	Recorded High	Recorded Low	Average
January	65.1	42.7	52.6	82	11	3.74
February	67.0	44.2	54.8	85	14	4.77
March	72.2	49.0	60.3	90	23	5.93
April	79.0	55.9	67.9	95	29	4.07
May	86.4	63.3	74.8	98	34	4.04
June	90.5	69.9	80.0	100	49	6.62
July	90.5	72.0	81.1	100	57	8.92
August	90.3	71.8	81.1	100	61	6.89
September	87.2	68.9	78.1	99	40	6.64
October	80.6	58.6	69.3	93	32	2.93
November	71.1	47.3	58.9	88	13	2.81
December	65.4	42.8	53.2	84	10	4.22
Annual			67.7			61.60

[a] Temperature in °F, precipitation in inches.

[b] Data prepared from U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Asheville, North Carolina.

TABLE II-7

FREQUENCY OF OCCURRENCE OF WIND DIRECTION
AND STABILITY CLASS
1972, TALLAHASSEE MUNICIPAL AIRPORT*

Direction	Wind Frequency Distribution Stability Class "A"	"B"	"C"	"D"	"E"	All Classes
N	2	27	40	142	115	326
NNE	3	27	21	40	29	120
NE	3	42	41	75	43	204
ENE	1	14	42	106	71	234
E	0	23	26	104	70	223
ESE	1	5	7	40	25	78
SE	1	8	15	44	22	90
SSE	0	5	14	46	15	80
S	1	10	30	143	71	255
SSW	1	5	23	47	40	116
SW	1	8	15	41	52	117
WSW	2	9	20	43	63	137
W	0	20	21	41	57	139
WNW	0	13	14	30	48	105
NW	2	12	21	41	54	130
NNW	0	7	14	54	75	150
TOTAL	24	245	385	1086	1180	

*Data obtained from the U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, Asheville, North Carolina.

TABLE II-8

RELATIVE FREQUENCY OF OCCURRENCE OF WIND DIRECTION AND STABILITY CLASS 1972, TALLAHASSEE MUNICIPAL AIRPORT*

	Relative Wind Frequency Distribution Stability Class					
Direction	"A"	"B"	"C"	"D"	"E"	All Classes
N	0.000913	0.009544	0.014598	0.050285	0.055153	0.129093
NNE	0.001370	0.009715	0.007566	0.014290	0.013333	0.047943
NE	0.001370	0.014873	0.014640	0.026512	0.019055	0.078256
ENE	0.000457	0.005007	0.014908	0.037306	0.033127	0.090297
E	0.000000	0.008302	0.009429	0.037566	0.032166	0.088849
ESE	0.000457	0.001776	0.002657	0.014585	0.011654	0.031240
SE	0.000457	0.002889	0.005437	0.016132	0.010626	0.036344
SSE	0.000000	0.001819	0.004869	0.016876	0.007456	0.031815
S	0.000457	0.003552	0.010948	0.050332	0.033127	0.097931
SSW	0.000457	0.001776	0.008251	0.016923	0.019419	0.046352
SW	0.000457	0.002889	0.005512	0.014750	0.024765	0.047799
WSW	0.000913	0.003231	0.007299	0.015790	0.030851	0.057189
W	0.000000	0.007168	0.007866	0.015164	0.028024	0.058426
WNW	0.000000	0.004665	0.005094	0.010865	0.023550	0.043690
NW	0.000913	0.004195	0.007716	0.014868	0.026069	0.052914
NNW	0.000000	0.002504	0.005169	0.019675	0.035734	0.061862
TOTAL	0.008219	0.083904	0.131849	0.371918	0.404110	

*Data obtained from the U. S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, Asheville, North Carolina.

Refer to the annual wind rose for 1972, Exhibit VI-1. Table II-9 shows the frequency of occurrence of joint wind speeds and directions for 1972.

High winds rarely occur in the Tallahassee area. Over the past 130 years, the frequency of hurricanes doing damage was approximately once every five years. The last hurricane which did appreciable damage occurred in 1941.

The dominating climatological influence on the mixing height fluctuations in the Tallahassee area is the Gulf of Mexico. Copious quantities of moisture are carried northward from the Gulf during the summertime resulting in high humidities and a high degree of cloud cover. The subsequent reduction in solar radiation yields average morning mixing depths of approximately 600 meters. Intense solar insolation during the summer afternoons lifts this mixing layer to about 1,600 meters.

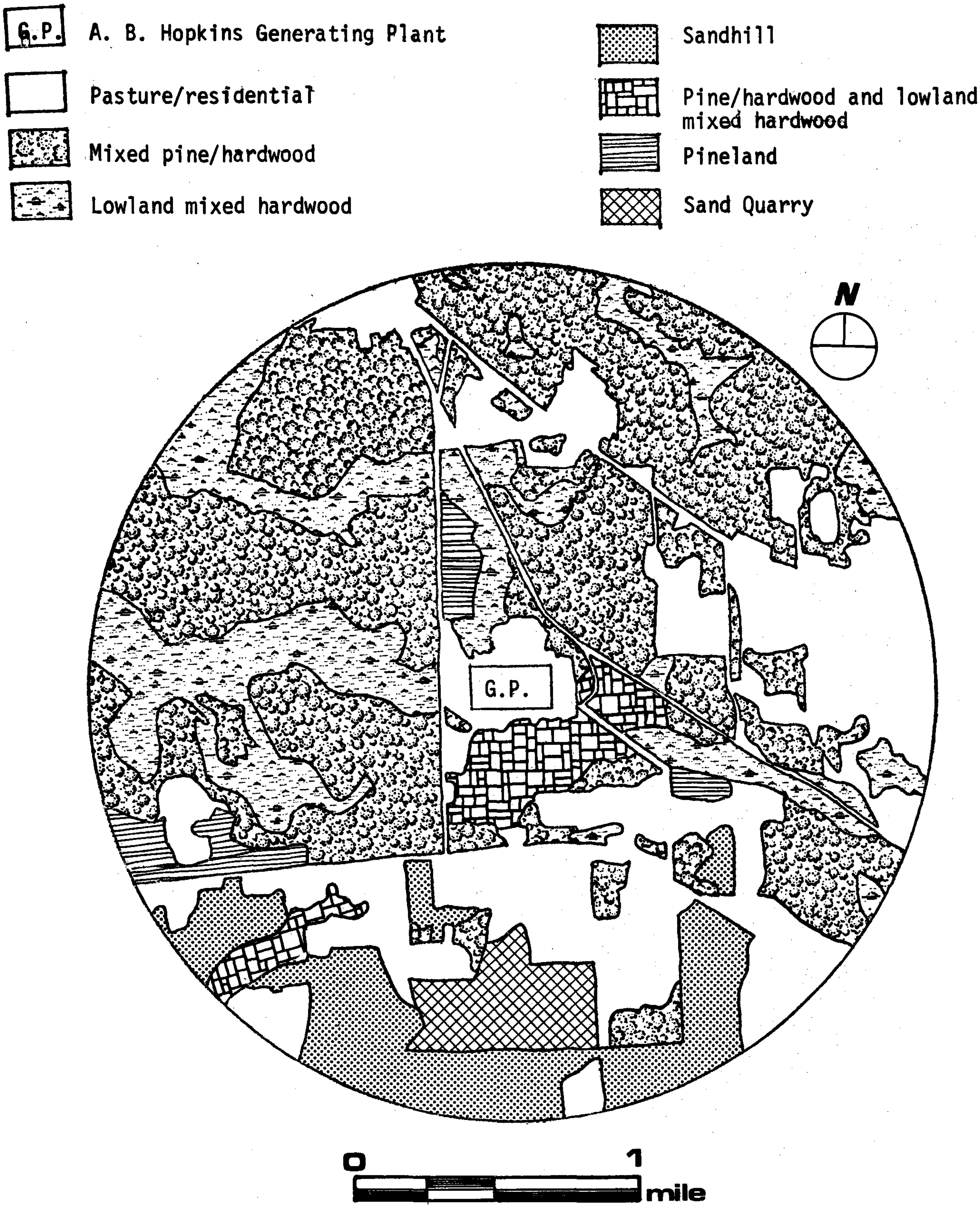
During the winter months, the moist but cooler mornings and much dryer afternoons yield mixing depths which vary from 500 to 1,000 meters from morning to afternoon.

All data were gathered by the U. S. Weather Station at the Tallahassee Municipal Airport.

2.7 ECOLOGY

2.7.1 Terrestrial Ecology

A field survey of the terrestrial system within 1.5 miles of the A. B. Hopkins Generating Station was performed during the period of January 8 through January 11, 1974. Data from this survey were used to prepare a generalized vegetation map (Exhibit II-16). Descriptions were made of dominant plant communities and their associated fauna. The effects of cooling tower drift and stack emissions upon vegetation within the impact area have been addressed.



Map of vegetation associations within 1.5 mile radius of A. B. Hopkins Generating plant; January 1974.

EXHIBIT II-16

TABLE II-9

FREQUENCY OF OCCURRENCE OF WIND DIRECTION AND WIND SPEED CLASSES, TALLAHASSEE - 1972

	Speed (KTS)							
Direction	1-3	4-6	7-10	11-16	17-21	Greater Than 21	Avg. Spd.	Total
N	41	117	102	65	1	0	7.4	326
NNE	7	55	41	17	0	0	7.0	120
NE	8	68	101	27	0	0	7.7	204
ENE	9	83	98	41	3	0	7.8	234
E	22	91	89	17	4	0	7.0	223
ESE	3	38	23	14	0	0	7.2	78
SE	9	41	26	12	1	1	7.1	90
SSE	7	33	30	10	0	0	7.0	80
S	32	64	97	57	4	1	8.1	255
SSW	15	45	34	21	1	0	7.4	116
SW	21	49	28	18	1	0	6.7	117
WSW	27	66	30	14	0	0	6.0	137
W	26	72	27	14	0	0	6.0	139
WNW	18	52	25	10	0	0	6.0	105
NW	22	54	41	10	3	0	6.6	130
NNW	22	73	37	18	0	0	6.4	150
AVG	3.0	4.9	8.4	12.7	18.4	22.5	6.1	
TOTAL	289	1001	829	365	18	2		

*All data obtained from the Environmental Data Service, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, Asheville, North Carolina.

The A. B. Hopkins Generating Station is located approximately four miles west of Tallahassee along the southern border of the Tallahassee hills. The Cody Scarp, which markes the northernmost advance of Pleistocene Seas and serves as a boundary between the Northern Highlands and the Gulf Coastal Lowlands, is located approximately one mile south of the generating station parallel to State Road 20.

The Ochlockonee River occupies a one-mile segment along the northwest border of the study area. Here the river floodplain is separated from adjoining areas by a steep thirty-foot bluff.

Lands in western and northwestern sections of the study area are used by a private hunting club, and owned by the state. Two small creeks drain this area into the Ochlockonee River.

Low density housing and trailer parks are found along segments of U. S. Route 90, State Routes S-260 and 20, and Bairneau Road. Sand quarrys, residential areas and pastures are common south of State Route 20 (Exhibit II-16). The northern edge of the Appalachicola National Forest is located about one-half mile from the southwest border of the study area.

2.7.2 Terrestrial Associations

Natural plant associations on the property may be divided into upland pine/hardwoods and lowland mixed hardwoods. Boundaries of these associations and their subdivisions are often indistinct. This is due to gradual changes in topography and drainage, exclusion of fire in some regions, and the fact that the study area represents a geological transition zone between Coastal Plain Lowlands and the Tallahassee hills. As can be seen on the vegetation map (Exhibit II-16), some sites are a mixture of two associations.

(a) Upland Pine/Hardwoods Association - This association may be subdivided into pineland, sandhill, and mixed pine/hardwood communities. Total acreage of these communities are 119, 385, and 1,860 acres, respectively. The remaining 1,193 acres of upland habitat are in residential areas or pasture. The residential/pasture "association" is discussed in Section 2.7.2 (c). Upland associations generally occur on lands approximately 100 feet or greater in elevation. The soil is sandy and usually drier than that of lower lying areas. p2.45

Pinelands are a fire controlled sub-climax association. The plant composition of these areas is dependent upon frequent ground fires which prevent the establishment of less fire resistant but highly competitive hardwood species. The overstory is dominated by slash pine. The associated understory and ground vegetation varies with soil drainage and soil type. Replacement of the longleaf pine overstory with slash pine has been made to take advantage of the higher slash pine growth rate. Recent lumbering has occurred in the southwest section of the study area and during January 1974, was occurring in northern portions of the site vicinity.

The incomplete canopy of the pines results in high light intensity at the understory. This promotes a dense growth of species such as saw palmetto, wiregrass, gallberry, blueberry, and various other herbs, grasses, and sedges (Table II-10). The fruit and leafy material of these species is used as food by various mammals such as deer, raccoon, rabbits, opossum, small rodents, quail,

Table II-10

Plant species found inhabiting 1.5 mile radius of A. B. Hopkins Generating Station in January 1974.

Species	Common Name	Upland Pine/Hardwood	Lowland Mixed Hardwood	Aquatic Habitat
Pinus elliottii	Slash Pine	A	O	
Pinus glabra	Spruce Pine	O	O	
Pinus echinata	Shortleaf Pine	C		
Pinus palustris	Longleaf Pine	R		
Pinus taeda	Loblolly Pine	O		
Taxodium distichum	Bald Cypress		O	O
Quercus nigra	Water Oak	C		
Quercus laurifolia	Laurel Oak	A	O	
Quercus alba	White Oak	R	C	
Quercus prinus	Basket Oak		C	
Quercus virginiana	Live Oak	O		
Quercus marilandica	Blackjack Oak	O		
Quercus falcata var. falcata	Southern Red Oak	R		
Quercus laevis	Turkey Oak	O		
Quercus incana	Bluejack Oak	O		
Quercus geminata	Scrub-live Oak	O		
Fagus grandiflora	American Beech		C	
Carya glabra	Pignut Hickory		O	
Carya tomentosa	Mockernut Hickory	O		
Betula nigra	River Birch		C	
Carpinus caroliniana	Blue-beech		C	
Ostrya virginiana	Eastern Hophornbeam		O	
Salix caroliniana	Carolina Willow		O	O
Liriodendron tulipifera	Yellow-poplar		R	
Magnolia grandiflora	Magnolia	O	C	
Magnolia virginiana	Sweetbay		C	
Liquidambar styraciflua	Sweetgum	O	C	
Acer rubrum	Red Maple		C	
Persea borbonia	Redbay		O	
Ulmus americana var. americana	American Elm		R	
Prunus angustifolia	Chicken Plum	O		
Prunus serotina	Black Cherry	O		
Ilex opaca	American Holly	C		
Ilex coriacea	Sweet Gallberry		O	
Ilex glabra	Gallberry	C	O	
Cercis canadensis	Redbud	R		
Cornus florida	Dogwood	O	O	
Osmanthus americana	Wild-olive		O	
Cyrilla racemiflora	Titi		C	
Vaccinium arboreum	Tree Sparkleberry	C	O	
Vaccinium sp.	Blueberry	O	O	
Crataegus sp.	Hawthorn	O	O	
Malus angustifolia	Southern Crab Apple	R	O	
Viburnum dentatum var. scabrellum	Viburnum		C	
Viburnum cassinoides	Witherod Viburnum		O	
Viburnum obovatum	Walter Viburnum		O	
Aralia spinosa	Devils-walkingstick		O	
Sambucus simpsonii	Elderberry		O	
Symplocos tinctoria	Common Sweetleaf		C	
Myrica cerifera	Wax Myrtle	A	O	
Rhododendron sp.	Wild Azalea	R	O	
Rhus copallina	Winged Sumac	O	C	
Euonymus americanus	Strawberry-bush		O	
Itea virginica	Sweet-spires		C	
Serenoa repens	Saw Palmetto	O		
Sabal minor	Blue Stem		O	
Yucca filamentosa	Yucca		O	
Hypericum spp.	St. John's Wort	O	O	
Hypericum gentianoides	Pineweed	O		
Smilax spp.	Greenbrier	C	C	
Gelsemium sempervirens	Yellow Jessamine	A	O	
Heterotheca graminifolia	Grassy-leaf Golden Aster	C		
Solidago microcephala	Goldenrod		O	
Solidago sp.	Goldenrod	O	O	
Elephantopus tomentosus	Elephant's Foot	C	O	
Eupatorium compositifolium	Dog Fennel	O		
Pterocaulon undulatum	Rabbit Tobacco	O		

Table II-10 (Cont.) Plant species found inhabiting 1.5 mile radius of A. B. Hopkins Generating Station in January, 1974.

Species	Common Name	Upland Pine/Hardwood	Lowland Mixed Hardwood	Aquatic* Habitat
Ambrosia artemisiifolia	Ragweed	O		
Geranium sp.	Geranium		O	
Callicarpa americana	American Beautyberry	O		
Rubus sp.	Blackberry	C	C	
Lycopus sp.	Bugleweed		R	
Viola primulifolia	Primrose-leaved Violet		O	
Viola walterii	Violet		O	
Polygonum hydropiperoides	Smartweed		O	R
Opuntia sp.	Prickly-pear	O		
Trillium cuneatum	Sweet-betsy		O	
Mitchella repens	Partridge Berry		C	
Hydrocotyle sp.	Water Pennywort		O	R
Typha latifolia	Cattail			O
Nymphoides sp.	Floating Heart			C
Vallisneria americana	Eelgrass			C
Sparganium sp.	Bur-reed			LD
Lemna minor	Duckweed			LD
Juncus effusus	Soft Rush			O
Scirpus sp.	Bulrush			A
Eleocharis sp.	Slender Spikerush			LD
Unidentified Cyperaceae spp.	Sedge			C
Xyris sp.	Yellow-eyed Grass		O	C
Arundinaria tecta	Switchcane		C	
Setaria sp.	Foxtail		O	
Andropogon sp.	Beardgrass	C	C	
Aristida sp.	Three-awn	C	R	
Unidentified Poaceae spp.	Grasses	C	C	
Polypodium polypodioides	Ressurection Fern		C	
Osmunda cinnamomea	Cinnamon Fern		C	
---	Unidentified Ferns		C	
Tillandsia usneoides	Spanish Moss		C	

*Aquatic habitat includes creeks, beaver-ponds and man-made ponds.
LD - Locally dense and dominant
A - Abundant
C - Common
O - Occasional
R - Rare

cardinals, dove, warblers, and sparrows. Predators such as bobcats, hawks, owls, and snakes (Table II-11) could inhabit the area.

Wildlife species are markedly reduced in densely planted pine plantations due to the limited understory and the low wildlife food value of the pines.

Frequent fires and dry soil maintain the sandhill association. The overstory is predominantly longleaf pine and turkey oak. Although not as fire resistant as pine, turkey oak adapts to dry conditions by minimizing transpiration losses. However, in areas managed for pine where burnings are frequent, turkey oak is eliminated. Ground vegetation in the sand hills is limited to a few grasses and herbs, prickly pear, and an occasional woody shrub (Table II-10). Indigenous wildlife adapt to this environment by burrowing or nocturnal habits which enable them to avoid desiccation. See Table II-11 for a list of animal species.

The exclusion of fire in pineland areas allows the establishment of more competitive hardwood species which form a mixed pine/hardwood association. Quantitative data obtained from six transects indicates that laurel oak (importance value = 96.9) and slash pine (importance value = 70.4) are the most important tree species encountered in the transect area (Table II-12). Other important and sometimes dominant tree species are water oak, sweetgum, hickory, southern magnolia, and shortleaf pine. For a listing of the understory and herbaceous species in this association, see Table II-10.

The diversity of this association is higher than other upland associations. The dense understory provides both cover and food for wildlife. (Black

Table II-11 A list of animal species expected or observed during the January 1974 field survey of the A. B. Hopkins Generating Station.

Species	Common Name	Observed Jan. 1974
Amphibians		
PSEUDOBRANCHUS STRIATUS AXANTHUS	NARROW-STRIPED DWARF SIREN	
PSEUDOBRANCHUS S. SPHENISCUS	SLENDER DWARF SIREN	
SIREN INTERMEDIA	LESSER SIREN	
SIREN LACERTINA	GREATER SIREN	
AMPHIUMA MEANS	AMPHIUMA	
DESMOGNATHUS FUSCUS AURICULATUS	SOUTHERN DUSKY SALAMANDER	
MANCULUS QUADRIDIGITATUS	DWARF SALAMANDER	
AMBYSTOMA CINGULATUM BISHOPI	RETICULATED FLATWOODS SALAMANDER	
AMBYSTOMA OPACUM	MARBLED SALAMANDER	
AMBYSTOMA TIGRINUM	EASTERN TIGER SALAMANDER	
DIEMICTYLUS VIRIDESCENS	RED SPOTTED NEWT	
DIEMICTYLUS V. LOUISIANENSIS	CENTRAL NEWT	
DIEMICTYLUS V. PIAROPICOLA	PENINSULA NEWT	
DIEMICTYLUS PERSTRIATUS	STRIPED NEWT	
PLETHODON GLUTINOSUS	SLIMY SALAMANDER	X
PSEUDOTRITON MONTANUS FLORIDANUS	RUSTY MUD SALAMANDER	
EURYCEA LONGICAUDA GUTTOLINEATA	THREE LINED SALAMANDER	
SCAPHIOPUS HOLBROOKI	EASTERN SPADEFOOT	
BUFO TERRESTRIS	SOUTHERN TOAD	X
BUFO QUERCICUS	OAK TOAD	
ACRIS GRYLLUS	CRICKET FROG	X
HYLA CRUCIFER	SPRING PEEPER	X
HYLA CINEREA	GREEN TREE FROG	X
HYLA FEMORALIS	PINE WOODS TREE FROG	
HYLA SQUIRELLA	SQUIRREL TREEFROG	
HYLA OCULARIS	LITTLE GRASS FROG	
HYLA VERSICOLOR	GRAY TREEFROG	
HYLA AVIVOCA	BIRDVOICED TREEFROG	
HYLA GRATIOSA	BARKING TREEFROG	
PSEUDACRIS NIGRITA	SOUTHERN CHORUS FROG	
PSEUDACRIS ORNATA	ORNATE CHORUS FROG	
GASTROPHRYNE CAROLINENSIS	NARROW MOUTHED TOAD	
RANA CATESBEIANA	BULL FROG	
RANA HECKSCHERI	RIVER FROG	
RANA GRYLIO	PIG FROG	
RANA CLAMITANS	BRONZE FROG	
RANA PIPIENS SPHENOCEPHALA	SOUTHERN LEOPARD FROG	X
RANA AREOLATA AESOPUS	FLORIDA GOPHER FROG	
Reptiles		
GRAPTEMYS PULCHRA	ALABAMA MAP TURTLE	
MACROLEMYS TEMMINCKI	ALLIGATOR SNAPPER	
CHELYDRA SERPENTINA	SNAPPING TURTLE	
GRAPTEMYS BARBOURI	BARBOURS MAP TURTLE	
KINOSTERNUM SUBRUBRUM	EASTERN MUD TURTLE	
KINOSTERNUM STEINDACHNERI	FLORIDA MUD TURTLE	
STERNOTHAERUS ODORATUS	STINKPOT	
TERRAPENE CAROLINA	EASTERN BOX TURTLE	
TERRAPENE C. BAURI	FLORIDA BOX TURTLE	X
PSEUDEMYS SCRIPTA	YELLOWBELLIED TURTLE	
PSEUDEMYS SCRIPTA ELEGANS	RED EARED TURTLE	
PSEUDEMYS CONCINNA SUWANNIENSIS	SUWANNEE COOTER	
PSEUDEMYS FLORIDANA	FLORIDA COOTER	X
PSEUDEMYS FLORIDANA PENINSULARIS	PENINSULA COOTER	
PSEUDEMYS NELSONI	FLORIDA RED BELLIED TURTLE	
DEIROCHELYS RETICULARIA	CHICKEN TURTLE	
TRIONYX SPINIFER ASPER	GULF COAST SHOFTSHELL	
GOPHERUS POLYPHEMUS	GOPHER TORTOISE	X
ANOLIS CAROLINENSIS	GREEN ANOLE	X
SCELOPORUS UNDULATUS	FENCE LIZARD	
CNEMIDOPHORUS SEXLINEATUS	SIX LINED RACER	
LYGOSOMA LATERALE	GROUND SKINK	
EUMECES LATICEPS	BROAD HEADED SKINK	
EUMECES INEXPECTATUS	FIVELINED SKINK	
EUMECES EGREGIUS SIMILUS	GEORGIA RED TAILED SKINK	
ALLIGATOR MISSISSIPIENSIS	AMERICAN ALLIGATOR	
OPHISAURUS ATTENUATUS	SLENDER GLASS LIZARD	
OPHISAURUS VENTRALIS	EASTERN GLASS LIZARD	
ABASTOR ERYTHROGRAMMUS	RAINBOW SNAKE	
FARANCIA ABACURA	MUD SNAKE	
NATRIX CYCLOPION	GREEN WATER SNAKE	
NATRIX CYCLOPION FLORIDANA	FLORIDA GREEN WATER SNAKE	
NATRIX ERYTHROGASTER	RED BELLIED WATER SNAKE	
NATRIX SIPEDON PICTIVENTRIS	BANDED WATER SNAKE	X

Table II-11 A list of animal species expected or observed during the January 1974 field survey of the A. B. Hopkins (Cont'd) Generating Station.

Species	Common Name	Observed Jan. 1974
Reptiles Cont'd.		
NATRIX RIGIDA	GLOSSY WATER SNAKE	
NATRIX TAXISPILOTA	BROWN WATER SNAKE	
HALDEA STRIATULA	ROUGH EARTH SNAKE	
DIADOPHIS PUNCTATUS	SOUTHERN RINGNECKED SNAKE	
THAMNOPHIS SIRTALIS	EASTERN GARTER SNAKE	
THAMNOPHIS SAURITUS	EASTERN RIBBON SNAKE	
STORERIA DEKAYI VICTA	FLORIDA BROWN SNAKE	
STORERIA OCCIPITOMACULATA O	RED BELLIED SNAKE	
OPHEODRYS AESTIVUS	ROUGH GREEN SNAKE	
RHADINAEA FLAVILATA	YELLOWLIPPED SNAKE	
COLUBER CONSTRICTOR PRIAPUS	SOUTHERN BLACK RACER	
MASTICOPHIS FLAGELLUM	EASTERN COACHWHIP	
DRYMARCHON CORAIS COUPERI	EASTERN INDIGO SNAKE	
HETERODON PLATYRHINOS	EASTERN HOGNOSE SNAKE	
ELAPHE GUTTATA	CORN SNAKE	
ELAPHE OBSOLETA QUADRIVITTATA	YELLOW RAT SNAKE	
PITUOPHIS MELANOLEUCUS MUGITUS	FLORIDA PINE SNAKE	
LAMPROPELTIS GETULUS	EASTERN KINGSNAKE	
LAMPROPELTIS GETULUS FLORIDANA	FLORIDA KINGSNAKE	
LAMPROPELTIS GETULUS GOINI	BLOTCHED KINGSNAKE	
LAMPROPELTIS DOLIATA	SCARLET KINGSNAKE	
LAMPROPELTIS CALLIGASTER R	MOLE SNAKE	
TANTILLA CORONATA	CROWNED SNAKE	
CEMOPHORA COCCINEA	SCARLET SNAKE	
CROTALUS ADAMANTEUS	EASTERN DIAMONDBACK RATTLESNAKE	
CROTALUS H. ATRICAUDATUS	CANEBRAKE RATTLESNAKE	
SISTRURUS MILIARUS	DUSKY PIGMY RATTLESNAKE	
AGKISTRODON PISCIVORUS	EASTERN COTTONMOUTH	
MICRURUS FULVIUS	CORAL SNAKE	
AGKISTRODON CONTORTRIX	SOUTHERN COPPERHEAD	
Birds		
PODILYMBUS PODICEPS	PIED-BILLED GREBE	
AYTHYA COLLARIS	RING-NECKED DUCK	
ANAS DISCORS	BLUE-WINGED TEAL	
ANAS CAROLINENSIS	GREEN-WINGED TEAL	
OXYURA JAMAICENSIS	RUDDY DUCK	
LOPHODYTES CUCULLATUS	HOODED MERGANSER	
AIX SPONSA	WOOD DUCK	X
HALIAEETUS LEUCOCEPHALUS L.	SOUTHERN BALD EAGLE	
AGUILA CHRYSAETOS CANADENSIS	GOLDEN EAGLE	
ACCIPITER COOPERII	COOPER'S HAWK	X
ACCIPITER STRIATUS	SHARP-SHINNED HAWK	
CIRCUS CYANEUS	MARSH HAWK	
BUTEO JAMAICENSIS	RED-TAILED HAWK	X
BUTEO LINEATUS	RED-SHOULDERED HAWK	
BUTEO PLATYPTERUS PLATYPTERUS	BROADWINGED HAWK	
BUTEO BRACHYURUS	SHORT TAILED HAWK	
FALCO COLUMBARIUS	PIGEON HAWK	
FALCO SPARVERIUS PAULUS	LITTLE SPARROW HAWK	
PANDION HALIAETUS	OSPREY	
ELANOIDES FORFICATUS FORFICATUS	SWALLOW TAILED KITE	
ICTINIA MISISIPPIENSIS	MISSISSIPPI KITE	
CORAGYPS ATRATUS	BLACK VULTURE	
CATHARTES AURA	TURKEY VULTURE	X
COLINUS VIRGINIANUS	BOBWHITE	X
MELEAGRIS GALLOPAVO OSCEOLA	FLORIDA TURKEY	
ARDEA HERODIAS	GREAT BLUE HERON	
BUTORIDES VIRESCENS	GREEN HERON	
NYCTANASSA VIOLACEA	YELLOW-CROWNED NIGHT HERON	
NYCTICORAX NYCTICORAX	BLACK-CROWNED NIGHT HERON	
FLORIDA CAERULEA	LITTLE BLUE HERON	
HYDRANASSA TRICOLOR	LOUISIANA HERON	X
CASMERODIUS ALBUS	COMMON EGRET	
LEUCOPHOYX THULA	SNOWY EGRET	
BUBULCUS IBIS	CATTLE EGRET	
EUDOCIMUS ALBUS	WHITE IBIS	
MYCTERIA AMERICANA	WOOD IBIS (STORK)	
GRUS CANADEUSIS	SANDHILL CRANE	
ANHINGA ANHINGA	ANHINGA	
RALLUS LIMICOLA	VIRGINIA RAIL	
PORZANA CAROLINA	SORA	
RALLUS ELEGANS	KING RAIL	
ARAMUS GUARAUNA	LIMPKIN	

Table II-11 (Cont'd) A list of animal species expected or observed during the January 1974 field survey of the A. B. Hopkins Generating Station.

Species	Common Name	Observed Jan. 1974
Birds Cont'd		
IXOBRYCHUS EXILIS	LEAST BITTERN	
BOTAURUS LENTIGINOSUS	AMERICAN BITTERN	
FULICA AMERICANA	AM COOT	
PORPHRULA MARTINICA	PURPLE GALINULE	
TOTANUS MELANOLEUCUS	GREATER YELLOWLEGS	
TOTANUS FLAVIPES	LESSER YELLOWLEGS	
CHARADRIUS VOCIFERUS	KILLDEER	
CAPELLA GALLINAGO	COMMON SNIPE	X
PHILOHELA MINOR	AMERICAN WOODCOCK	
COLUMBIGALLINA PASSERINA	GROUND DOVE	X
ZENAIDURA MACROURA	MOURNING DOVE	X
COCCYZUS AMERICANUS	YELLOW-BILLED CUCKOO	
COCCYZUS ERYTHROPTHALMUS	BLACK BILLED CUCKKOO	
TYTOALBE PRATINCOLA	BARN OWL	
BUBO VIRGINIANUS	GREAT HORNED OWL	
OTUS ASIO	SCREECH OWL	
STRIX VARIA	BARRED OWL	
ASIO FLAMMEUS	SHORT-EARED OWL	
CHORDEILES MINOR C.	FLORIDA NIGHTHAWK	
CAPRIMULGUS CAROLINENSIS	CHUCK-WILL'S-WIDOW	
CAPRIMULGUS VOCIFERUS	WHIP-POOR-WILL	
CHAETURA PELAGIA	CHIMNEY SWIFT	
ARCHILOCHUS COLUBRIS	RUBY THROATED HUMMINGBIRD	
MEGACERYLE ALCYON	EASTERN BETTED KINGFISHER	
DRYOCOPUS PILEATUS	PILEATED WOODPECKER	X
MELANERPES ERYTHROCEPHALUS	RED HEADED WOODPECKER	
SPHYRAPICUS VARIUS	YELLOW-BELLIED SAPSUCKER	X
CENTURUS CAROLINUS	RED-BELLIED WOODPECKER	
COLAPTES AURATUS	YELLOW-SHAFTED FLICKER	X
DENDROCOPUS VILLOSUS	SOUTHERN HAIRY WOODPECKER	X
DENDROCOPOS PUBESCENS	DOWNY WOODPECKER	
DEUDROPUS BOREALIS	RED COCKADED WOODPECKER	
TYRANIS DOMINICENSIS	GRAY KINGBIRD	
TYRANNUS TYRANNUS	EASTERN KINGBIRD	
MYIARCHUS CRINITUS	GREAT CRESTED FLYCATCHER	
MYIARCHUS BOREUS	NORTHERN CRESTED FLYCATCHER	
EMPIDONAX VIRESCENS	ACADIAN FLYCATCHER	
PYROCEPHALUS RUBINUS MEXICANUS	VERMILON FLYCATCHER	
CONTOPUS VIRENS	EASTERN WOOD PEWEE	
SAYORNIS PHOEBE	EASTERN PHOEBE	
HIRUNDO RUSTICA	BARN SWALLOW	
IRIDOPROCNE BICOLOR	TREE SWALLOW	
STELGIDOPTERYX SERRIPENNIS	ROUGHWINGED SWALLOW	
PROGNE SUBIS	PURPLE MARTIN	
CYANOCITTA CRISTATA	BLUE JAY	X
CORVUS OSSIFRAGUS	FISH CROW	X
CORVUS BRACHYRHYNCHOS	COMMON CROW	
PARUS CAROLINENSIS	CAROLINA CHICKADEE	
PARUS BICOLOR	TUFTED TITMOUSE	
CERTHIA FAMILIARIS	BROWN CREEPER	
SITTA PUSILLA PUSILLA	BROWN-HEADED NUTHATCH	
SITTA PUSILLA CANICEPS	GRAY-HEADED NUTHATCH	
SITTA CAROLMENSIS CAROLINENSIS	WHITE-BREASTED NUTHATCH	
TROGLODYTES AEDON	HOUSE WREN	
THRYOMANES BEWICKII	BEWICKS WREN	
MIMUS POLYGLOTTOS	MOCKINGBIRD	X
DUMETELLA CAROLINENSIS	CATBIRD	
TOXOSTOMA RUFUM	BROWN THRASHER	X
TURDUS MIGRATORIUS	ROBIN	X
HYLOCICHLA GUTTATA	HERMIT THRUSH	X
HYLOCICHLA MUSTELINA	WOOD THRUSH	
SIALIA SIALISGRATA	FLORIDA BLUEBIRD	
SIALIA SIALIS	EASTERN BLUEBIRD	
HYLOCICHLA FUSCESCENS F.	VEERY	
POLIOPTILA CAERULEA	BLUE-GRAY GNATCATCHER	
REGULUS CALENDULA	RUBY-CROWNED KINGLET	
REGULUS SATRAPA	GOLDEN-CROWNED KINGLET	
ANTHUS SPINOLETTA	WATER PIPIT	
BOMBYCILLA CEDRORUM	CEDAR WAXWING	
LANIUS LUDOVICIANUS	LOGGERHEAD SHRIKE	X
STURNUS VULGARIS	STARLING	X
VIREO SOLITARIUS	SOLITARY VIREO	
VIREO GRISUES	WHITE EYED VIREO	
VIREO FLAVIFRONS	YELLOW-THROATED VIREO	
VIREO OLIVACEUS	RED-EYED VIREO	
VIREO ALTILOHUUS BARBATULUS	BLACK WHISPERED VIREO	
MNIOTILTA VARIA	BLACK AND WHITE WARBLER	

Table II-11 (Cont'd) A list of animal species expected or observed during the January 1974 field survey of the A. B. Hopkins Generating Station.

Species	Common Name	Observed Jan. 1974
Birds Cont'd.		
PARULA AMERICANA	PARULA WARBLER	
DENDROICA DOMINICA	YELLOW-THROATED WARBLER	
VERMIVORA CELATA	ORANGE-CROWNED WARBLER	
DENDROICA CORONATA	MYRTLE WARBLER	X
DENDROICA PLAMARUM	PALM WARBLER	
HELMITHEROS VERMIVORUS	WORM-EATING WARBLER	
DENDROICA TIGRINA	CAPE MAY WARBLER	
DENDROICA CAERULESCENS	BLACK-THROATED BLUE WARBLER	
DENDROICA PINUS	PINE WARBLER	X
DENDROICA DISCOLOR	PRAIRIE WARBLER	
LIMNOTHLYPIS SWAINSONI	SWAINSONS WARBLER	
DENDROICA MAGNOLIA	MAGNOLIA WARBLER	
DENDROICA VIRENS	BLACK THROATED GREEN WARBLER	
DENDROICA DOMINICA	YELLOW-THROATED WARBLER	
DENDROICA PALMARUM HYPOCHRYSEA	YELLOW PALM WARBLER	
OPORONIS AGILIS	CONNECTICUT WARBLER	
WILSONIA CITRINA	HOODED WARBLER	
OPORORNIS FORMOSUS	KENTUCKY WARBLER	
DENDROICA PENSYLVANICA	CHESTNUT SIDED WARBLER	
DENDROICA PETECHIA	YELLOW WARBLER	
VERMIVORA PEREGRINA	TENNESSEE WARBLER	
PROTONOTARIA CITREA	PROTHONOTARY WARBLER	
VERMIVORA RUFICAPILLA R.	NASHVILLE WARBLER	
DENDROICA FUSCA	BLACKBURNIAN WARBLER	
VERMIVORA BACHMANII	BACHMAN'S WARBLER	
VERMIVORA PINUS	BLUE-WINGED WARBLER	
DENDROICA CASTANEA	BAY BREASTED WARBLER	
SEIURUS AUROCAPILLUS	OVENBIRD	
SEIURUS NOVEBORACENSIS	NORTHERN WATER THRUSH	
SEIRUS NOVEBORACENSIS NOTABLIS	GRINNELL'S WATER THRUSH	
SEIURUS MOTACILLA	LOUISIANA WATER THRUSH	
GEOTHLYPIS TRICHAS	YELLOWTHROAT	
ICTERIA VIRENS	YELLOW BREASTED CHAT	
SETOPHAGA RUTICILLA	AMERICAN REDSTART	
PASSER DOMESTICUS	HOUSE SPARROW	X
DOLICHONYX ORYZIVORUS	BOBOLINK	
STURNELLA MAGNA	EASTERN MEADOWLARK	X
AGELAIUS PHOENICEUS	RED-WINGED BLACKBIRD	
EPHAGUS CAROLINUS	RUSTY BLACKBIRD	
CASSIDIX MEXICANUS	BOAT-TAILED GRACKLE	
QUISCALUS QUISCULA	COMMON GRACKLE	
MOLOTHRUS ATER	EASTERN COWBIRD	
ICTERUS SPURIUS	ORCHARD ORIOLE	
ICTERUS GALBULA	BALITMORE ORIOLE	
PIRANGA OLIVACEA	SCARLET TANAGER	
PIRANGA RUBRA	SUMMER TANAGER	
RICHMONDENA CARDINALIS	CARDINAL	X
PASSERINA CYANEA	INDIGO BUNTING	
CARPODACUS PURPUREUS	PURPLE FINCH	
SPINUS TRISTIS	AMERICAN GOLDFINCH	
PIPILO ERYTHROPHTHALMUS	RUFOUS-SIDED TOWHEE	X
PIPILOE CANASTER	ALABAMA TOWHEE	
SPIZELLA PASSERINA	CHIPPING SPARROW	
ZONOTRICHIA ALBICOLLIS	WHITE-THROATED SPARROW	
MELOSPIZA MELODIA	SONG SPARROW	
PASSERCULUS SANDWICHENSIS	SAVANNAH SPARROW	
POOECETES GRAMINEUS	VESPER SPARROW	
SPIZELLA PUSILLA	FIELD SPARROW	
MELOSPIZA GEORGIANA	SWAMP SPARROW	
AMMODRAMUS PRATENSIS	EASTERN GRASSHOPPER SPARROW	
PASSERHERBULUS HENSLOWI	WESTERN HENSLOW'S SPARROW	
CHONDESTES GRAMMACUS	EASTERN LARK SPARROW	
AINIOPHILA AESTIVALIS	PINEWOODS SPARROW	
ZONOTRICHIA LEUCOPHRYS	WHITE CROWNED SPARROW	
AINIOPHILA AESTIVALIS BACHMANII	BACHMAN'S SPARROW	
JUNCO HYEMALIS	SLATE-COLORED JUNCO	

Table II-11 (Cont'd) A list of animal species expected or observed during the January 1974 field survey of the A. B. Hopkins Generating Station.

Species	Common Name	Observed Jan. 1974
Mammals		
DASYPUS NOVEMCINCTUS	ARMADILLO	
DIDELPHIS MARSUPIALIS	OPOSSUM	X
ODOCOILEUS VIRGINIANUS	WHITE TAIL DEER	X
URSUS AMERICANUS	BLACK BEAR	
PROCYON LOTOR	RACCOON	X
MUSTELA FRENATA	LONGTAIL WEASEL	
MUSTELA VISON	MINK	
LUTRA CANADENSIS	RIVER OTTER	
UROCYON CINEREOARGENTEUS	GRAY FOX	
CANIS LATRAN	COYOTE	
SPILOGALE PUTORIUS	SPOTTED SKUNK	X
MEPHITIS MEPHITIS	STRIPED SKUNK	
FELIS CONCOLOR	FLORIDA PANTHER	
LYNX RUFUS	BOBCAT	X
SCIURUS CAROLINENSIS	EASTERN GRAY SQUIRREL	X
SCIURUS NIGER	EASTERN FOX SQUIRREL	
GLAUCOMYS VOLANS	SOUTHERN FLYING SQUIRREL	
GEOMYS PINETIS	POCKET GOPHER	
CASTOR CANDENSIS	BEAVER	X
SYLVILAGUS FLORIDANUS	EASTERN COTTONTAIL	X
SYLVILAGUS PALUSTRIS	MARSH RABBIT	
SCALOPUS AQUATICUS	EASTERN MOLE	X
NEOFIBER ALLENI	FLORIDA WATER RAT	
NEOTOMA FLORIDANA	EASTERN WOODRAT	
ORYZOMYS PALUSTRIS	RICE RAT	
SIGMODON HISPIDUS	HISPID COTTON RAT	
PEROMYSCUS POLIONOTUS	OLD FIELD MOUSE	
PEROMYSCUS GOSSYPINUS	COTTON MOUSE	
PEROMYSCUS NUTTALI	GOLDEN MOUSE	
BLARINA BREVICAUDA	SHORTTAIL SHREW	
PITYMYS PINETORUM	PINE VOLE	
CRYPTOTIS PARVA	LEAST SHREW	
MYOTIS AUSTRORIPARIUS	MISSISSIPPI MYOTIS	
PIPISTRELLUS SUBFLAVUS	EASTERN PIPISTREL BAT	
LASIURUS BOREALIS	RED BAT	
LASIURUS CINEREUS	HOARY BAT	
NYCTICEIUS HUMERALIS	EVENING BAT	
LASIURUS INTERMEDIUS	EASTERN YELLOW BAT	
LASIURUS SEMINOLUS	SEMINOLE BAT	
TADARIDA BRASILIENSIS	MEXICAN FREETAIL BAT	
MYOTIS LUCIFUGUS	LITTLE BROWN BAT	
PLECOTUS RAFINESQUEI	EASTERN BIG-EARED BAT	

Table II-12 Relative importance of tree species in upland and lowland habitats within 1.5 mile radius of A. B. Hopkins Generating Station, January 1974.

Habitat & Species	Relative Density	Relative Dominance	Relative Frequency	Importance	dbh Inches
Upland pine/hardwood					
Quercus laurifolia	34.2	36.7	26	96.9	4.61
Pinus elliottii	20.7	34.7	15	70.4	6.12
Quercus nigra	15.9	14.6	10	40.5	4.46
Liquidambar styraciflua	4.9	2.1	15	8.5	3.25
Vaccinium arboreum	9.8	2.0	10	12.8	2.0
Pinus echinata	1.2	7.1	5	13.3	13.0
Cornus florida	6.1	1.9	5	13.0	3.0
Myrica cerifera	6.0	.3	5	11.3	1.2
Prunus serotina	1.2	.67	5	6.9	4.0
Lowland Mixed Hardwoods					
Carpinus caroliniana	34.9	20.2	20	75.1	3.72
Magnolia virginiana	10.8	19.0	20	49.8	4.55
Magnolia grandiflora	20.5	9.3	16	45.8	3.29
Unidentified oak	4.8	4.3	16	25.1	5.0
Quercus rubra	2.4	11.7	10	24.1	12.0
Unidentified #5	2.4	7.4	10	19.8	9.5
Quercus nigra	2.4	16.9	5	24.3	14.5
Liquidambar styraciflua	9.6	1.4	5	16.0	1.75
Unidentified #2	4.8	3.8	5	13.6	4.5
Quercus alba	1.2	5.8	5	12.0	12.0
Persea barbonia	1.2	.04	5	6.2	1.0
Viburnum dentatum var. scabrellum	1.2	.04	5	6.2	1.0
Fagus grandiflora	1.2	.04	5	6.2	1.0
Unidentified #4	1.2	.16	5	6.2	2.0
Unidentified #1	1.2	.04	5	6.2	1.0

cherry, sparkleberry, dogwood, wax myrtle, holly, catbriers, and muscadine grape all produce berries eaten by wildlife. For a list of animal species observed or expected in this habitat, see Table II-11.

(b) Lowland Mixed Hardwoods - Lowland associations occupy approximately 672 acres of floodplain and other areas subject to poor drainage. The soils are moist, highly organic and generally quite acidic.

Deciduous trees dominate the overstory in this association. The transects indicated blue beech, sweetbay, and southern magnolia are the most important species in the survey area (Table II-12). Important mast producing species are water oak, white oak and basket oak. Pines were infrequently encountered. For a list of other plant species of this association see Table II-10.

Raccoon and deer tracks were commonly observed during the field survey. Two beaver ponds were sighted. These provide feeding and refuse areas for wildlife. Other species encountered or expected in this association are listed in Table II-11.

(c) Pasture/Residential Areas - Pasture/residential areas occur on mixed pine/hardwood or sandhill regions which have been totally or partially cleared. In residential areas men, dogs, cats, gray squirrels, and various Passeriformes (song birds) are the dominant fuana. Faunal species associated with pasture are cattle, horses, squirrel, rabbit, various small rodents, and hawks. Vegetation is a composition of natural and certain introduced species.

(d) Sand Quarry - A sand quarry operation of approximately 125 acres is located south of State Route 20.

(e) Important Species - An animal or plant species is designated "important" by meeting the following criteria: (1) it is commercially or recreationally valuable, (2) it is rare or endangered, (3) it affects the well-being of some important species within criteria (1) and (2) above, or (4) it is critical to the structure and function of the ecological system. In this section the status of important species found within the study area is discussed.

(f) Important Plant Species - No plant species considered to be rare or endangered were observed during the survey. Slash pine is the only commercially valuable species. Oaks produce mast used by "important" species such as deer, squirrel, hog and turkey; therefore, they could be considered important plants. Other than slash pine in the pineland areas, and longleaf pine and turkey oak in the sandhill regions, no one species can be considered critical to the structure and function of its ecosystem (Table II-12).

(g) Important or Recreationally Valuable Animal Species - Table II-13 indicates these animals regarded as important or recreationally valuable which were either observed or expected to occur in the vicinity of the A. B. Hopkins Generating Station.

Whitetail deer is the most important big game animal in the state. Its preferred habitat consists of moderately open pineland and mixed forests containing sufficient quantities of leafy understory vegetation. Numerous deer tracks were observed along the unpaved roads in the hunting reserve west of the plant.

Table II-13 Observed or expected commercially and/or recreationally valuable animal species and their preferred habitats. A. B. Hopkins Field survey, January, 1974

	Observed	Spoor sighted	Expected	Mixed Pine/hardwood	Pineland	Sandhill	Lowland mixed-Hardwood	Pasture	Ponds & Creeks
Whitetail Deer		X		P*	0	0	0		
Bobcat		X		0		0	P		
Grey Fox			X	P	0	0	P		
Beaver		X					0		P
Raccoon		X		0	0		P		
Opossum		X		P	0		0	0	
Cottontail Rabbit		X		P	0	0	P	0	
Marsh Rabbit			X				P		
Fox Squirrel			X	0	P	0		0	
Grey Squirrel	X	X		P			P	0	
Turkey			X	P	P		0	0	
Bob-white, Quail		X		0	P			P	
Mourning Dove	X			P	P			P	
Wood Duck	X						P		P
Hooded Merganser			X				P		P

*P - Preferred
0 - Occasionally used

The proposed expansion of the Hopkins plant will lead to increased human activity in the local area, during construction. Short-term impacts may involve some relocations of species to less disturbed areas.

Utilizing portions of the same habitat as deer are gray squirrel, fox squirrel and turkey. The gray squirrel was sighted a number of times during the field survey. Little change in its status should occur due to the proposed expansion of the Hopkins facility. The fox squirrel is less common than the gray squirrel and none were sighted during the study. Its limited tolerance to man might cause relocation of some individuals during the proposed plant construction. Turkey were also reported but not sighted in the study area. Its status should be little affected by the proposed facility expansion.

Bob-white quail and mourning dove prefer habitats of pineland and pasture. Both species are present on the property. Because of their high tolerance of man they should not be significantly affected by the proposed expansion of the Hopkins facility.

Two other game species, the cottontail rabbit and the marsh rabbit, probably reside on the property. Neither were sighted, but cottontail tracks were observed. Expansion of the Hopkins plant should not alter the status of either species.

The wood duck and the hooded merganser are the only significant waterfowl species which may utilize the study area. They are residents of wooded lakes, ponds, and streams. A pair of wood ducks and several nesting cavities were observed during the field study. Their status should not be altered by the proposed expansion of the Hopkins facility.

The raccoon, opossum, beaver, gray fox, and bobcat are subject to occasional hunting and trapping. Actual or spoor sightings were made for raccoon, opossum, beaver, and bobcat during the field survey. The gray fox was not observed but is a likely resident in the study area. The raccoon, opossum, and beaver should not undergo any change in population density or distribution due to the proposed expansion of the Hopkins plant. However, the gray fox and bobcat are less tolerant of man, and the increased human activity resulting from the proposed expansion may cause a slight population shift from present areas into less disturbed regions. No significant population loss is anticipated. For a list of observed or expected commercially valuable species and their preferred habitats see Table II-13.

(h) Threatened Species -

> "A species of native fish and wildlife shall be regarded as threatened with extinction whenever the Secretary of the Interior finds, after consultation with the affected States, that its existence is endangered because its habitat is threatened with distruction, drastic modification, or severe curtailment, or because of over-exploitation, disease, predation, or because of other factors, and that its survival requires assistance. In addition to consulting with the States, the Secretary shall, from time to time, seek the advice and recommendations of interested persons and organizations, including, but not limited to, ornithologists, ichthyologists, ecologists, herpetologists, and mammalogists. He shall publish in the Federal Register the names of the species of native fish and wildlife found to be threatened with extinction in accordance with this paragraph." (Air Pollution Control Association, 1970).

Table II-14 provides a list of threatened species which may be utilizing habitats in the study area. Although none of these species were

Table II-14 Threatened species which might occur on habitats within a 1.5 mile radius of the A. B. Hopkins generating station.

	Likelihood of using Study area	Mixed Pine/hardwood	Pineland	Sandhill	Lowland Mixed hardwood	Pasture	Ponds & Creeks
Florida Panther	Fair	P	0	0	P		
Florida Water Rat*	Poor				0		P
Southern Bald Eagle	Poor					0	P
Short-tailed Hawk	Poor				P		P
American Osprey*	Poor				0		P
Wood Ibis*	Poor				0		P
Red-cockaded Woodpecker	Poor		P				
Alligator**	Fair						P

* Status-undertermined
** Not threatened, but protected by Florida Law

P = Preferred
0 = Occasionally used

sighted by the field team, two species deserving special mention are the Florida panther and the southern bald eagle.

The Florida panther prefers extensive, unmolested tracts which support a large deer population. This habitat exists in the hunting reserve located west of the plant site. It is important to note that a panther was sighted near Lake Talquin in 1969 (U. S. Department of Interior, 1973). If panthers still inhabit the Lake Talquin area, it is likely that they occasionally range into the study area.

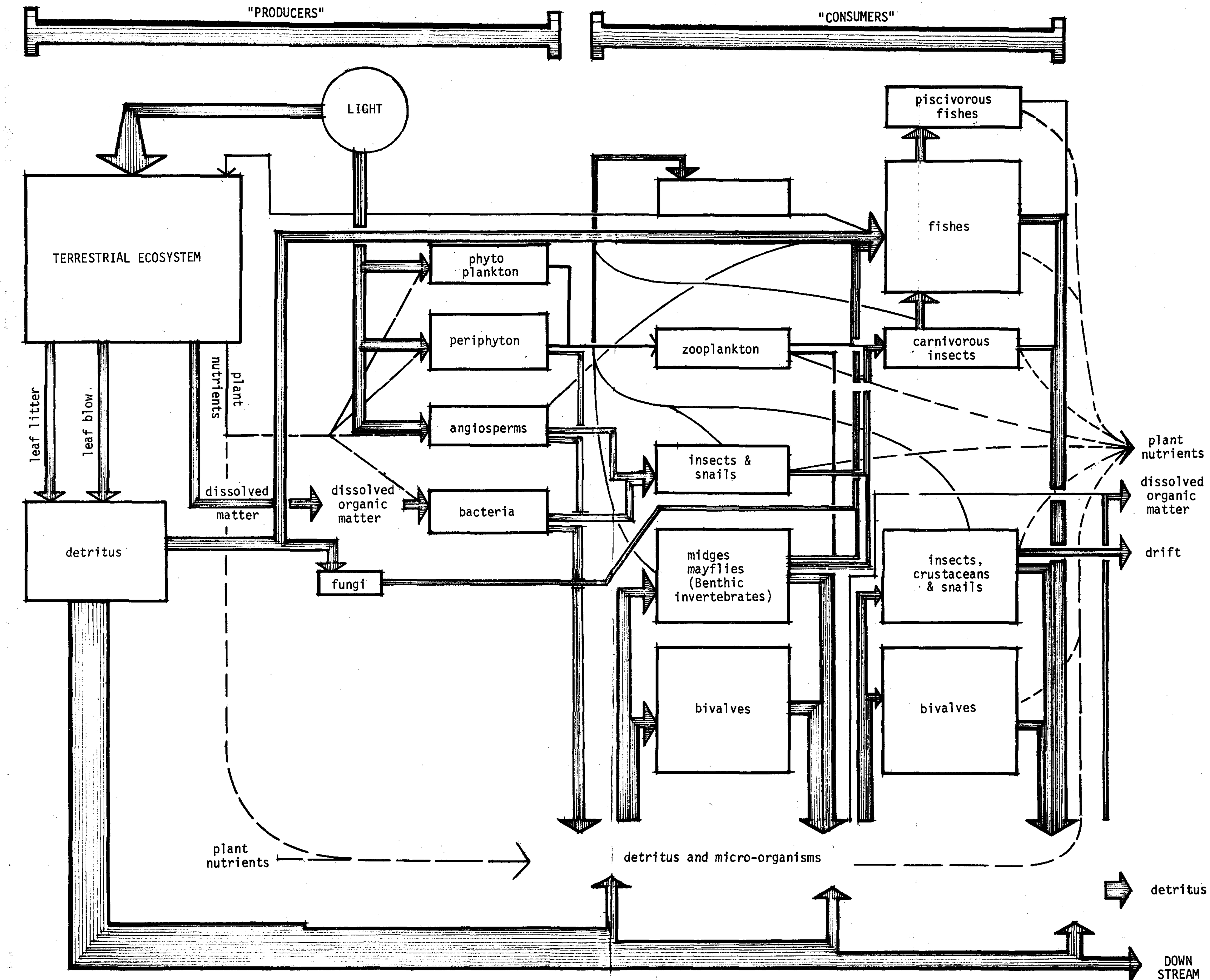
Although the southern bald eagle would probably not feed much in the study area, suitable nesting habitat does occur along the Ochlockonee River. A possible nest was reported in the area. However, the field team was unable to validate the report and no eagles were sighted during the field survey. Expansion of the Hopkins plant should not adversely affect either of these species.

(i) Species Vital to the Structure or Function of the Ecosystem - No such animal species were noted on the study area.

(j) Pre-existing Stresses - Secondary and dirt roads exist in the area. Traffic is light and limited to the paved roads. A sustained yield forestry program is practiced which limits succession to young, productive, commercial timber species. Hunting occurs in season but apparently is not a significant stress.

2.7.3 Aquatic System

(a) General - The aquatic habitats in the region of the A. B. Hopkins Generating Station are the Ochlockonee River and the riverine portion of Lake Talquin reservoir. As shown in Exhibit II-17, the A. B. Hopkins



A simplified diagram of energy flow for the aquatic habitats present in the vicinity of the A. B. Hopkins Generating Station. (Modified from Hynes, 1972).

EXHIBIT II-18

Generating Station blowdown is received by the outfall stream. After traveling a distance of approximately 3.7 miles, the outfall stream empties into the riverine portion of Lake Talquin reservoir.

The primary energy source for the outfall stream, the Ochlockonee River, and the riverine portion of Lake Talquin is organic matter imported from the surrounding terrestrial system. Exhibit II-18 presents a generalized flowchart of materials and energy flow through the system. The base of the trophic web consists of dissolved and particulate organic matter (detritus) feeders which are consumed by primary carnivores. Successive levels of organisms feeding at a variety of substrates results in an efficient utilization of available energy and materials.

Even though Lake Talquin reservoir is drawn down and allowed to refill each winter, water quality parameters are indicative of eutrophic conditions. The lake has periodic phytoplankton blooms, high nutrient levels and anoxic conditions during periods of thermal stratification.

During the winter months, the littoral benthic community of Lake Talquin reservoir is periodically exposed to lake drawdown to the five-foot depth contour. The shallow, sandy, littoral zone was observed to be partly covered by a filamentous algal mat. A flocculated clay sediment is characteristic of the deep water zone. Dominant benthic invertebrates of the deep water zone include an exotic species of clam, Corbicula, and a variety of other indigenous bivalve species. Chironomids and burrowing mayfly larvae are important components of the deep water zone.

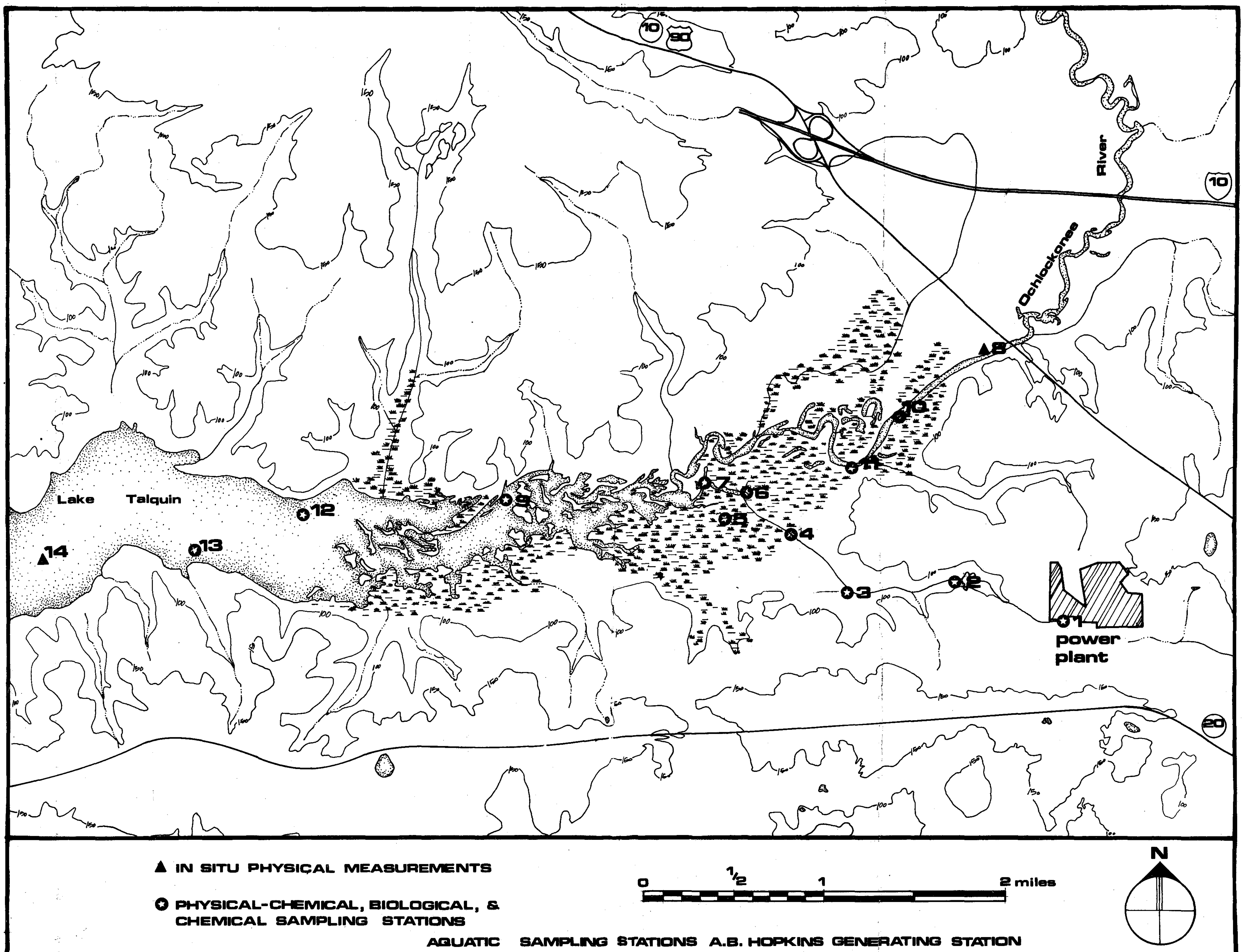


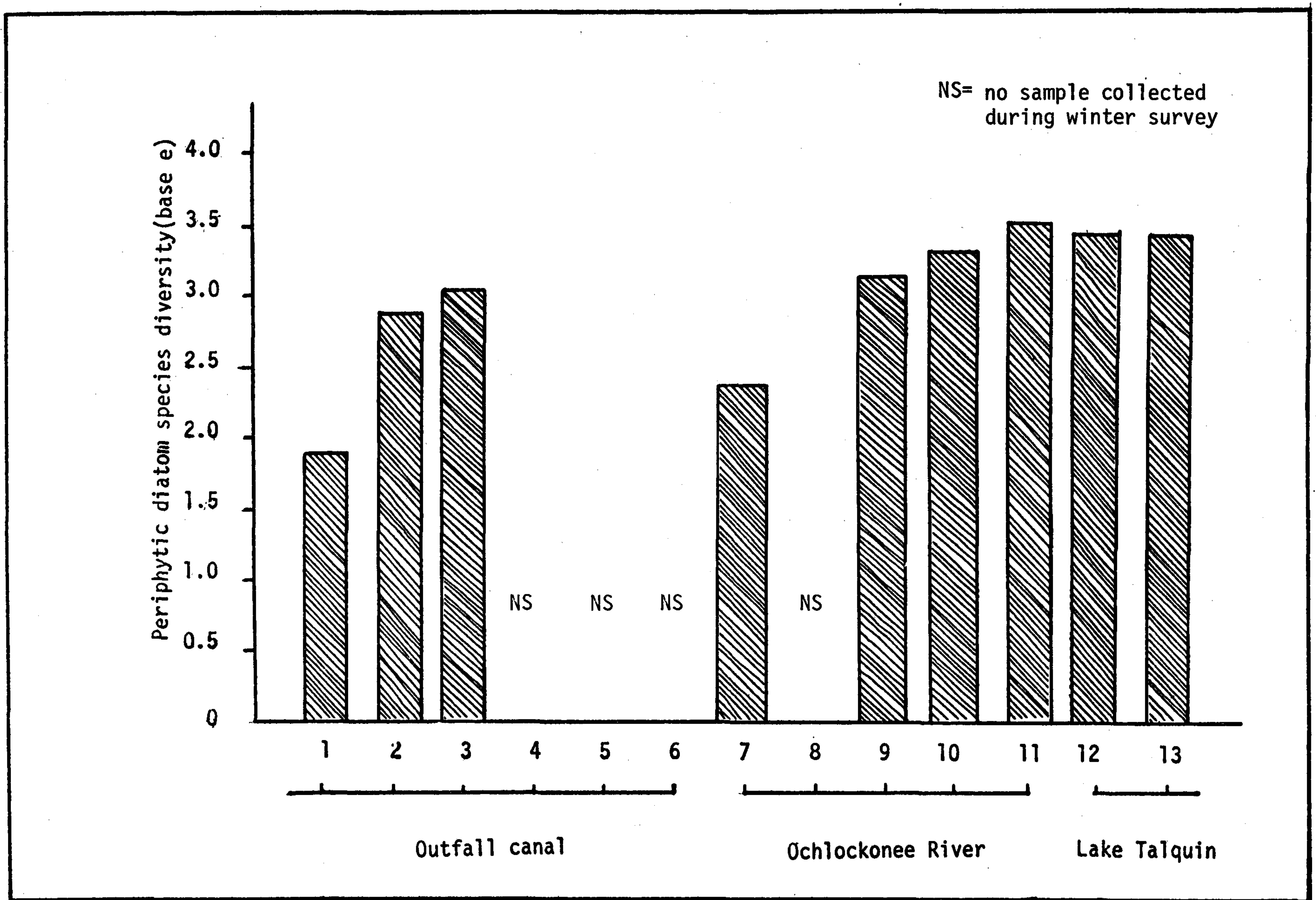
EXHIBIT II-17

The river and reservoir provide a sport fishery of regional importance. Included among the sport fish are the largemouth bass, bluegill, redear sunfish, black crappie, and striped bass. The physical constraints of stream flow and depth within the A. B. Hopkins outfall stream effectively limits the fishery production to minnows.

(b) Baseline Data - Periphyton and Phytoplankton - The important producer organisms within the power plant outfall creek during December, 1973, were the periphyton which were represented by 68 species of diatoms at Stations 1, 2, and 3. The dominant species were Achnanthes exigua var. heterovalva, A. ostrupi, Eunotia vanheurckii var. intermedia, Navicula viridula, Nitzschia fronticola, N. palea, and Synedra rumpens var. familiaris.

Results of the winter field survey on periphyton indicate that the power plant effluent inhibited the diatom population of the periphyton at Station 1. At the location 295 individuals per composite sample were counted and only 10 species recorded (Table II-15).

Species diversity indices of the periphyton were low at Station 1 in comparison to other stations located in the outfall stream, Ochlockonee River, and Lake Talquin reservoir (Exhibit II-19). The species diversity index at Station 1 was 1.88. The other stations in the outfall canal (2 and 3), exhibited periphyton diversity indices of 2.84 and 3.02, respectively. The average diversity of Stations 2 and 3 was 2.93 which is less than the overall average of 3.22 recorded for other stations (7, 9, 10, 11, 12, 13). Species diversity indices of the



Shannon-Weaver species diversity indices(base e) for periphytic diatoms collected at nine stations in the vicinity of the A.B. Hopkins Generating Station. Samples collected during the period of December 7-8,1973.

Table II-15 Phytoplankton data from samples obtained in the vicinity of the A. B. Hopkins Generating Station collected data from December 7-8, 1973. (cells/ml)

Stations (Refer to figure 2.7-6)	Outfall Creek 22	Ochlocknee River Station 10	77	9	Lake Talquin 12	13
Chlorophyceae						
Carteria sp.	5.0					
Chlamydomonas sp.		5.0	5.0	5.0	5.0	10.1
Chlorogonium sp.				5.0		
Cosmarium sp.	5.0					
Crucigenia crucifera (Wolle) Collins						40.6
Micractinium pusillum Fresenius			20.3			
Mougeotia sp.	50.8					
Scenedesmus dimorphous (Turp.) Kuetz	20.3					
S. longus var. naegelii (de Breb.) G. M. Smith				40.6		
S. quadricauda var. longispina (Chod.) G. M. Smith		20.3			20.3	20.3
Sphaerellopsis sp.				5.0		
Unidentified Green Sphere	5.0		5.0	5.0	10.1	5.0
Unidentified species	5.0			5.0		45.7
Myxophyceae						
Anabaena sp.	20.3		30.5			
Merismopedia punctata Meyen				60.9		
Lyngbya sp.				50.8		
Unidentified Blue Green Colony					101.6	
Chrysophyceae						
Mallomonas sp.	5.0					
Vaucheria sp.						5.0
Euglenophyceae						5.0
Euglena sp.		5.0			5.0	15.2
Phacus sp.						5.0
Trachelomonas horrida Palmer	5.0					
T. robusta Swirenko	15.2					
Cryptophyceae						
Cryptomonas erosa Ehr.	5.0					
Cryptomonas sp.	5.0		5.0	5.0		30.5
Rhodomonas sp.	5.0			5.0		10.1
Bacillariophyceae						
Achnanthes hungarica (Grun.) Grun. var. Nom.	5.0		5.0	5.0	5.0	
A. lanceolata var. apiculata Patr.					5.0	
A. ostrupi (A.Cl.) Hust.	5.0		15.2	5.0		20.3
A. sp. 1		10.1				
Amphora sp.				5.0		
Capartogamma crucicula (Grun. ex Cl.) Ross var. Nom.				5.0		
Cocconeis placentula Ehr. var. Nom.			15.2		5.0	
Cyclotella mengenianiana Kutz.		10.1				
C. sp. 1	5.0		5.0			
Eunotia curvata (Kutz.) Largerst. var. Nom.	5.0		15.2			
E. vanheurckii var. intermedia (Krasske ex Hust.) Patr.			5.0			5.0
E. sp. 1				5.0		
Frustulia rhomboides var. capitata (A. Meyer) Patr. comb. nov.			5.0		5.0	
F. rhomboides var. saxonica (Rabh.) DeT.				5.0		
Gomphonema gracile var. naviculoides (Wm. Sm.) Grun.						5.0
G. sp. 1			5.0		5.0	
Gyrosigma sciotense (Sulliv. & Wormley) Cl. var. Nom.				5.0	5.0	
G. sp. 1					5.0	
Melosira granulata var. angustissima Muller						5.0
M. sp. 1						5.0
M. sp. 2		5.0	15.2	25.4		5.0
Navicula capitata var. hungarica (Grun.) Ross		10.1	20.3	15.2		5.0
N. gastrum (Ehr.) Kutz. var. Nom.		5.0	10.1	10.1		
N. pupula Kutz. var. Nom.			5.0	5.0		
N. pupula var. mutata (Krasske) Hust.		5.0				5.0
N. pusilla W. Sm. var. Nom.					5.0	
N. radiosa Kutz. var. Nom.		15.2	5.0	15.2		
N. rhynchocephala var. germainii (Wallace) Patr. comb. nov.	5.0	25.4	5.0	40.6	10.1	15.2
N. sp. 1	5.0		5.0			
Neidium sp.	5.0		10.1			
Nitzschia acicularis (Kg.) W. Sm.	10.1			5.0		
N. filiformis (W. Sm.) Schutt	25.4	15.2	10.1	15.2	5.0	20.3
N. palea (Kutz.) W. Sm.			5.0			
N. paradoxa (Gmelin) Grun					10.1	
N. plana W. Sm. *		5.0		5.0		
N. tryblionella var. victoriae Hantzch.				5.0		
Pinnularia acuminata W. Sm. var. Nom.			5.0		5.0	
P. sp. 1	20.3					
Rhopalodia gibba (Ehr.) O. Müll.					5.0	
Stauroneis anceps var. gracilis Rabh.			5.0			
Stephanodiscus sp. 1						5.0
Synedra rumpens var. familiaris (Kutz.) Hust.	35.5					
S. ulna (Nitz.) Ehr. var. Nom.	20.3	25.4	20.3	40.6		10.1
Unknown diatom species						
Total number species/station	25	14	26	26	17	23
Total number individual cell	298.2	161.8	257.5	394.6	212.2	298.4
Shannon General diversity to base e.	2.86	2.40	3.03	2.79	2.07	2.81

* Species identification tentative

Table II-15 Periphyton data from samples obtained in vicinity of the A. B. Hopkins Generating Station. Collected data from (Cont'd) December 7-8, 1973. (Numbers indicate those encountered in counting 300 valves).

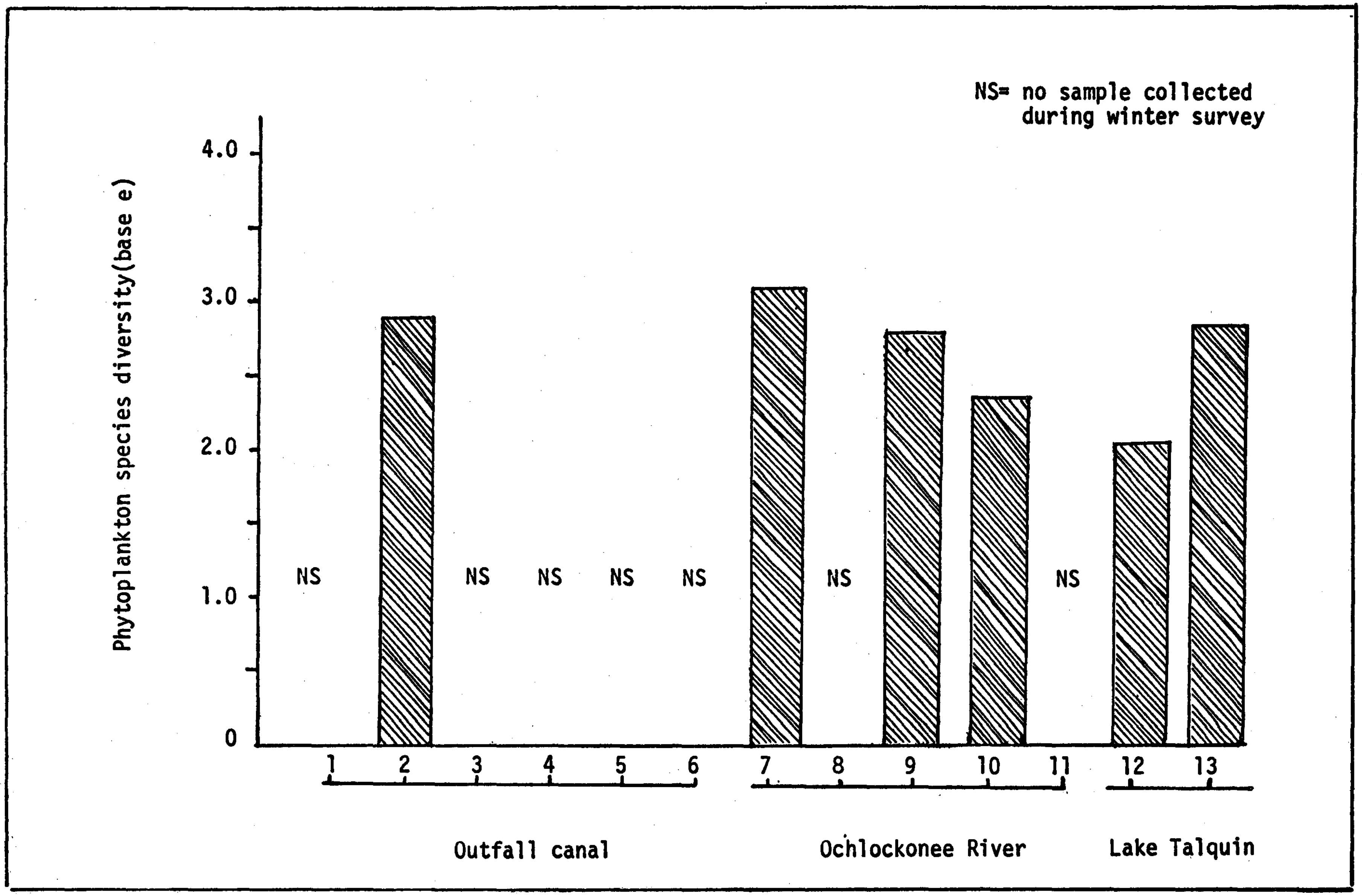
Taxa Stations	Outfall Creek 1	2	3	Ochlockonee River 10	11	7	9	Lake Talquin 12	13
N. clausii Hantsch. * *	1		2						
N. closterium (Ehr.) W. Sm.		2	7					1	1
N. constricta (Greg.) Grun.								1	1
N. denticula Grun.		6	3	3					3
N. filiformis (W. Sm.) Schutt			4	21	12	3	2	3	
N. fonticola Grun.	33	21	13	4		8	7	14	9
N. lorenziana Grun.				8	12	3	1		4
N. obtusa var. scapelliformis Grun.		24							
N. palea (Kutz.) W.Sm.	12	12	54	31	7	14	16	5	22
N. paradoxa (Gmelin) Grun.			6	3			1	1	
N. punctata (W.Sm.) Grun.									1
N. sigma (Kutz.) W.Sm.		2	1					3	7
N. tryblionella var. debilis (Arn.) Grun.					8		1		
N. tryblionella var. victoriae Hantzch.					4		1	3	2
N. sp. 1	6	1			11	4	6	3	
N. sp. 2			2	4				3	
N. sp. 3					2		1	4	
Opephora martyi Herib. var. Nom.				3		2		1	
Pinnularia abujensis var. linearis	30	1							
P. abujensis var. subundulata			1						3
P. acuminata W. Sm. var. Nom.								1	
P. appendiculata (Ag.) Cl. var. Nom.					3			1	6
P. braunii var. amphicephala (A. Mayer) Hust.					2	2			
P. divergens W. Sm. var. Nom.				1	1		2	1	
P. divergens var. undulata (M. Perag. & Herib) Hust. Patr.									3
P. maior (Kutz.) Rabh. var. Nom.			1			1			1
P. nodosa (Ehr.) W. Sm. var. Nom.								1	
P. obscura Krasske var. Nom.							8		
P. subcapitata Greg. var. Nom.			1						
P. sp. 1			1						
P. sp. 2					1				
P. sp. 3						1			
Rhopalodia gibba (Ehr.) O. Mull.		3							
R. gibberula (Ehr.) O. Mull.	127	7							
Stauroneis anceps var. gracilis Rabh.		1						2	3
Stephanodiscus sp.				2	5			3	15
Surirella angusta Kutz. var. Nom.			1						
S. robusta Ehr. var. Nom.			1						
S. sp. 1		4					4	1	
Synedra acus Kutz. var. Nom.		1							
S. delitissima W. Sm. var. Nom.		1							
S. parasitica (W. Sm.) Hust. var. Nom.							1		
S. rumpens var. familiaris (Kutz.) Hust.		45	1						
S. ulna (Nitz.) Ehr. var. Nom.		2	2		4		2		4
Unknown species	6	10	3	5	5		9	3	2
*Tentative species identifications									
Total Number of Species/station	14	40	55	41	52	55	44	59	42
Sample size (N)	300	300	300	297	300	302	300	300	300
Shannon General Species Diversity (to the base e)	1.88	2.84	3.02	3.35	3.5	2.48	3.15	3.42	3.41

periphyton were high in both the Lake Talquin and the Ochlockonee River. The average values were 3.42 and 3.12, respectively. The dominant periphyton species recorded during December, 1973, in Lake Talquin and the Ochlockonee River were: Achnanthes ostrupi, Achnanthes sp. 3, Cyclotella glomerata, Navicula capitata var. hungarica N. radiosa, N. viridula, N. sp. 1, Nitzchia fonticola, and N. palea.

Phytoplankton samples were collected from a beaver pond (Station 2) located downstream from the power plant outfall, and from five stations located in the Ochlockonee River and Lake Talquin reservoir (Stations 7, 9, 10, 12, and 13). Common species recorded at Station 2 were: Mougeotia sp., Anabaena sp., Nitzschia palea, Rhopaldia gibba, and Synedra rumpens var. familiaris (Table II-16). A total of 25 species of algae, principally diatoms, were present at Station 2. Diatoms accounted for 67 percent of the phytoplankton, green algae 91.1 percent, blue-green algae 20.3 percent, Euglenoids 20.2 percent and all others 1 percent.

A moderately high phytoplankton species diversity of 2.86 was recorded for Station 2. However, phytoplankton abundance was low at 298 cells per milliliter (Table II-16). The phytoplankton diversity index of 2.86 at Station 2 was approximately the same as the periphyton diversity of 2.84 at the same station, see Exhibit II-20.

Species diversity according to the Shannon-Weaver general diversity index (Odum, 1971) ranges from less than 1.0 in highly stressed systems that are represented by a few species and large populations to greater than 3.5 in highly stable systems that are represented by a larger number of species and small populations.



Phytoplankton species diversity indices calculated for six sites in the vicinity of the A.B. Hopkins Generating Station. Samples collected during the period December 7-8, 1973.

EXHIBIT II-20

Table II-16 /Periphyton data from samples obtained in vicinity of the A. B. Hopkins Generating Station. Collected data from December 7-8, 1973. (Numbers indicate those encountered in counting 300 valves).

Taxa	Stations	Outfall Creek			Ochlockonee River				Lake Talquin	
		1	2	3	10	11	7	9	12	13
Achnanthes conspicua A. Mayer			5	8	4	3	2	3	1	6
A. exigua var. heterovalva Krasske			50	21		3	3	1	1	
A. hungarica (Grun.) Grun. var. Nom.			9		5			2	1	
A. lanceolata (Bréb) Grun. var. Nom.				2		10	2	2		
A. lanceolata var. apiculata Patr.				4	4	7	2	1		
A. lanceolata var. dubia Grun.				3		2				
A. lemmermanni Hust. Var. Nom.									2	
A. ostrupi (A. Cl.) Hust.			28	3	4	6	4	3	19	
A. peragalli (Brun & Herib) var. Nom.*				1		1				
A. sp. 1		25	15	2	4	12	7	6	23	
A. sp. 2			2		8	8		4	4	16
A. sp. 3		3		1	4	4	119	30	16	24
A. sp. 4							1			
Amphora sp.		6			3	4				
Anomoeneis serians var. brachysira (Breb. ex. Kutz) Hust				1						
Caloneis bacillum (Grun.) Cl. var. Nom.		38								
C. sp. 1			1	5						
Capartagamma crucicula (Grün ex Cl.) Ross var. Nom.				3	1	3	4			
Cocconeis pediculus Ehr.			1			3	2			
C. placentula Ehr. var. Nom.					1			1	1	
Cyclotella glomerata Bachmann			2	1				1	12	15
C. mengeniániana Kutz.			2	1					2	
Cymbella sp.					4	2				
Diploneis ovalis (Hilse) Cl.				1	4	5			3	1
D. smithii (Bréb. ex W. Sm.) Cl.									2	
Epithemia sorex Kutz.			1							
Eunotia curvata (Kutz.) Largest var. Nom.			1							
E. formica Ehr. var. Nom.									1	
E. indica Grun. var. Nom.									2	
E. pectinalis var. minor				24		1	6	5	1	
E. serra var. diadema (Ehr.) Patr.									1	
E. vanheurckii var. intermedia (Krasske ex Hust.) Patr.			26	4		9		7	3	9
E. sp. 1				1	4	2				
Fragilaria sp.									1	
Frustulia rhomboides var. capitata (A. Meyer) Patr. comb nov.				4	4	3	2	1	2	9
F. rhomboides var. saxonica (Rabh.) DeT.				3		9	3	3	9	5
F. sp. 1				6			2			
Gomphonema carolinense Hagelstein var. Nom.						1				
Gomphonema gracile var. naviculoides (W. Sm.) Grun.			1			4				3
G. parvalum Kutz. var. Nom.			3		4	1	2		3	
G. sp. 1										1
G. sp. 2						2				4
Gyrosigma sciotense (Sulliv. & Wormley) Cl. var. Nom.					17	18	3	19	2	
G. sp. 1					4			5	4	14
Hantzschia amphioxys (Ehr.) Grun.		3		1	4	2	2	1	8	4
Melosira granulata (Ehr.) Ralfs.									9	10
M. granulata var. angustissima Müller.								2	7	
M. italica var. valida Grun.					7					
M. sp. 1				1		1			1	6
M. sp. 2				1		2			2	4
M. sp. 3				4						5
Meridion circulare var. constrictum (Ralfs.) V.H.				1						
Navicula capitata var. hungarica (Grun.) Ross					23	34	23	29	10	15
N. expansa Hagelst. var. Nom.		3	1	1						
N. gastrum (Ehr.) Kutz. var. Nom.								3		2
N. globulferia Hust. var. Nom.								1		
N. ilopangoensis Hust. var. Nom.			2	1		1	2	16	1	3
N. pupula Kutz. var. Nom.			1	1		4	2	2		
N. pupula var. mutata (Krasske) Hust.				6	5	1	3		2	
N. pupula var. rectangularis (Greg.) Grun.				1		6	2			
N. pusilla W. Sm. var. Nom.				1						
N. pygmaea Kutz. var. Nom.										2
N. radiosa Kutz. var. Nom.			1	3	7	6	12	23	53	16
N. rhynchocephala var. germanii (Wallace) Patr. comb. nov.			1	2	8		3	3		
N. schroeteri var. escambia Patr. *					3					
N. viridula (Kutz.) emend V.H. var. Nom.			1	66	35	17	7	24	4	19
N. viridula var. linearis Hust.									2	
N. viridula var. restellata (Kutz ?) Cl.					13					
N. sp. 1		6		2	19	11	9	39	14	12
N. sp. 2					4	10	37		10	5
Neidium sp.			1							
Nitzschia acicularis (Kg.) W.Sm.			2	4	3	3		6	3	4
N. amphibia Grun.					2	2			3	

For example, untouched Floridan systems generally exhibit diversities in the range of 2.5 to 3.0. The range of 0.5 unit is attributed to varying types of habitats and natural stress factors. In a comparison of diversity indices of biological components, e.g., phytoplankton, within a system for the purpose of assessing effects of man-induced stress, it is necessary to know what constitutes a significant difference between samples, we contend this to be approximately 0.5 units of the samples were collected on the same day.

As can be expected in a detritus forced stream system, low phytoplankton population densities were recorded at the stations located in the Ochlockonee River (Stations 7, 9, 10, and 11) and the Lake Talquin reservoir (Stations 12 and 13). Estimates ranged from 161 to 394 cells per ml with a mean of 265 cells per ml. A total of 58 species of phytoplankton were recorded from stations located in the Ochlockonee River and Lake Talquin reservoir (Table II-16). Diatoms accounted for 58 percent of the phytoplankton, green algae 19 percent, blue-green 16 percent, euglenoids 3 percent, and all others 4 percent. Dominant species were: Scenedesmus, spp., Merismopedia punctata, Lyngbya sp., and an unidentified blue-green colonial form, Achnanthes sp. 1, Navicula capitata var. hungarica, N. gastrum, N. sp. 1, Nitzschia palea.

Summary data for periphyton and phytoplankton are presented in Table II-17.

(c) Baseline Data - Benthic Macroinvertebrates - Over 95 percent of the total numerical standing crop of benthic organisms recorded at the

Table II-17 Summary of periphyton and phytoplankton data collected in the vicinity of the A. B. Hopkins Generating Station during December 7 and 8, 1973.

	Sampling Stations[a]								
	Outfall Canal			Ochlockonee River				Lake Talquin	
	1	2	3	7	9	10	11	12	13
Periphyton (Qualitative)									
No. of species/sample[b]	14	40	55	35	44	41	52	59	42
No. of individuals/sample[b]	300	300	300	302	300	297	300	300	300
Shannon-Weaver species diversity indices (base e)	1.88	2.84	3.02	2.48	3.15	3.35	3.5	3.42	3.41
Phytoplankton (Quantitative)									
No. of species/ml.	N.S.	25	N.S.	26	26	14	N.S.	17	23
No. of individuals/ml.	N.S.	298	N.S.	257	395	161	N.S.	212	298
Shannon-Weaver species diversity indices (base e)	N.S.	2.86	N.S.	3.03	2.97	2.40	N.S.	2.07	2.81

[a]N.S. - not sampled.

[b]Qualitative information as sample size varied.

sites investigated was in the form of herbivores and ominivores linked to the detrital energy flow. The most important of these were: chironomids, pelecypods and oligochaetes. Chironomus attenuatus dominated the communites in numbers with a density of 282 organisms/m^2. The pelecypods, although not numerically as important, were the largest invertebrates in the Ochlockonee River and Lake Talquin. They consume correspondingly large amounts of detritus. Common bivalves observed were Megalonia gigantia, Sphaerium, Anodonta imbecillis, Lampsilis sp. and the introduced clam, Corbicula manilensis (Table II-18 and II-20).

Four stations were sampled for benthic invertebrates in the power plant outfall stream (Stations 1, 2, 3, and 7; Exhibit II-17).

Station 1, located immediately below the blowdown outfall, was devoid of benthic life. This station was characterized by high water temperature (23°C), high pH (9.12), and high concentrations of salts (conductivity = 600 µmhos/cm).

Station 2 was located downstream in a beaver pond. The depth at this station was approximately 3 feet. Sediments were comprised of detrital (leaf litter) material. Four benthic species were collected which totaled 45 organisms/m^2. The Shannon-Weaver species diversity index (base e) at Station 2 was calculated to be 1.33 (Table II-19). The benthic population is low and in part reflects the effect of thermal stress in this portion of the canal.

Station 3 was characterized by low flow, a sand bottom overlain by leaf litter and fine organic ooze. Temperature was at ambient level of 11°C during sampling. Station 3 exhibited a low diversity index (1.59) and high numbers

Table II-18 Benthic macroinvertebrates collected during the winter survey for the A. B. Hopkins Generating Station on December 7 and 8, 1973.

Benthic Macroinvertebrate	Stations 1	2	3	10	11	7	9	12	13	Av no./m^2
Mollusca										
Gastropoda										
Mesogastropoda										
Viviparidae										
Campeloma sp.								9		1
Bulimidae										
Amnicola sp.									18	2
Lyogyrus sp.									18	2
Lymnaeidae										
Psudosuccinea columella									9	1
Fossaria cubensis								27	18	5
Bivalvia										
Heterodonta										
Corbiculidae										
Corbicula manilensis				38	19		9	18	18	11
Sphaeridae										
Sphaerium sp.			171			153	117	387	9	93
Eulamellibranchia										
Unionidae										
Elliptoideus sp.					19					2
Insecta										
Diptera										
Orthorrhapha										
Chaoboridae										
Chaoborus punctipennis							9			1
Chironomidae										
Chironomus attenutus			437	304	190	675	387	90	459	282
Coelotanypus concinnus							27	153	36	24

Table II-18 (Cont'd) Benthic macroinvertebrates collected during the winter survey for the A. B. Hopkins Generating Station on December 7 and 8, 1973.

Benthic Macroinvertebrates	Stations 1	2	3	10	11	7	9	12	13	Av no./m^2
Procladius sp.		9			19					3
Tanytarsus sp.							45	828	153	114
Stenochironomus sp.								9		1
Cryptochironomus sp.									27	3
Cladotanytarsus			19							2
Polypedilum sp.		9	76							9
Ceratopogonidae										
Bezzia sp.			19				9			3
Odonata										
Anisoptera										
Libellulidae										
Epicordulia regina		9								1
Gomphidae										
Gomphus cavillaris							9			1
Plecoptera										
Unid. instar sp. A			57							6
Ephemeroptera										
Hexageniidae										
Hexagenia limbata			38			18	36			10
Trichoptera										
Leptoceridae										
Oecetis sp.								9		1
Psychomyiidae										
Polycentropis sp.								9		1
Phylocentropus placidus								9		1

Table II-18 (Cont'd) Benthic macroinvertebrates collected during the winter survey for the A. B. Hopkins Generating Station on December 7 and 8, 1973.

Benthic Macroinvertebrates	Stations 1	2	3	10	11	7	9	12	13	Av no./m^2
Oligohaeta										
Pleisopora										
Naididae										
Unid. sp. A.			57					18		8
Tuhificidae										
Unid. sp. A.										
Prosopora									9	1
Lumbriculidae										
Lumbriculus inconstans		18	703				18			12
Lumbricidae										
Unid. sp. A.			19							2
Total density/station (no./m^2)	0	45	1596	342	247	846	666	1566	774	
Av no./m^2	676/m^2									

[a]Samples collected with a 9 x 9 inch Ponar Dredge.

[b]Samples collected in duplicate at stations 2, 7, 8, 9, and 10.

[c]Reported in no./m^2.

Table II-19 Diversity indices of the benthos samples collected during the winter survey for the A. B. Hopkins Generating Station during December 7 and 8, 1973.

Station	Habitat	Index
	Benthos Diversity Indices	
1	Power Plant Stream	0.0
2		1.33
3		1.59
7		.57
Total		1.51
9	Ochlockonee River	1.42
10		.35
11		.79
Total		1.11
12	Lake Talquin	1.40
13		1.40
Total		1.66

[a]Diversity indices were calculated with the Shannon-Weaver Formula (Base e).

Table II-20 Macroinvertebrate densities collected during the winter survey for the A. B. Hopkins Generating Station on December 7 and 8, 1973.

Station	Densities[a,b] / Habitat	Density Av no./m^2
1	Power Plant Effluent Stream	0
2		45
3		1596
7		846
Av no./m^2		622
9	Ochlockonee River	666
10		342
11		247
Av no./m^2		418
12	Lake Talquin	1566
13		774
Av no./m^2		1170
Total (*Av no./m^2)		676

[a]Samples collected with a 81 $inch^2$ Ponar Dredge, stained with rose bengal screened in a U.S. Standard #30 seive, separated and preserved in 5-10% formalin.

[b]Stations 1, 2, 3, & 7 were located in the power plant effluent stream, stations 9, 10, and 11 were located in the Ochlockonee River and stations 12 and 13 were located in Lake Talquin.

of stress tolerant invertebrates, Chironomous attenuatus and Lumbriculus inconstans were recorded with densities 437 and 703/m^2, respectively. This station also exhibited the highest total density with a value of 1,596 organisms/m^2.

Station 7, located in the Ochlockonee River at the mouth of the outfall stream was characterized by a three-foot depth muck bottom. Suspended detrital material was observed at Station 7 and at all river and reservoir sampling stations. Four benthic species were collected at this station. Chironomus attenuatus was the dominant midge at the density of 675 organisms/m^2. A low diversity index of 0.57 was calculated (Table II-19).

Stations 9, 10, and 11, located in the Ochlockonee River, represent deep water sites. The dominant organism was the midge, Chironomus attenuatus, with densities of 387, 304, 190 individuals/m^2 at Stations 9, 10, and 11, respectively. The introduced clam, Corbicula manilensis was collected at Stations 9, 10, and 11. The diversity indices at Stations 9, 10, and 11 were low, with values 1.42, 0.35, and 0.79, respectively.

Stations 12 and 13, located in the Lake Talquin reservoir, were characterized by detrital material suspended in the water and deposited in the bottom. Station 12 with a depth of 7 feet, was dominated by the midge larvae Tanytarsus, where density was 828 organisms/m^2. The dominant organism at Station 13 was the midge larvae, Chironomus attenuatus, with a diversity of 459 organisms/m^2. Station 12 exhibited the second highest total density with a value of 1,566/m^2. The diversity indices at Stations 12 and 13 were low, both with values of 1.40.

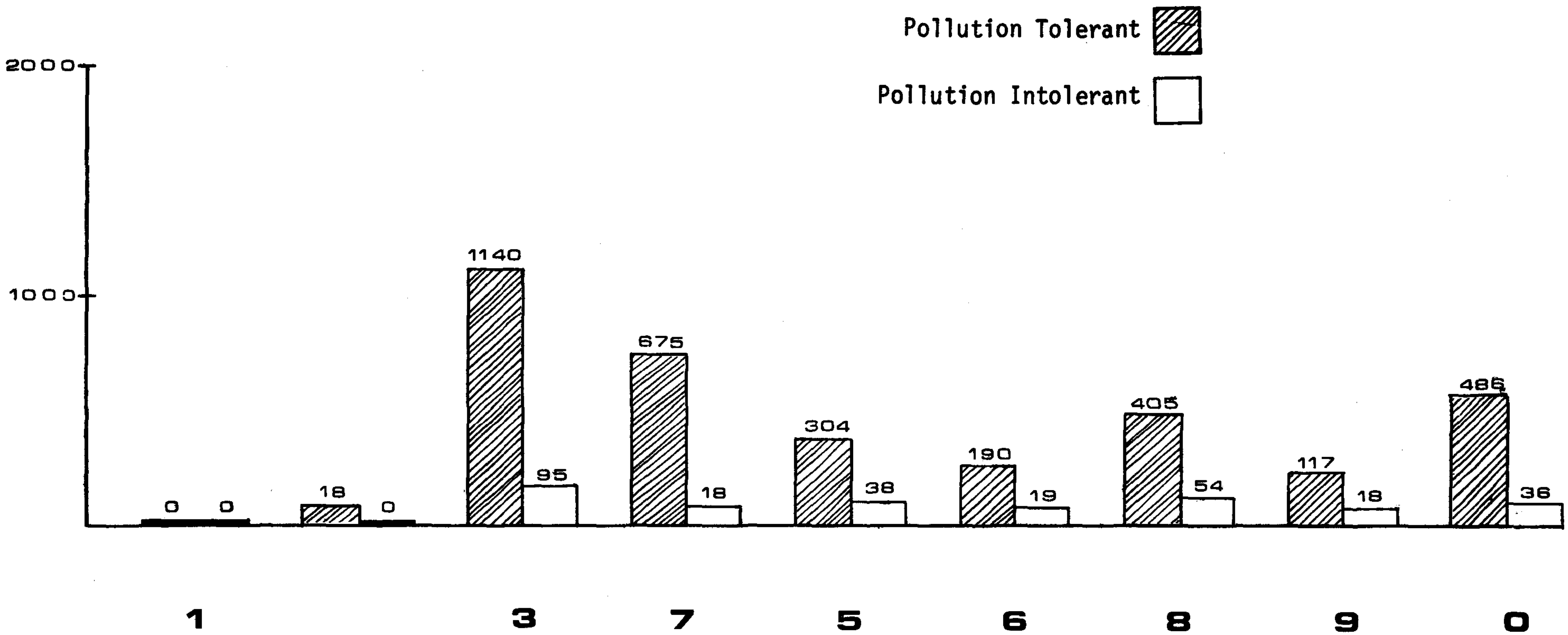
In a comparison of averages (Table II-19) Lake Talquin exhibited a benthic diversity of 1.66, followed by the power plant stream of 1.51 and the Ochlockonee River of a 1.11. Lake Talquin showed the greatest population density with a value of 1,170. The density in the power plant stream and Ochlockonee River were 622 and 418 organisms/m^2, respectively (Table II-20). The power plant stream, particularly Stations 3 and 7, showed the highest densities of stress tolerant organisms. The dominance of tolerant benthic organisms and low species diversity in the power plant stream indicates high stress, (Exhibit II-21).

(d) Baseline Data - Fish - No fish collections were made during the winter survey in the outfall stream. Size constraints limit its importance as a fishery. Lake Talquin was sampled in 1973 by the State Game and Freshwater Commission. These data are available as Study V., Lake Management and Research Annual Progress Report.

2.8 AMBIENT AIR QUALITY

No on-site monitoring of ambient air quality was undertaken. Determination of existing background levels for SO_2 and particulate matter would be difficult, since natural gas is presently used for fuel over 50 percent of the time of plant operation. Therefore, a "worst condition" would need to be monitored when the plant was burning only fuel oil.

In using predictive models for expected air quality, conservative assumptions were made concerning emission rates. Results of these models are presented in Section 5.4.



Densities /m^2 of pollution tolerant and intolerant macroinvertebrates collected during the survey for the A. B. Hopkins Generating Station on December 7 and 8, 1973.

EXHIBIT II-21

2.9 OTHER ENVIRONMENTAL FEATURES

During the period of biological sample collection (December 7-8, 1973), the Lake Talquin reservoir was undergoing a winter drawdown. These drawdowns are referenced in Study V. Lake Management and Research Annual Progress Report of the Game and Freshwater Fish Commission.

SECTION 3

<u>INCOMPLETE DOCUMENT</u>

PLEASE NOTE THAT ONE OR MORE PAGES WERE MISSING FROM THIS DOCUMENT AT THE TIME OF SCANNING.

SECTION 3 - THE PLANT

3.1 EXTERNAL APPEARANCE

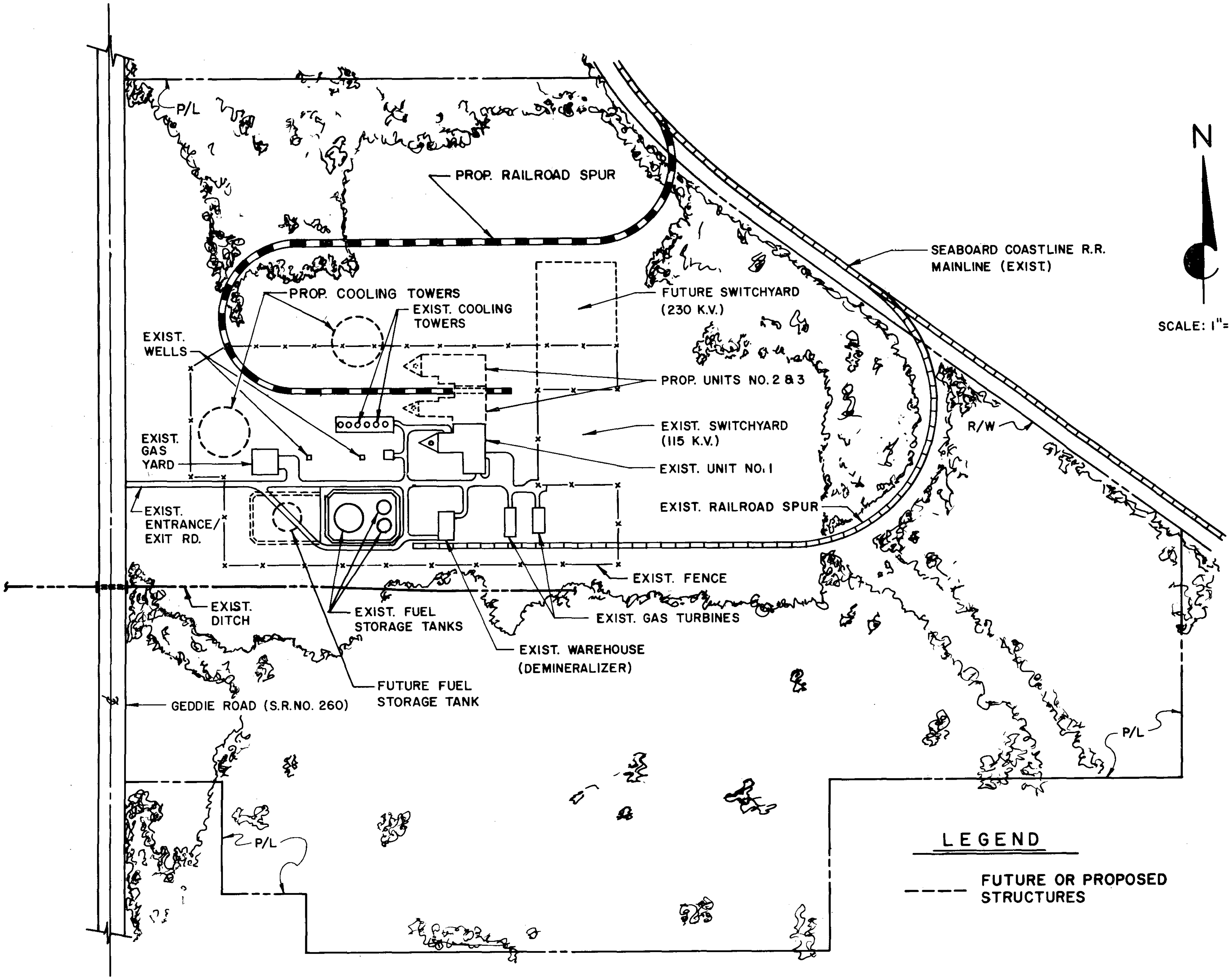
The generating facilities located at the Hopkins Station will occupy an area of approximately 35 acres within a total acreage of 231 acres owned by the City of Tallahassee. The plant area which is enclosed by security fencing is set back from State Road 260 approximately 400 feet, and has a finished plant grade of 135 feet above mean sea level.

The dominant features of the proposed plant will be three boiler stacks of 200, 250, and 300 feet height for Units 1, 2, and 3, respectively; cooling towers; and the elevated water storage tank. Other features will include boiler and turbine-generator buildings, fuel oil storage tanks and dykes, gas turbine buildings, transmission line, switchyard, and warehouse building. Plant layout is presented in Exhibit III-1.

The site is largely cleared with grass growing in cleared areas not occupied by plant structures, presenting an aesthetically pleasing appearance.

3.2 FUELS

At present, fuel contracts are held by the City of Tallahassee for the existing generating units at the Hopkins plant site for natural gas and No. 6 residual fuel oil with a typical sulfur content of 1.85 percent. It is planned that Unit 2 will have the capability of burning gas and fuel oil in combination, or fuel oil alone. This capability will possibly be incorporated in Unit 3 construction also, if the quantities of natural gas available at the site increase substantially by the time of Unit 3 construction. The dual-fuel capability is an economic consideration which also lends



PLANT LAYOUT
ARVAH B. HOPKINS GENERATING STATION

EXHIBIT III-1

flexibility to the power plant operation, with regards to maintaining pollutant emissions at required levels. This is due to the fact that the new units which will normally operate on low (0.75 percent) sulfur fuel oil, may burn fuel oil with higher (maximum 1.8 percent) sulfur content in combination with natural gas and remain in compliance with SO_2, NO_x, and particulate emission rates as established by Chapter 17-2 of the Florida Administrative Code.

3.2.1 Fuel Consumption

Table III-1 gives projected annual fuel consumption rates for Units 1, 2 and 3. Products of combustion are discussed in Section 3.7. Fuel consumption rates are based on the calorific values of the fuels given in subsection 3.2.2, and an expected normal operating load for each of the proposed units of 2.051×10^9 Btu/hr. The megawatt-hours generated is based on heat value of the fuel consumed and an approximate overall efficiency of 34 percent.

3.2.2 Fuel Analysis, Storage and Transportation

(a) Natural Gas - The following is an analysis of the natural gas as delivered via pipeline to the Hopkins plant site:

Ethane (CH_4)	94.35% by Volume
Methane (C_2H_6)	3.67% by Volume
Propane	0.62% by Volume
Nitrogen	0.39% by Volume
Carbon Dioxide	0.70% by Volume
I-Butane	0.11% by Volume
N-Butane	0.09% by Volume
I-Pentane	0.03% by Volume
N-Pentane	0.02% by Volume
Hexanes	0.02% by Volume
Total:	100.00% by Volume

Specific Gravity @ 60°F - 0.5904
Calorific Value 1,029 Btu/Ft^3

FUEL OIL	UNIT 1			UNITS 1 & 2			
YEAR	1974	1975	1976	1977	1978	1979	1980
CONSUMPTION (MILLIONS OF BARRELS)	0.106	0.225	0.225	1.071	1.289	1.332	1.476
THOUSANDS OF MEGAWATT-HOURS GENERATED	68	144	144	686	825	846	945
NATURAL GAS							
CONSUMPTION (MILLIONS OF FT.^{3})	4124	3549	3600	3754	3778	3802	3825
THOUSANDS OF MEGAWATT-HOURS GENERATED	433	373	378	394	397	399	402

FUEL OIL	U.1&2	UNITS 1,2 & 3					
YEAR	1981	1982	1983	1984	1985	1986	
CONSUMPTION (MILLIONS OF BARRELS)	1.608	2.868	2.868	3.096	3.318	4.589	
THOUSANDS OF MEGAWATT-HOURS GENERATED	1029	1835	1835	1982	2124	2937	
NATURAL GAS							
CONSUMPTION (MILLIONS OF FT^3)	3848	3998	4020	4043	4064	4085	
THOUSANDS OF MEGAWATT HOURS GENERATED	404	420	422	425	427	429	

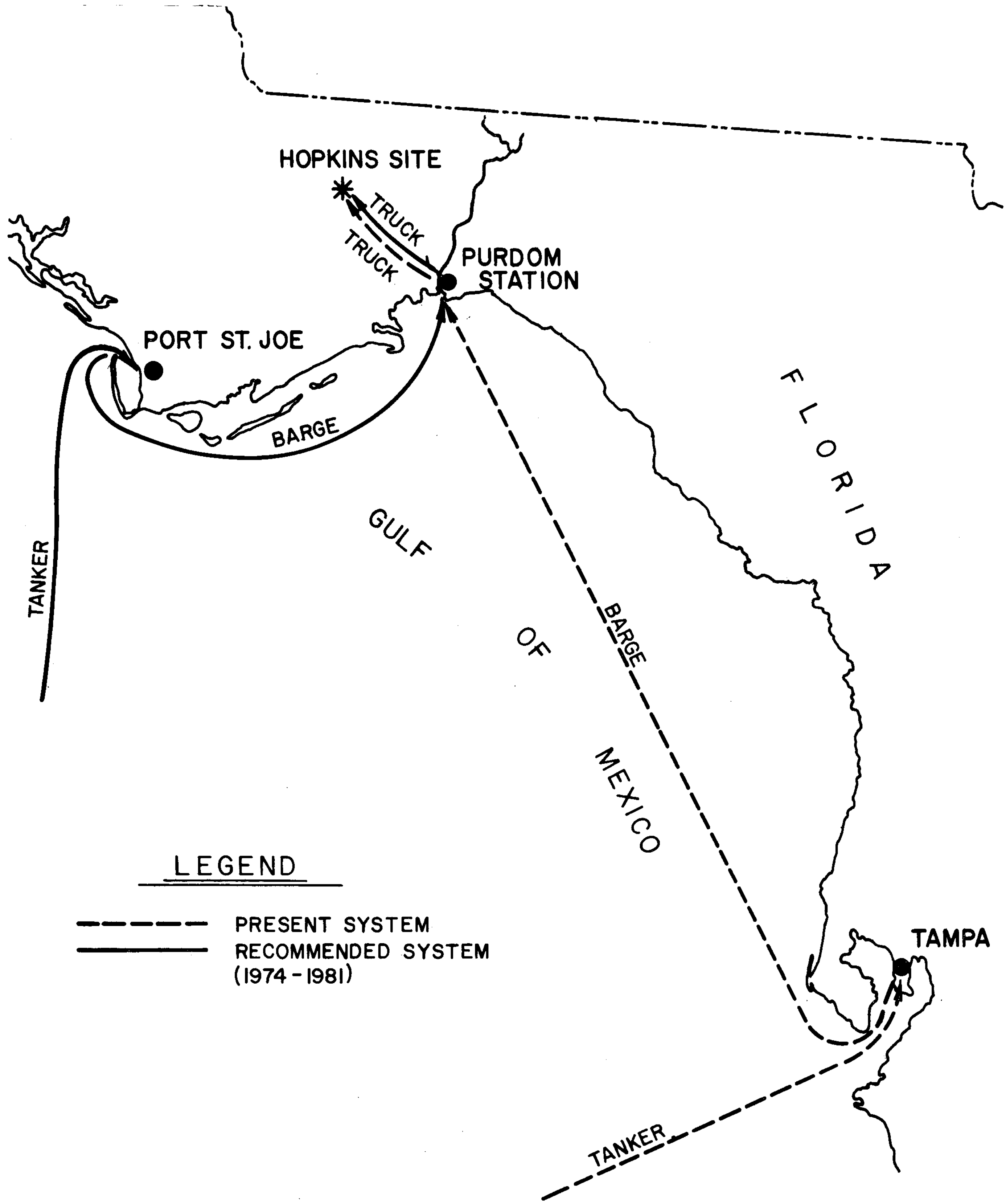
PROJECTED FUEL CONSUMPTION

TABLE III-1

The quantities of gas allotted to the Hopkins plant fluctuate a good deal over the period of a year. However, the availability of gas at periods of peak load (June - September) is greater than at periods of lesser loads (December - April), according to plant usage records. Thus, gas is available at times during periods of peak oil demand when it would be advantageous to utilize the dual-fuel capability and burn oil with higher sulfur content than normal.

The Sam O. Purdom Generating Station located at the mouth of the St. Marks River also receives a portion of the allotted gas, but is of second priority to the Hopkins plant due to the accessibility of the Purdom Station to oil barges. As may be seen in Table III-1, the quantities of gas predicted to be available to the Hopkins plant remain essentially unchanged through 1986. It is not planned to expand existing gas handling and storage facilities for Units 2 and 3.

(b) Fuel Oil - At present, No. 6 fuel oil is transported by tanker to the port of Tampa and subsequently barged to the Sam O. Purdom Generating Station at the mouth of the St. Marks River. See Exhibit III-2. Oil is delivered to the Hopkins Station via tank-trucks from the storage facilities at the Purdom Station. Storage capacity at the Purdom Station is currently 155,000 barrels (1 barrel = 42 gallons) which represents approximately 48 days of reserve for the Purdom Station. A 180,000 barrel tank will be installed at the Hopkins Station in 1976 to bring the storage capacity at the site to 235,000 barrels, including the 55,000 barrel storage for No. 6 oil which now exists. The storage tanks are enclosed by dykes to provide containment of any possible oil spill.



FUEL OIL TRANSPORTATION SYSTEMS

EXHIBIT III-2

Future plans for transportation of fuel oil have been examined in a study made by the Tallahassee Electric Power Production Department, "Long Range Fuel Oil Supply Report." The report concludes that the most economically feasible plan for oil transportation through 1981 would be to receive oil from tankers at Port St. Joe, Florida, located on the Gulf of Mexico, barge it to the Purdom Station via the Intracoastal Waterway, and continue transportation of oil to the Hopkins Station via tank-trucks. In order to receive oil from tankers at Port St. Joe, the City of Tallahassee would need to purchase or lease land for storage of the oil. However, barging oil from Port St. Joe as opposed to Tampa would represent a substantial savings, due to the shorter distance involved.

To meet the oil transportation need after 1981, several alternatives have been examined. Three plans which are presently economically comparable and suitable are presented in the City of Tallahassee report referenced above:

Plan A

(1) Continuation of tanker deliveries to Port St. Joe.

(2) Continuation of barge deliveries to the Purdom Station from Port St. Joe.

(3) Delivery of Hopkins Station requirement via pipeline between the Purdom Station and the Hopkins site.

(4) Future construction (possibly 1986 or later) of an offshore terminal facility near St. Marks for delivery of system's requirements to the Purdom Station via a submarine pipeline.

Plan B

(1) Continuation of tanker delivery to Port St. Joe.

(2) Delivery of Hopkins requirement via a pipeline from Port St. Joe to the Hopkins Station.

(3) Delivery of Purdom's requirement by barge from Port St. Joe or by truck from Hopkins Station.

Plan C

(1) Continuation of system utilized during the 1973-1981 period for the Hopkins and Purdom Stations.

(2) Selection of new power plant site for future expansion.

At the present time, it is felt that valid conclusions cannot be drawn on the relative feasibility of any of the three above plans due to the uncertainty of fuel oil availability and transportation.

No. 6 fuel oil presently being delivered to the Hopkins site has the following typical analysis:

Carbon	86.55% by Volume
Hydrogen	10.75% by Volume
Oxygen	0.30% by Volume
Nitrogen	0.40% by Volume
Sulfur	1.85% by Volume
Ash	0.15% by Volume
Total	100.00% by Volume
Free Moisture	0.2 %
Calorific Value	18,300 Btu/lb.
Viscosity	51 SSF @ 122°F
Specific Gravity 60/60	0.952

Fuel oil with the above analysis will be burned in Unit 2 or Unit 3 only if natural gas is available to burn in combination with the fuel oil in quantities sufficient to maintain the boiler stack emissions in compliance with state standards.

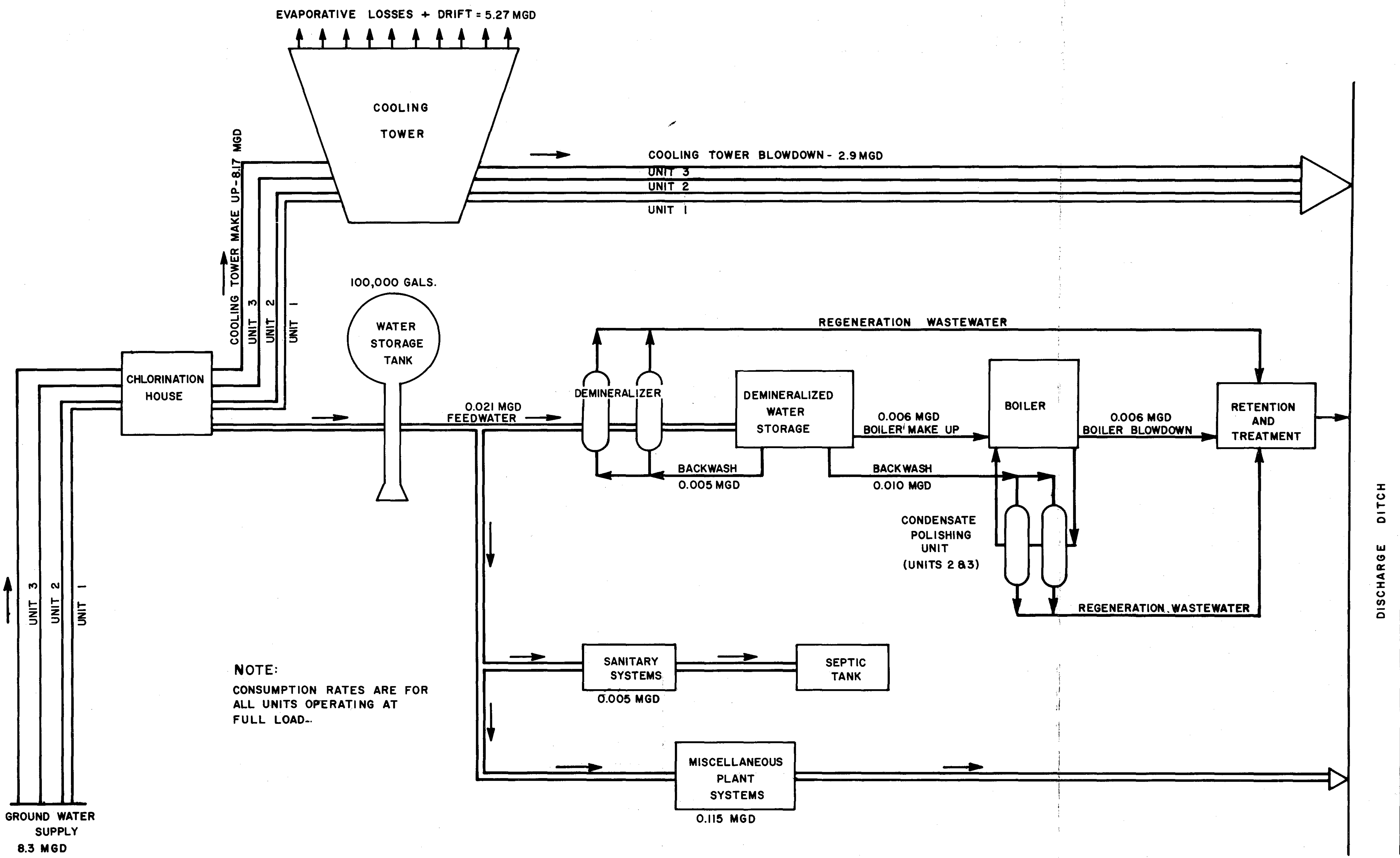
3.3 PLANT WATER USE

As discussed in Section 2.5, the present source of water at the Hopkins plant site is groundwater. Two wells of 1,500 gpm capacity each are currently being used for existing facilities, with a maximum 1.54 mgd being utilized at the plant.

Exhibit III-3 is a flow diagram for plant water usage. Quantitative tabulation of all existing and projected water usage rates are presented in Table III-2. The maximum and minimum values represent instantaneous flows in gallons per minute and daily flows in millions of gallons per day for conditions of maximum and minimum plant operating loads. Shutdown values represent consumption rates for periods in which the generating units are not operating.

3.3.1 Cooling System Demand

The majority (96 percent) of the total demand at the plant is required for make-up water in the cooling system. The mechanical draft, wet cooling towers require make-up to replace water lost to atmospheric evaporation and drift, and to maintain a stable concentration of total dissolved solids in the recirculating cooling water. The make-up water requirements for the cooling towers will vary due to the variation of the heat dissipation requirement of the condenser. Thus, minimum load on the generating units will establish minimum flow requirements in the cooling



PLANT WATER USE FLOW DIAGRAM

EXHIBIT III-3

	UNITS	MAXIMUM		MINIMUM		SHUTDOWN	
		GPM	MGD	GPM	MGD	GPM	MGD
COOLING SYSTEM A. DRIFT	1	112	0.16	112	0.16	0	0
	1 & 2	184	.10 0.26	184	0.26	0	0
	1,2 & 3	256	.11 0.37	256	0.37	0	0
B. EVAPORATION	1	794	0.79	117	0.31	0	0
	1 & 2	2851	2.06 2.85	636	1.11	0	0
	1,2 & 3	4908	2.05 4.90	1095	1.92	0	0
C. BLOWDOWN	1	336	0.47	75	0.23	0	0
	1 & 2	1206	1.69 1.22	269	0.82	0	0
	1,2 & 3	2076	2.9 1.21	464	1.42	0	0
D. TOTAL MAKE-UP	1	1242	1.42	364	0.70	0	0
	1 & 2	4242	3.38 4.80	1089	2.19	0	0
	1,2 & 3	7242	3.37 8.17	1815	3.71	0	0
DEMINERALIZER A. NORMAL	1	50	0.009	0	0.0014	0	0
	1 & 2	50	0.014 .005	0	0.0096	0	0
	1,2 & 3	75	0.021 .007	0	0.017	0	0
B. REGENERATION	1	0	0.003	0	0	0	0.003
	1 & 2	0	0.003	0	0	0	0.003
	1,2 & 3	0	0.005	0	0	0	0.005
SANITARY SYSTEMS	1	50	0.003	0	0.003	50	0.003
	1 & 2	75	.001 0.004	0	0.004	75	0.004
	1,2 & 3	100	.001 0.005	0	0.005	100	0.005
MISCELLANEOUS	1	80	0.115	30	0.06	50	0.13
	1 & 2	80	0.115	30	0.06	100	0.26
	1,2 & 3	80	0.115	30	0.06	150	0.39
TOTAL	1	1422	1.54	394	0.76	100	0.136
	1 & 2	4450	3.4 4.94	1119	2.27	175	0.27
	1,2 & 3	7500	3.36 8.30	1845	3.80	250	0.40

Total Unit 2 only 3.4 mgd
Total Unit 3 " 3.36 mgd

WATER USAGE RATES

TABLE III-2

system. Values presented as minimum flows in Table III-2 were established from plant records of Unit 1 operation. For purposes of projecting cooling system water usage rates, historical load variations for Unit 1 were used as the basis for future load variations.

Flows due to cooling tower drift are represented as being constant flows for both minimum and maximum loads because the drift is generated by a mechanical process, rather than an evaporative process which would vary with the operating load.

3.3.2 Demineralizer

The Hopkins Station currently is using a mixed-bed ion exchange unit with a 50 gpm capacity. The unit removes dissolved solids from the supply water to maintain a high purity water supply for boiler make-up water and for regeneration of the ion exchange resins. The boilers for Units 2 and 3 will be equipped with condensate polishing units which are parallel-bed ion exchange units. These polishing units will purify a portion of the boiler feedwater, reducing the need for chemical treatment of the boiler water and reducing the quantity needed for boiler make-up water.

The current demineralizer unit has been determined to be of sufficient capacity to produce the deionized water required for Units 1 and 2. However, it is anticipated that Unit 3 will require additional demineralizer capacity.

The maximum demand of the demineralizer will occur when the unit operates at capacity. The demineralizer feedwater is fed from the elevated water storage tank (see Exhibit III-3) and the resulting deionized water is stored in tanks. The deionized water is then used as needed for make-up water in the boilers and also for backwash during the regeneration of the demineralizer and the condensate polishing units.

3.3.3 Sanitary Systems

The flows projected for sanitary systems are based on existing water consumption at the plant and projections of loads attributable to additional personnel needed for Units 2 and 3.

3.3.4 Miscellaneous

The miscellaneous category of water consumption rates includes flows which are required for various mechanical systems associated with the operation and maintenance of the generating units, including the following:

(a) Fan bearing cooling water,

(b) Air compressor after-cooler,

(c) Sample coolers,

(d) Hydrogen coolers, and

(e) Turbine bearing oil cooler.

These cooling water requirements represent a water consumption rate for Unit 1, in that the condenser cooling systems and auxiliary cooling systems are essentially separate. However, for the proposed Units 2 and 3, a closed-loop recirculating cooling system will be incorporated for the auxiliary cooling requirements, which will eliminate the need for additional cooling water. This type system is reflected in the tabulation of "miscellaneous" flows in Table III-2, which indicates no additional water usage for Units 2 and 3, except during plant shutdown periods.

3.3.5 Plant Shutdown Flows

During periods of plant shutdown, it is expected that the only water demands will be from the sanitary systems and miscellaneous flows associated with maintenance of the plant systems, such as fan and air heater wash water. However, the demineralizer may also be used during periods of plant shutdown to increase the plant's supply of deionized water or to regenerate ion exchange resins.

3.3.6 Emergency Shutdown Periods

In the event of well pump failure, standby pumps will be started to maintain the plant water supply. The elevated water storage tank, which has a capacity of 100,000 gallons, may also be used as a short-range water supply.

3.3.7 Water Analysis

A typical analysis of the water which is available from wells at the site is as follows:

Calcium, as $CaCO_3$ (ppm)	74
Magnesium, as $CaCO_3$ (ppm)	52
Total Hardness, as $CaCO_3$ (ppm)	126
Methyl Orange Alkalinity as $CaCO_3$ (ppm)	86
Sulfate, as SO_4 (ppm)	7
Chloride, as Cl (ppm)	12
Silica, as SiO_2 (ppm)	12
pH	7.9
Specific Conductance, Micromhos	240
Temperature	69°F

3.4 HEAT DISSIPATION SYSTEM

Excess thermal energy from the turbine-generators will be dissipated in a closed-loop system, due to the limited water supply at the site. The heat dissipation system for the existing Unit 1 is a mechanical draft, wet cooling tower, using groundwater for make-up. The proposed cooling systems for Units 2 and 3 will also be mechanical draft, wet cooling towers using groundwater for make-up in Unit 2 and possibly Unit 3.

The steam condensers for Units 2 and 3 will have a design temperature rise of 17°-20°F and the design circulating cooling water flow rate will be 145,000 gallons per minute for each unit. Make-up water requirements for each of the proposed units will be 3,000 gallons per minute for a total additional demand of 6,000 gallons per minute.

3.4.1 Cooling Tower Design

The proposed cooling towers will be multi-cell towers, with either a circular or a rectilinear configuration. The multi-cell tower is desirable over a single fan tower in terms of system reliability, which is critical at the Hopkins site due to limited water supply.

Each cooling tower is designed for a maximum wet-bulb temperature of 79°F. This criterion is based on historical wet-bulb temperature variation recorded at the Tallahassee Municipal Airport. The cooling towers will be designed to cool water to a 10°F approach of the design value of the wet-bulb temperature.

The rate of heat dissipation by each of the proposed towers will be approximately 1.33 x 10^9 Btu/hr and as a result of the evaporative heat dissipation process, air discharged from the towers will be warm and nearly saturated, constituting a thermal plume. The characteristics of the plume with regards to fogging potential are examined in Section 5.4.3.

Water consumption rates for the proposed cooling towers are presented in Table III-3. These rates are based on the following factors, where Q is the circulating water flow rate:

Drift	0.0005 Q
Evaporative Losses	0.014 Q
Blowdown	0.006 Q
Total (Make-up)	0.020 Q

Does not agree with Table III-2 p 3-8

These flow rates assume maximum operating load, and four cycles of concentration maintained in the cooling tower. The recommended range of operation for the cooling towers, based on the existing system, is four to six cycles of concentration.

3.4.2 Circulating Water Chemical Treatment

The groundwater used for make-up water supply creates serious scaling problems due to the hardness of the water. A typical analysis of water from the existing wells is presented in Section 3.3. In order to reduce scale in the tower, the circulating water is treated as follows:

(a) An organic phosphate based sequestrant ($N(CH_2PO_3H_2)_3$), designed for use in recirculating water systems to prevent the deposition of iron and calcium, is fed continuously. The recommended range of concentration for the additive is 3-5 ppm, maintained at 5 ppm as complex phosphate.

(b) Sulfuric acid (H_2SO_4) at 70° F and 66° Be is applied daily to maintain the pH of the circulating water at 8.0-8.5. The purpose of the pH adjustment is to convert calcium bicarbonate ($Ca(HCO_3)_2$) to calcium sulfate ($CaSO_4$) which is more stable and soluble, thus reducing scale formation.

In addition to scale retarding additives, chlorine (Cl_2) is fed automatically to control algal growth in the cooling tower. Chlorine is fed at 0.35-0.5 ppm to tower make-up water and when needed, the circulating water is "shock treated" to 0.75-1.0 ppm.

3.4.3 Monitoring

Cooling tower make-up flows and blowdown flows are monitored continuously for the existing unit. In addition, water quality parameters are measured daily with grab samples from cooling tower blowdown. The samples are analyzed in the plant laboratory for the following parameters:

Specific Conductance	Methyl Orange Alkalinity
pH	Complex Phosphate
Chlorides	Hardness
Phenolphthalein Alkalinity	Sulfates

The make-up water chloride concentration is also measured. This reading is used to determine the actual cycles of concentration at which the cooling tower is operating, where

$$\text{Cycles of Concentration} = \frac{\text{Chloride Level in Blowdown}}{\text{Chloride Level in Make-up}}$$

The value for cycles of concentration represents the effective number of cycles which a unit of make-up water will make through the cooling system before being replaced with additional make-up. Thus, as the number of cycles increases, the make-up water and blowdown from the cooling tower decreases. The limiting factor is the concentration of dissolved solids in the circulating cooling tower, which are the source of scale deposition. The proposed cooling towers will have a recommended range of 4-6 cycles of concentration.

3.4.4 Alternate Heat Dissipation Systems

Examination of alternatives to mechanical draft, wet cooling towers indicates that at present the proposed system is the best system with regards to economic considerations and environmental impact.

(a) Once-through Cooling - Groundwater was not considered for once-through cooling due to the large flows (290,000 gpm) involved, and average annual low flow in the Ochlockonee River (45 cfs) would not be sufficient to supply the 650 cfs requirements for Units 2 and 3. Therefore, the only alternate source of water would be Lake Talquin. Pumping water from Lake Talquin was not considered to be a feasible alternative to cooling towers due to the distance of the lake from the plant site involving high initial cost and high pumping cost. In addition, the degradation to aquatic communities and Class III waters associated with once-through cooling would probably create a good deal of public and governmental opposition.

(b) Cooling Ponds - Cooling ponds were not considered for a cooling system due to the extensive land procurement (1-3 acres/MW) which would be required. At least 500 acres would have to be acquired and transformed from a terrestrial to an aquatic environment. Cooling ponds provided with spray modules would require considerably less land area than ponds without spray modules, but the high rate of drift or misting would make the make-up water requirements higher than with cooling towers.

(c) Other Types of Cooling Towers

(1) Natural Draft Cooling Towers - Capital costs for natural draft cooling towers are approximately three times the cost of a mechanical draft tower and more land area is required for natural draft towers. Natural draft cooling towers are generally used only in plants greater than 500 MW capacity

(2) Mechanical Draft Dry Cooling Towers - Although water consumption on this type of tower will be almost negligible, power requirements for operating dry towers are approximately four times the requirements for wet towers, for the same generating capacity. Dry cooling towers can typically cool circulating water only to 30°-35° F above the dry-bulb temperature, whereas wet towers can typically cool circulating water to within 6°-10° F of the wet-bulb temperature. Thus, system efficiency would be much less with a dry cooling tower than with a wet cooling tower, increasing fuel requirements.

(3) Wet-Dry Cooling Towers - This type of cooling tower utilizes a heat exchanger, as used in dry cooling towers, in addition to a wet cooling tower, which further cools the water from the heat exchanger by evaporation. These towers are used principally where cooling tower plume abatement is necessary due to the fact that the water consumption rate is less than with a wet cooling tower. However,

the wet-dry tower has the same disadvantage as the dry tower, in that the efficiency of the cooling system is lower than with use of a wet tower, and consequently, fuel requirements are higher. In addition, power requirements of a wet-dry tower are greater than requirements for a wet tower, and blowdown from a wet-dry tower will constitute a greater themal problem than blowdown from a wet tower, due to lower cooling efficiency.

(4) Mechanical Draft Wet Cooling Towers With Surface Water Make-up - Due to the problems which arise from withdrawing large amounts of water from the aquifer (Section 2.5), it is worthwhile to examine the possibility of using surface water for make-up water. The nearest source of surface water which would be available in quantities as needed for cooling tower demand would be the Ochlockonee River.

Subsection 2.5.2 presents the feasibility of withdrawing water from the aquifer at the rates required for plant operation. It appears feasible that the present site area will allow withdrawal of groundwater sufficient for the water consumption rate projected for Units 1 and 2, without deleterious effects. However, to provide additional water needed for Unit 3, the present acreage of the site does not appear sufficient for well placement. Thus, to provide water after Unit 2, two alternatives are to be considered:

Alternate 1

Purchase additional land to accommodate drilling of additional high capacity wells.

Alternate 2

Install a pipeline and pumping facilities to pump water from the Ochlockonee River or Lake Talquin. This alternate may also require additional water treatment facilities at the site, and attendant degradation to aquatic communities must also be considered.

3.5 CHEMICAL AND BIOCIDE WASTES

The expected discharge from the Hopkins site will consist of cooling tower blowdown, boiler blowdown, ion exchange regeneration wastes, and miscellaneous flows associated with various internal plant systems. Table III-3 gives a breakdown of the flow composition with respect to the different discharge sources:

TABLE III-3

PLANT DISCHARGE VOLUME COMPOSITION

Source	Unit 1	Units 1 and 2	Units 1, 2, and 3
Cooling Tower Blowdown	80%	90%	94%
Boiler Blowdown	1.5%	0.4%	0.3%
Ion Exchange Regeneration Wastes	0.5%	0.5%	0.4%
Miscellaneous Plant Systems	18%	9%	5.3%

The discharge composition presented represents a period in which the ion exchange resins are being regenerated, which will occur approximately once a week. For periods when no generation occurs, the cooling tower blowdown will comprise a larger percentage of the total discharge.

3.5.1 Waste Treatment

It is proposed that the boiler blowdown and the ion exchange resin regeneration wastes be collected and retained to adjust pH and temperature. Subsequent to treatment, these wastes will be discharged into the plant discharge ditch.

The discharge from the treatment facility will be high in dissolved solids, but it is expected that the flow, which will comprise approximately 1 percent of the total flow, will be diluted to a great extent by cooling tower blowdown. It is proposed that cooling tower blowdown and the flows designated as miscellaneous plant system flows be discharged without treatment, with the exception of intermittent flows resulting from equipment wash.

3.5.2 Cooling Tower Blowdown Discharge

The chemical treatment of the circulating cooling waters is described in Subsection 3.4.3. Chemical analysis of the blowdown is presented below:

Total Hardness, as $CaCO_3$ (ppm)	360
Calcium, as $CaCO_3$ (ppm)	250
Magnesium, as $CaCO_3$ (ppm)	110
Phenolphthalein Alkalinity, as $CaCO_3$ (ppm)	10
Methyl Orange Alkalinity, as $CaCO_3$ (ppm)	170
Sulfate, as SO_4 (ppm)	240
Chloride (ppm)	48
pH	8.3
Specific Conductance, Micromhos	550
Complex Phosphate, as P_2O_5 (ppm)	5

Assessment of the impact of the plant discharge on aquatic communities in the receiving body of water is presented in Section 5.1. For purposes of the assessment, the chlorine residual which is maintained in the tower make-up water is assumed to be reduced to negligible levels at the point of discharge into the Ochlockonee River, due to time-related chlorine decay.

3.5.3 Boiler Blowdown

The majority of the discharge from boiler blowdown will be attributable to the Unit 1. This is due to the fact that the design of Units 2 and 3 boilers will incorporate condensate polishing units, which make the boiler blowdown very small.

The condensate polishing units will be parallel-bed ion exchange units which will receive approximately 25 percent of the condensate flow from the condenser. This portion of the condensate will be "polished" to a very high purity by the ion exchange resins and fed into the boiler together with the untreated condensate. The 25 percent very pure condensate will act to dilute any dissolved solids in the total amount of condensate, thus maintaining the boiler feed water at a high level of purity. This condensate treatment will reduce the need for chemical treatment and virtually eliminate boiler blowdown for Units 2 and 3. During periods of regeneration of the ion exchange resins of the polishing units, the condensate will continue to circulate untreated until the polishing unit is completely regenerated. The backwash from the regeneration process will be treated to adjust pH.

Unit 1 incorporates chemical treatment of boiler feedwater to prevent boilerscale formation from dissolved solids in the feedwater. This process requires a measure of boiler blowdown to maintain a safe level of dissolved solids, and the blowdown will contain concentrations of chemical additives. These chemical additives are as follows:

Additive	Concentration
35% Solution Hydrazine (H_2NNH_2)	0.1 ppm
5% Carboxymethylcellulose, 3% Sodium Sulfonate, 1% Caustic Soda, and 0.5% Polyoxy ethylene glycol	2 ppm
40% Morpholine (Diethylene Imidoxide)	0.14 ppm
95.5% Sodium Sulfite, 0.5% Cobalt Chloride	0.185 ppm
Sodium Phosphate	0.12 ppm

The approximate volume of the boiler blowdown for Unit 1 is normally 5,600 gallons per day. When the blowdown for all units is discharged subsequent to being treated, it will comprise approximately 0.4 percent of the total discharge. It is anticipated that the dilution effect of the cooling tower blowdown will decrease the concentrations of the chemical additives resulting from the boiler blowdown to nondetectable levels.

3.5.4 Ion Exchange Regeneration Wastes

Backwash of the ion exchange resins used in the demineralizer and the condensate polishing units will result in discharges with pH varying from low values to high values. This pH variation results from feeding sulfuric acid and sodium hydroxide during the regeneration cycle.

The total volume of the backwash for the existing demineralizer for one regeneration cycle is approximately 3,000 gallons. Regeneration will occur as needed, and normally occurs once a week for Unit 1. Increased demand for deionized water for Units 2 and 3 will make it necessary to regenerate the demineralizer more frequently. It is estimated that the condensate polishing units will need regeneration about once a week.

In addition to a varying pH, the regeneration wastes will have a high concentration of dissolved solids, for essentially all of the solids removed by the resins from the deionized water will be removed from the resins by the backwash.

3.5.5 Discharges from Miscellaneous Plant Systems

Wash water from fan and air heater wash will be generated approximately twice a year. This waste will contain suspended solids and will be routed to a treatment facility to remove the suspended solids and adjust the pH prior to discharge.

3.6 AIR EMISSIONS

Major sources of airborne pollutants associated with the proposed Units 2 and 3 will include boiler stack effluents and cooling tower drift.

3.6.1 Stack Effluents

It is anticipated that Units 2 and 3 will operate at all times within the limits of emission established in Chapter 17-2.04 of the Florida Administrative Code. As discussed in Section 3.2, the new units will normally operate on 0.75 percent sulfur fuel oil, with the capability of burning higher sulfur (1.8 percent maximum) oil in combination with natural gas.

The steam generating boiler for Unit 2 has been purchased and it is assumed for the purposes of this study that Unit 3 boiler construction will be identical to Unit 2. Table III-4 presents relative quantities of fuel oil and natural gas that may be burned in Units 2 and 3 to remain in compliance with emission standards for new fossil fueled steam generators.

TABLE III-4

FUEL COMPOSITION
(Oil + Gas = 100 Percent)

	Oil	Natural Gas
0.75% Sulfur Oil	100%	0%
1.0 % Sulfur Oil	73%	27%
1.5 % Sulfur Oil	49%	51%
1.8 % Sulfur Oil	41%	59%

(a) SO_2 Emission Level - For any combination fuel listed in Table III-4, the SO_2 emission level will be 0.8/lb/MBTU. The relative quantities were derived using the following equation:

(A calorific value of 18,300 Btu/lb was assumed)

$$\frac{0.8 \text{ Lb } SO_2}{\text{MBTU}} \div \frac{(1 \times 10^6 \text{ Btu})}{18,300 \text{ Btu/Lb}} \times (\text{Sulfur Content}) \times 2 = \%\text{Oil Allowable}$$

(b) NO_2 Emission Level - Design specifications for Unit 2 boiler, specify that boiler construction shall limit the NO_x production to 227 ppm of the boiler fuel gas. Therefore, on a basis of flue required for production of 10^6 Btu:

1) Gas $\frac{(10^6 \text{ Btu})}{1,030 \text{ Btu/Ft}^3} = 970.8 \text{ Ft}^3\text{/MBTU}$

Combustion of natural gas produces flue gas at the rate of 23.88 $\frac{\text{Ft}^3 \text{ Flue Gas}}{\text{Ft}^3 \text{ Gas}}$ @ 650°F.

Thus, $(970.8 \frac{Ft^3\ Gas}{MBTU}) \times (23.88 \frac{Ft^3\ Flue\ Gas}{Ft^3\ Gas}) \times (0.000227) = 5.26 \frac{Ft^3\ NO_2}{MBTU}$

$(5.26\ Ft^3\ NO_2) \times (0.057 \frac{Lb}{Ft^3}) = 0.299 \frac{Lb\ NO_2}{MBTU}$

2) Oil $\frac{10^6\ Btu}{18{,}300\ Btu/lb} = 54.6 \frac{Lb}{MBTU}$

Combustion of fuel oil produces flue gas at the rate of approximately 388 $\frac{Ft^3}{Lb}$ @ 600°F.

$(54.6 \frac{Lb}{MBTU}) \times (388 \frac{Ft^3}{Lb}) \times (0.000227) \times (0.06 \frac{Lb\ NO_2}{Ft^3} = 0.289 \frac{Lb\ NO_2}{MBTU}$

These calculations indicate that any combination of gas and oil will maintain NO_2 emission levels below the 0.3 $\frac{Lb}{MBTU}$ limit.

(c) Particulate Matter - Low ash fuel oil will be burned in the proposed units to insure compliance with the 0.1 $\frac{Lb}{MBTU}$ limit. For any combination fuel, particulate emission levels will necessarily be lower than levels resulting from burning fuel oil alone, as combustion of natural gas produces negligible values of particulate emission.

(d) Boiler stack construction will determine the dispersion characteristics and resultant ground level concentrations of pollutants. The predicted dispersion characteristics are presented in Section 5.4 Proposed stack design characteristics are listed below.

	Unit 2	Unit 3
Stack Height	250 Feet	300 Feet
Exit Diameter	15 Feet	15 Feet
Exist Temperature	275 °F	275 °F
Maximum Stack Gas Velocity	60 Ft/Sec	60 Ft/Sec
Average Stack Gas Velocity	55 Ft/Sec	55 Ft/Sec
Stack Gas Flow Rate at 100% Load	625,000 ACFM	625,000 ACFM

3.6.2 Cooling Tower Drift

Drift from a mechanical draft wet cooling tower consists of small droplets (typically 0.01-inch in diameter) of water which are entrained in the air stream through the cooling tower. The proposed cooling towers are designed to limit the drift rate to 0.05 percent of the total circulating water rate, or 72.5 gpm for each cooling tower.

The cooling tower drift for the proposed cooling towers will have the same chemical characteristics as the water circulating in the tower (see Section 3.4). However, the present major concern with drift from the standpoint of environmental impact is from increased salt concentration levels in the area surrounding the cooling tower. The cooling water which comprises the drift will have a chloride (Cl^-) content of approximately 50 ppm, based on operation of the existing cooling tower. Effects of the cooling tower drift on terrestrial communities are assessed in Section 2.7.

3.7 SANITARY AND OTHER WASTE SYSTEMS

3.7.1 Sanitary and Chemical Laboratory Waste

The sanitary waste from the proposed additions to the Arvah B. Hopkins Generating Station will be discharged to a 2,500 gallon septic tank system. The effluent from the septic tank will be introduced to the subsoils by way of an absorption field. As the groundwater supplies in this area are derived primarily from the Floridan aquifer, it is not believed that the effect from the means of treatment will be harmful.

The waste resulting from water testing in the generating station laboratory will be discharged to the same septic tank as the sanitary waste. The tests run and their frequency are listed in Table III-5. The relatively small amounts of chemicals used in these tests will have very little effect upon the operation of the septic tank system because of the large amount of dilution that occurs before these chemicals reach the septic tank itself.

TABLE III-5

LABORATORY WATER ANALYSIS

Test Run	Frequency
Sulfite	Daily
Phenolphthalein Alkalinity	Daily
Chloride	Daily
Conductivity (corrected)	Daily
Methyl Orange Alkalinity	Daily
Hardness	Daily
Silica	Daily
Chlorine	Daily
Hydrazine	Every Two Days
Free Mineral Acids	Monthly
Sulfide	Monthly
Calcium	Monthly
Iron	Monthly
Ammonia	Monthly
Copper	Monthly
Carbon Dioxide	Monthly

3.7.2 Solid Waste

The addition of Units 2 and 3 will result in the production of 82.5 and 100.5 pounds/day, respectively, of domestic solid waste. This solid waste will be disposed of at a local sanitary landfill site.

3.8 ASSOCIATED TRANSMISSION FACILITIES

At present, a 115 Kv transmission system originates at the Hopkins Station for distribution of the existing generating capacity. An additional 230 Kv system is currently in the design phase with completion schedule in 1976. The purpose of the planned 230 Kv system is to provide a tie-in to the distribution system of Florida Power Corporation at Crawfordville, in Wakulla County. This tie-in was planned as the result of recommendations of a study made for the City of Tallahassee by R. W. Beck and Associates, "Long-Range Power Supply Report."

With the installation of the 230 Kv system, the City of Tallahassee will purchase power when needed from FPC, until Unit 2 commences operation, at which time power may be sold to FPC. Thus, for the purposes of this study, the new 230 Kv system will be considered as exsiting transmission facilities, with regard to Units 2 and 3.

The only new transmission lines which will be considered to be associated with the proposed units are the lines which will transmit power from the generators to the switchyard located on the site. The environmental impact of these transmission lines is considered negligible for the purposes of this application.

SECTION 4

SECTION 4 - ENVIRONMENTAL EFFECTS OF PLANT CONSTRUCTION

4.1 LAND CLEARING

The proposed construction would alter approximately 15 percent of the entire site of 231 acres. The vegetation that will be cleared from the plant site during proposed construction will be grass cover and scrub vegetation, as the site was cleared of trees during the construction of the existing plant. At present, the plant site is clear of large stands of trees with the exception of trees around the property line.

The construction at the plant site should have little or no impact on the resources of the area. The construction lay-down areas will be in presently cleared areas and removal of present low cropped vegetation will be kept to a minimum.

At present, the site area is served by existing paved roads and rail. However, it is planned to add an additional length to rail spur to handle large components to the proposed plant site area. With the construction of the rail, a minimum of clearing and grubbing will be needed to perform the construction activity.

4.2 WATER USE DURING CONSTRUCTION

During the construction process, water would be supplied from existing wells for potable purposes. Large volumes of water that will be required for concrete and related activities will be used at the concrete batch plants and be delivered premixed to the plant site area by truck.

Water for compaction of the rail spur bed can be obtained from the plant drainage ditch. Water required for purging and testing of piping and components will be used from existing water storage facilities and wells at the plant site. Discharge of these wastes will be via natural drainage system at the plant. Dewatering effluent from plant construction will be discharged into a natural drainage course that exists at the site area. Due to the vegetation cover (grasses) erosion and siltation is expected to be kept at a minimum impact to the surrounding area.

4.3 WASTE GENERATION AND DISPOSAL ASSOCIATED WITH CONSTRUCTION

Waste generated during plant construction will be handled in accordance with established policies of Leon County and the State of Florida Health Department. Sanitary wastes will be collected in self-contained toilet units, pumped, and removed to designated areas in the Leon County area.

Construction waste generated during the construction process will be trucked to a designated landfill area, and no burying of metal or wood products will be permitted during or after the construction process.

In the event that burning of debris is required, such burning will be under controlled conditions, dictated by policies of the Department of Pollution Control and the Leon County Fire Marshall. Care will be taken to prevent brush and forest fires. Liquid waste such as cleaning chemicals, fuels, lubricants, and bitumens will be deposited and discharged into tanks to await subsequent removal from the plant site to designated areas.

4.4 EFFECTS ON AIR QUALITY DURING CONSTRUCTION

Care will be taken during the construction process to reduce dust during dry weather. Bare areas will be watered to reduce dust in heavily trafficed areas. At present, the site is served by paved roads to the immediate plant area. For hauling of dirt fill or compaction material, vehicle covers will be used along with watering of material during dry periods to prevent spillage and dust enroute from the borrow area to the site.

Material required for fill other than material available from the excavation will be from an approved borrow area. Equipment to be used during the construction process will be properly maintained to reduce noise levels and air pollution as much as applicable.

4.5 NOISE LEVELS DURING CONSTRUCTION

An ambient noise survey was conducted at the plant site January 23, 1974. The purpose of this survey was to measure the existing ambient noise levels at the property lines of the plant site in order to predict the future noise levels during the time of construction for the plant addition.

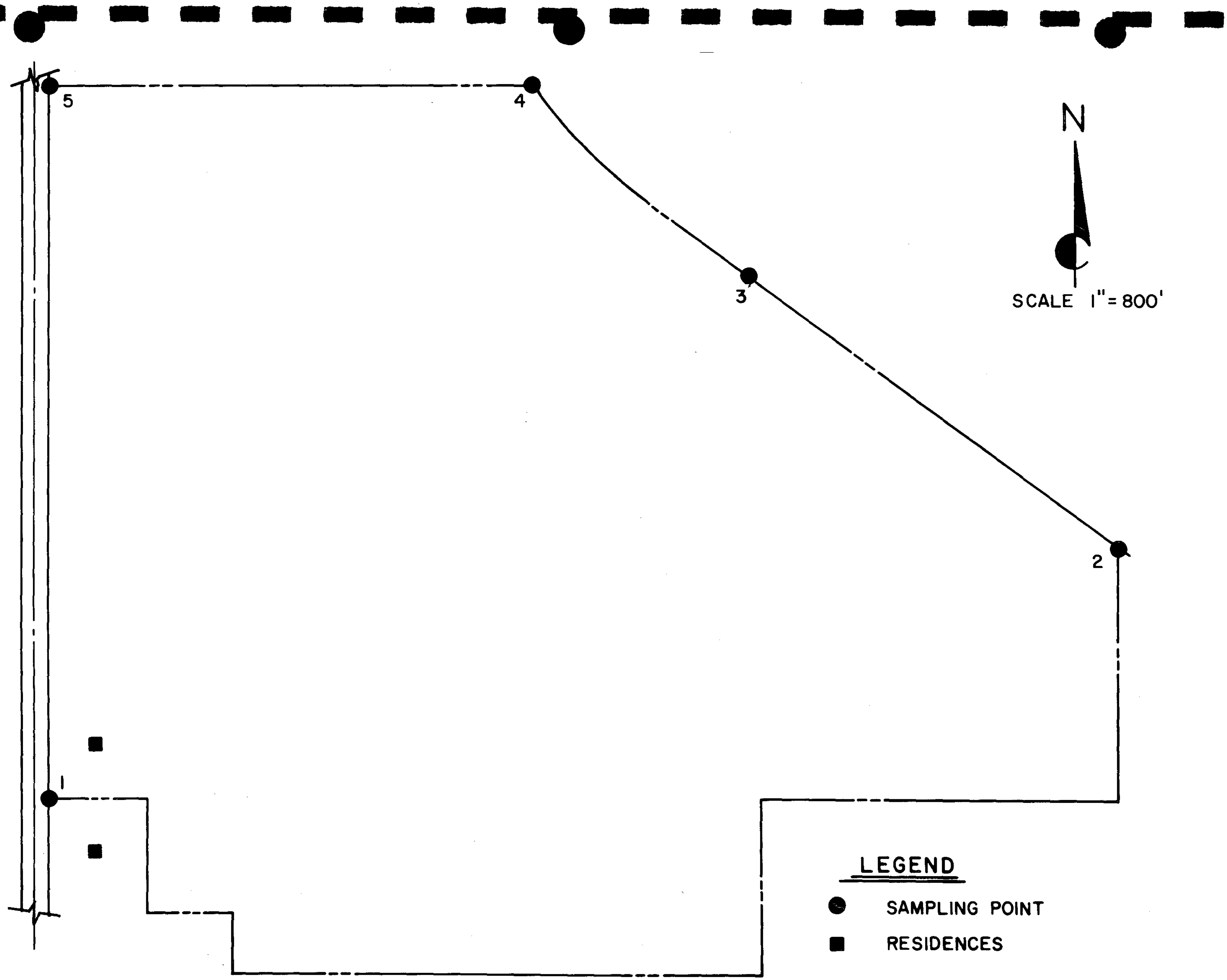
4.5.1 Ambient Sound Survey

Five sampling points were established on the property lines of the plant site to record the ambient noise levels. The sampling points are shown on Exhibit IV-1.

The methodology given in Report 117 of the Cooperative Highway Research Program (NCHRP) was followed in this survey. The instruments used in the

EXHIBIT IV-1

SAMPLING POINTS
FOR AMBIENT SOUND SURVEY



survey are as follows:

- Sound level meter, B & K Model 2209, 1-inch microphone No. 4145, extension rod VA 0196, adapter DB 0375, and random incidence corrector VA 005.

- Piston phone, B & K Model 4220.

A summary of the survey results is shown in Table IV-1.

TABLE IV-1

SUMMARY OF EXISTING AMBIENT NOISE LEVELS AT THE PLANT SITE

Station No.	Daytime dB(A)			Nighttime dB(A)		
	L_{10}	L_{50}	L_{90}	L_{10}	L_{50}	L_{90}
1	59	59	57	57	57	55
2	59	57	55	59	55	51
3	59	57	55	59	59	57
4	69	67	67	59	57	57
5	69	67	65	59	59	57

L_{10} is the noise level that is exceeded 10 percent of the time, L_{50} is the noise level that is exceeded 50 percent of the time, and L_{90} is the noise level that is exceeded 90 percent of the time. From past experience with this sampling method, a 95 percent confidence level can be realized for all the L_{10} data.

The ambient levels that were recorded at the sampling points as indicated on Exhibit IV-1 encompass the entire site as controlled by the existing property boundaries. At present, there are two permanent residences within close proximity to survey Points 1 and 3. As indicated in Table IV-1, the noise levels for both nighttime and daytime are between 57 and 59 dB(A) constant.

The readings presented in Table IV-1 represent only noise levels which may be attributed solely to plant operation. Noise from vehicular traffic, which was irregular, was not taken into account as this type noise was determined to be non-representative of steady-state ambient noise.

4.5.2 Effects of Construction

As indicated in Section 2.2, the area surrounding the plant site is sparsely populated. Some increase in ambient noise levels will be inevitable during the start of construction with the increase of traffic to and from the plant site. At present, average daily vehicular traffic on State Road 260 is about 670 vehicles (Department of Transportation). It is anticipated that an estimated 100 additional vehicles will use the road during construction of Unit 2 and again with the construction of Unit 3. This additional traffic represents an increase of 15 percent and, at present, it is expected that no significant impact on noise levels will be realized.

Actual construction noise at the site will be created only during daylight hours. Noise during construction will result from operation of such equipment as pile drivers, cranes, large trucks, and pneumatic equipment. To determine possible noise levels which would be imposed in addition to the ambient levels measured, a review of applicable regulations and standards which apply to ambient and worker exposure noise levels for this type construction was made. Information reviewed included state ordinances, Environmental Protection Agency (EPA) regulations and standards, applicable National Electrical Manufacturer's Association (NEMA) Performance Standards, and the Occupational Safety and Health regulations for Public Employees enforced by the State of Florida.

From consideration of ambient noise levels and expected noise resulting from construction, it has been determined that noise levels should not exceed the normal threshold of tolerance levels for the residents nearest the site.

SECTION 5

SECTION 5 - ENVIRONMENTAL EFFECTS OF PLANT OPERATION

5.1 EFFECTS OF OPERATION OF HEAT DISSIPATION SYSTEM

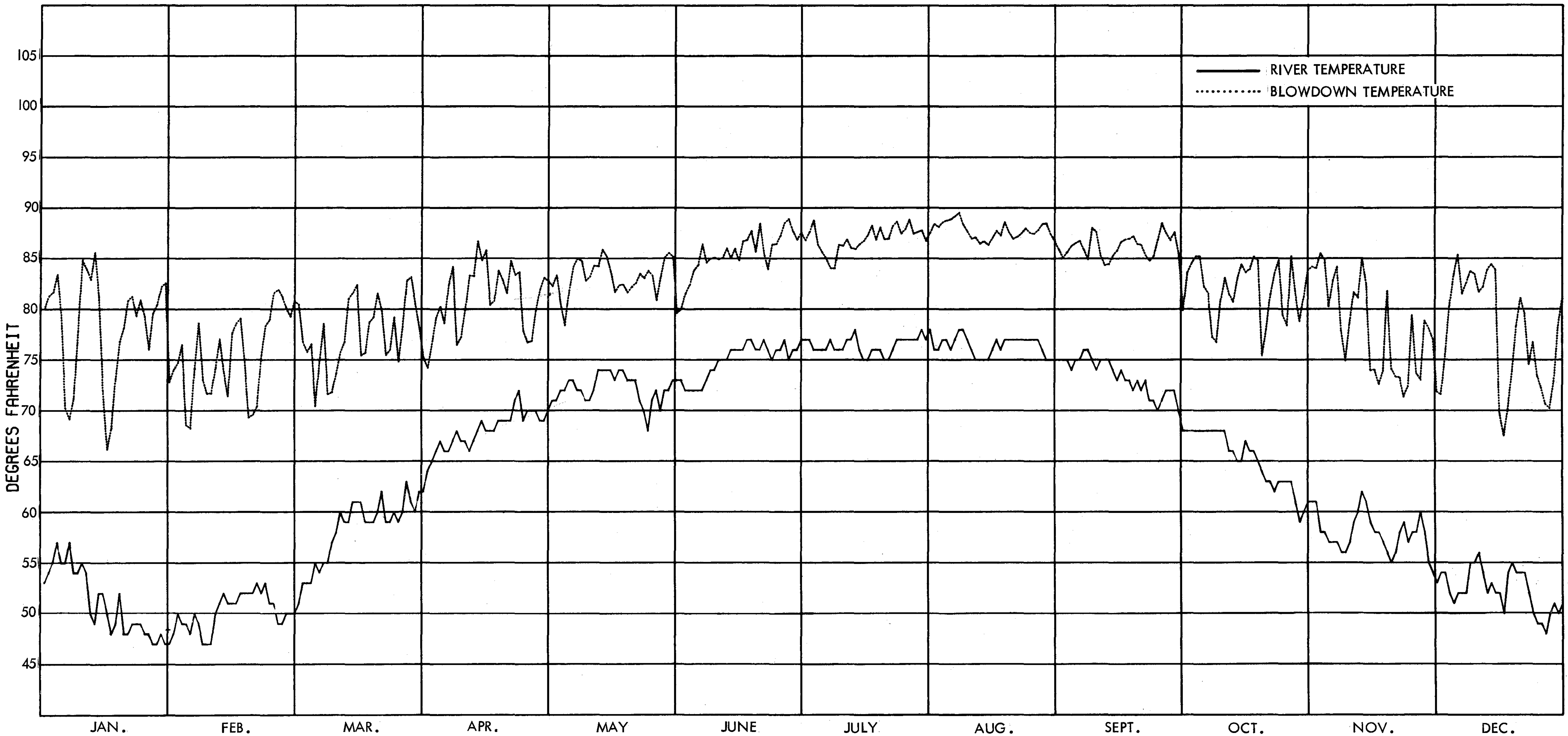
5.1.1 Blowdown Characteristics

The cooling tower blowdown will be discharged without treatment into the discharge ditch at the plant site which empties into a natural drainage channel. The discharge will follow the natural channel for approximately two miles before discharging into the Ochlockonee River just above Lake Talquin.

The blowdown rate will be approximately 2,000 gallons per minute for all three units operating at full load. Diurnal temperature variation of the blowdown and the ambient river temperature for the period of a year are presented in Exhibits V-1 and V-2.

For the purposes of thermal analysis, any cooling effect taking place in the ditch which carries the plant discharge to the river has not been addressed. In addition, the blowdown temperatures represent a condition of full load plant operation at all times.

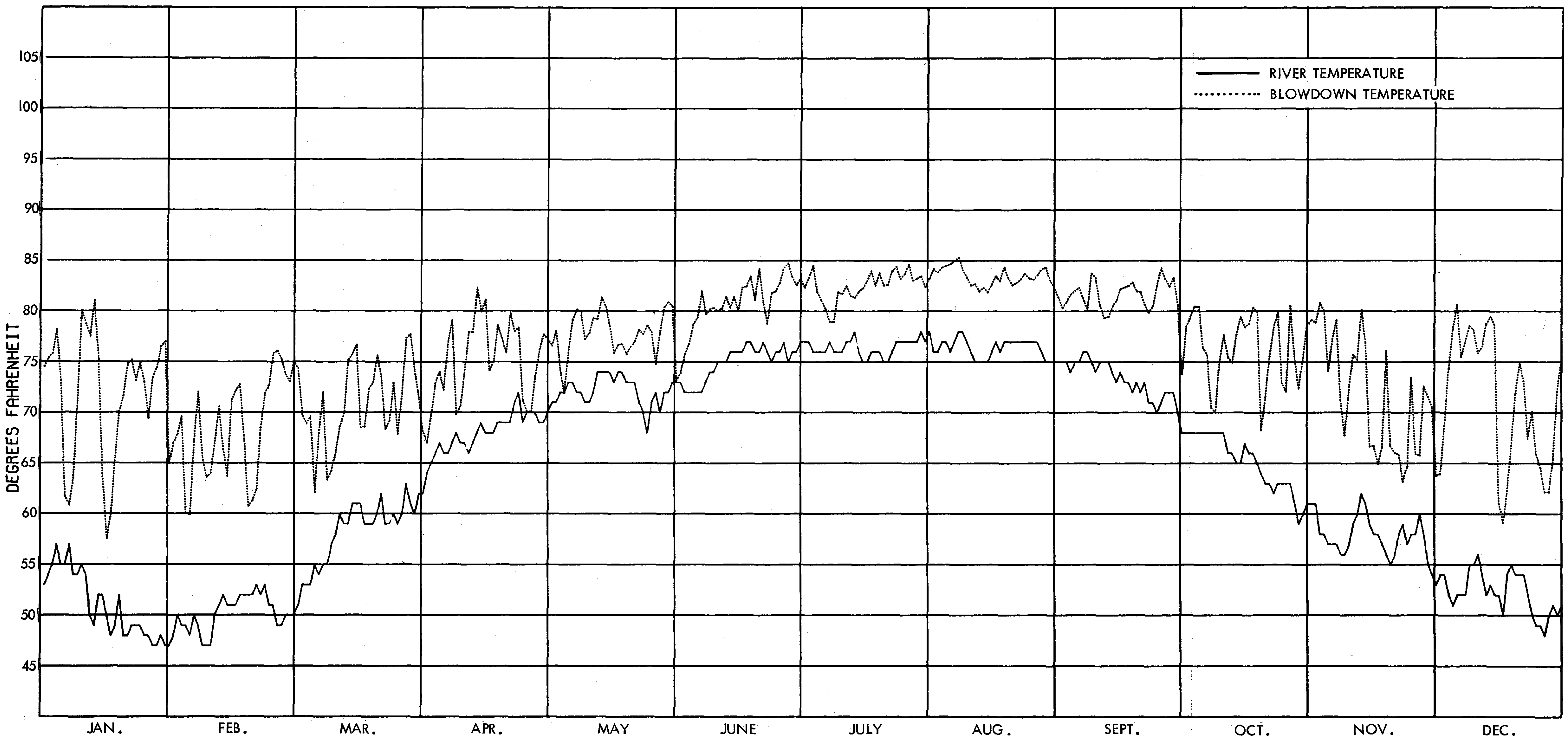
Exhibit V-3 presents diurnal variation of wet-bulb temperature in relation to river temperature variation. The wet-bulb temperature is the limiting value for an ideal evaporative cooling process. Thus, Exhibit V-3 indicates that even with an ideal cooling tower, the blowdown, with temperature equal to the wet-bulb temperature, would constitute a discharge in violation of thermal limitations imposed by Chapter 17-3.05 FAC for approximately 20 percent of the year.



BLOWDOWN TEMPERATURE – 10 DEGREE APPROACH TOWER

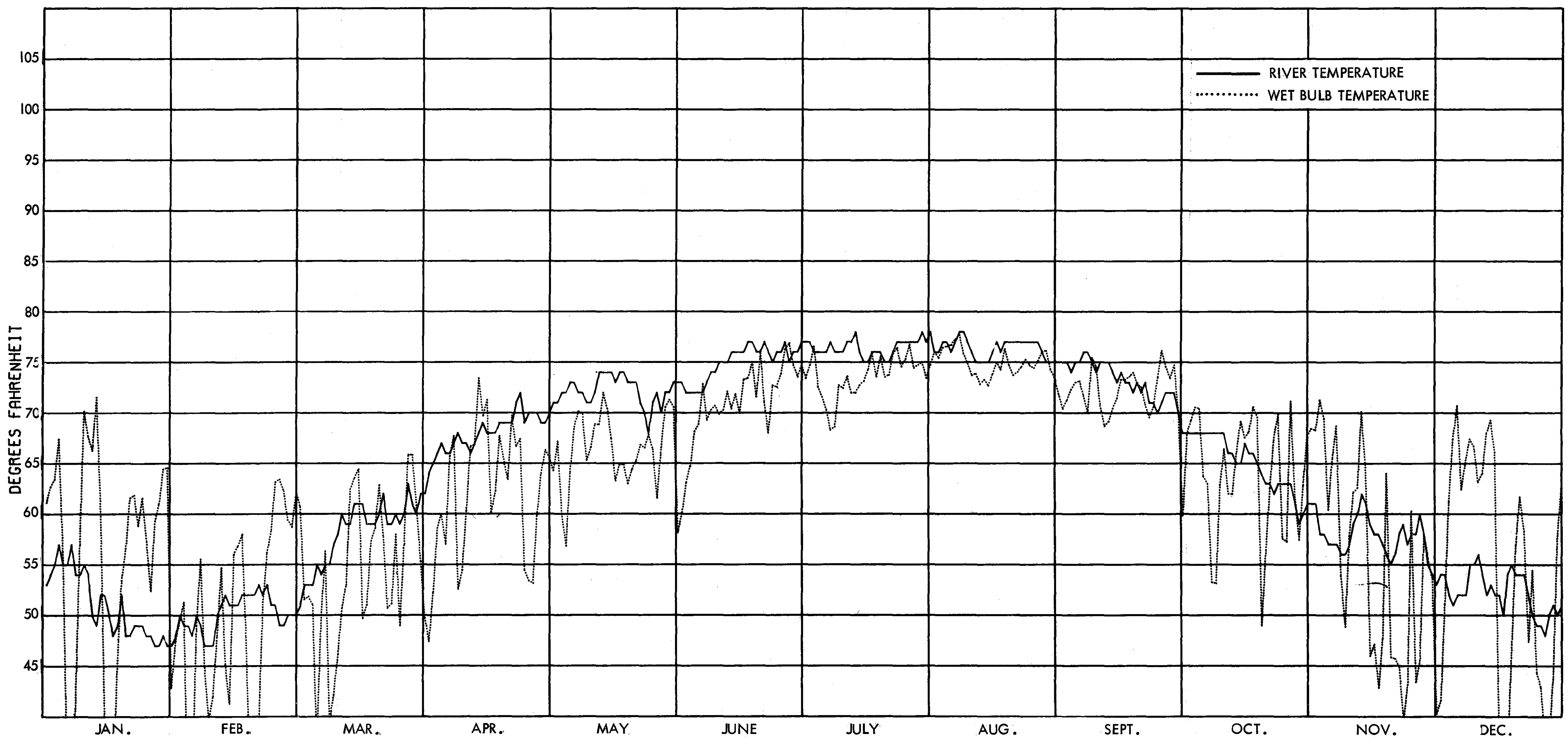
Are these average temperatures ?

EXHIBIT V-1



BLOWDOWN TEMPERATURE — 6 DEGREE APPROACH TOWER

EXHIBIT V-2



WET BULB TEMPERATURE — 1972

EXHIBIT V-3

Table V-1 presents the percentage of time during each month that the ambient wet-bulb temperature for 1972 was over 3°F and 5°F greater than the ambient temperature of the Ochlockonee River.

TABLE V-1

TIME THAT 1972 WET-BULB TEMPERATURE REPRESENTS VIOLATION OF THERMAL LIMITATIONS

Month	% Time Over (Amb + 3°F)	% Time Over (Amb + 5°F)
January	60.65%	56.23%
February	36.64%	18.54%
March	20.17%	10.89%
April	5.42%	0.84%
May	0 %	0 %
June	0.42%	0 %
July	0 %	0 %
August	0 %	0 %
September	5.42%	1.26%
October	24.6 %	12.1 %
November	32.76%	25.84%
December	50.0 %	44.76%

Thus, if the plant discharge continues to be routed to the river, the only means of meeting thermal limitations as set forth in Chapter 17-3.05, would be some form of dilution of the blowdown before discharge into the river.

5.1.2 Possible Effects

Model study data which assumes a 10°F approach tower and uses 1972 Tallahassee weather data indicates a maximum tower outlet temperature of 89.6°F occurring during late July. If a 6°F approach is assumed, a maximum tower outlet temperature of 87.2°F is obtained. If these data and model assumptions are correct, tower outlet temperatures should remain in the mid to upper 80°F range through the summer. Data were not available to determine the probability of occurrence and duration of temperatures in excess of those reported for 1972.

If a diurnal mean tower outlet temperature is calculated for the data of the maximum outlet temperature, 86.0 $\pm$ 2°F is obtained. In contrast, small temperate zone streams experience approximately a 10°F diurnal temperature variation. A constant environment results in an improved energy use efficiency and biotic stability. It also results in higher populations of those organisms intolerant of higher stress systems. Any benefit accrued to the outfall system through this logic sequence is probably lost due to other factors which are operating simultaneously and exert a greater effect on the system. In summary, the available data indicate that tower outlet temperatures should not exceed 90°F which is a state imposed upper limit. The discharge stream will have a more stable diurnal and seasonal thermal regime than unmodified local systems.

It can be seen from the data (Table V-2) that 12 and 9°C differences exist between the outfall station and the lake and river, respectively, at the time of sampling. Under present thermal loading, winter thermal recovery occurs

Table V-2

HOPKINS GENERATING STATION STUDY

WATER QUALITY DATA

DECEMBER 10, 1973

Sample Station	Temp. (°C)	DO (mg/l)	Depth (m)	pH	$SO_4^=$ (mg/l)	Cl- (mg/l)	TOC (mg/l)	TIC (mg/l)	NO_3^- (mg/l)	NH_3 (mg/l)	TON (mg/l)	Total P (mg/l)	Ortho P (mg/l)	Zn (µg/l)	Fe (mg/l)	Cu (µg/l)	Pb (µg/l)	DO (% Sat.)	Cond. (umho/cm)
Cooling Tower Makeup	-	-	-	8.15	7.4	12.5	3.0	25	<0.010	<0.017	0.780	-	0.017	260	0.10	<10	2.3	-	280
Cooling Tower Blowdown	-	-	-	8.43	52	29.5	<0.1	47	0.116	<0.017	1.63	1.130	0.148	610	0.20	28	3.3	-	740
Stream 1	23 (°F 73.4)	12.4	-	9.12	41	25.5	<0.1	42	0.059	0.030	1.16	0.765	0.148	100	0.20	<10	1.3	143	600
2	17	8.5	-	8.20	65	27.0	<0.1	42	0.070	<0.017	0.890	0.700	0.208	120	0.40	<10	1.8	88	650
3	14 (57.2)	10.4	-	7.86	37	15.0	9.2	19	0.050	<0.017	1.24	0.148	0.090	<10	0.30	<10	1.8	100	315
~~Stream~~ River 7	13.5 (56.3)	8.5	1.0	7.37	6.5	23.5	13.3	11.0	0.900	1.20	1.56	0.300	0.227	<10	1.90	<10	1.6	81	180
Upstream R. 8=	11 (51.8)	8.4	3	7.54	7.3	23.0	13.7	10.0	0.668	0.900	1.57	0.230	0.129	<10	0.40	<10	1.8	76	180
Downstream River 9	14	7.4	3.7	7.34	6.0	23.5	14.5	10.0	0.828	0.900	1.74	0.292	0.179	<10	1.90	<10	2.4	71	170
Upstream R 10	11	8.5	2.4	7.54	7.3	24.0	13.9	9.0	0.608	0.730	1.56	0.275	0.122	<10	0.40	<10	0.7	77	170
Upstream R. 11	11	8.5	-	7.49	6.5	21.0	13.9	9.0	0.788	0.730	1.51	0.295	0.149	<10	1.00	<10	1.0	77	170
Lake 12	14	6.8	2.5	7.22	7.3	25.0	14.2	11.0	0.542	0.730	1.76	0.290	0.176	<10	1.90	<10	2.7	65	170
13	13.5	7.3	1.0	7.19	7.4	31.0	16.3	10.0	0.490	0.730	0.850	0.235	0.178	<10	1.90	<10	1.3	70	190
14	14	7.6	2.4	7.33	8.0	43.0	14.5	10.0	0.440	0.730	0.900	0.240	0.172	<10	1.80	<10	2.7	73	230

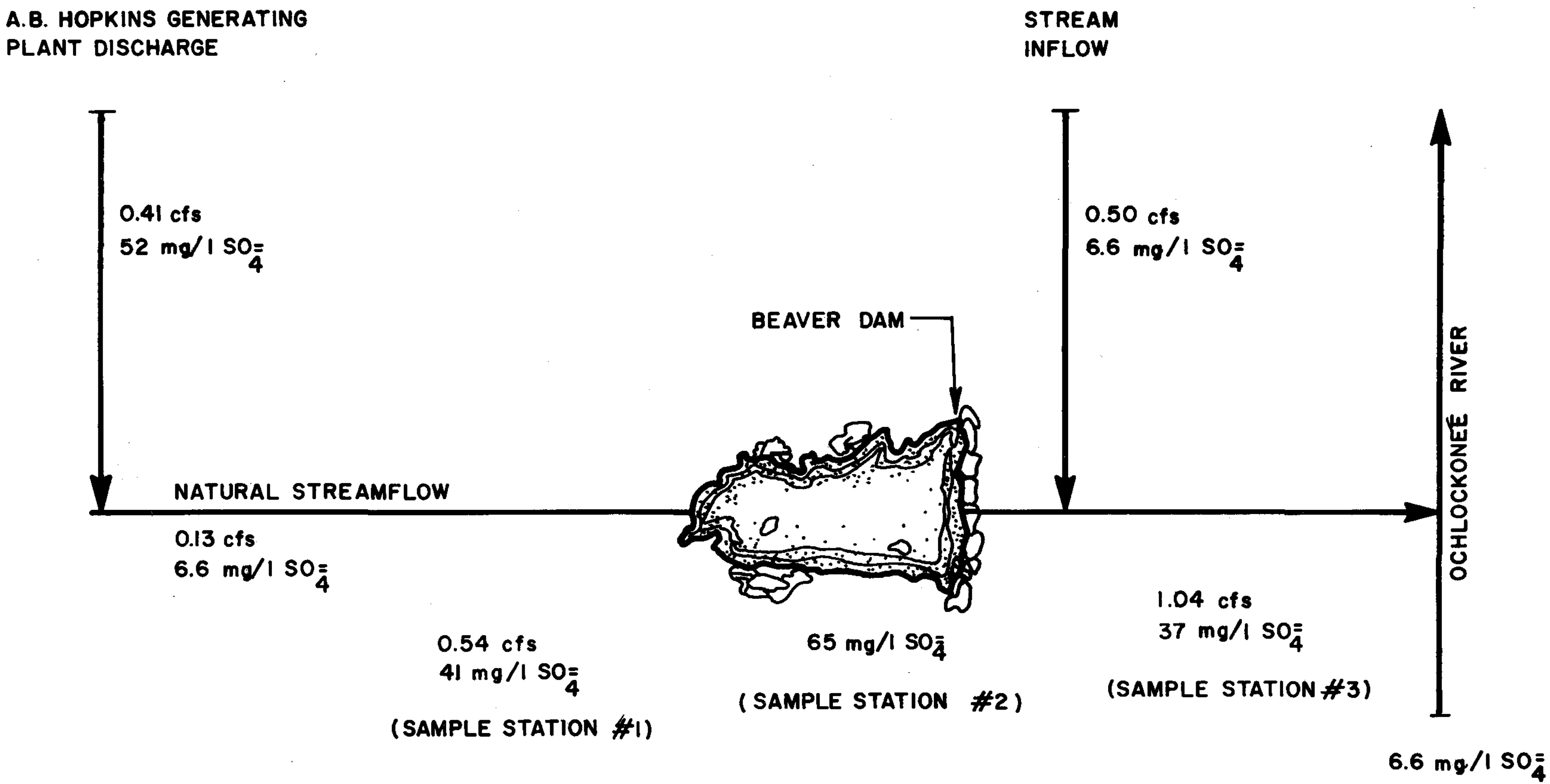
at Station 3 which is approximately 1.5 miles downstream from the outfall. No modeling effort was attempted to indicate the point of thermal recovery after plant expansion. The point would vary seasonally in relation to atmospheric and stream flow characteristics at a given time.

The seasonal movement of the thermal recovery zone edge is a phenomenon similar to the one occurring in spring fed creeks, where biotic shifts occur which compensate for the movement. However, power plant thermal releases differ in that summer releases are greater than the regional ambient and, therefore, represent a stress increment on the anticipated ambient. It is unlikely that a thermal exclusion zone will occur for a sufficient distance below the blowdown outfall of the A. B. Hopkins Station that the river or lake will be affected. In a regional sense any thermal effects occurring in the outfall stream should be insignificant. The remaining summer sampling period should indicate the present zone of summer thermal influence and effect differences occurring at the stations.

5.2 EFFECTS OF CHEMICAL AND BIOCIDE DISCHARGES

5.2.1 Water Quality Effects

Water quality data were collected for the generating station supply water, discharge water, outfall creek, Ochlockonee River, and Lake Talquin. The sample stations at which water samples were collected on December 10, 1973, are shown in Exhibit V-4. Cooling tower makeup water is supplied by two wells located on-site. The plant discharge and cooling tower blowdown water enters the outfall



SCHEMATIC DIAGRAM OF APPROXIMATED FLOW RATES IN THE A.B. HOPKINS OUTFALL CREEK.

EXHIBIT V-4

creek near sample Station 1. Station 2 is just below a small impoundment in the outfall creek caused by a beaver dam. Station 3 is still in the outfall creek but downstream from the confluence with another stream of flow approximately one-third that of the outfall creek. Stations 7, 8, 9, 10, and 11 are located in the Ochlockonee River. Station 7 is in the vicinity of the mouth of the outfall creek, however the mouth of the creek is not clearly defined in the marsh area near this station. The remaining three sample stations (12, 13 and 14) are located in the open waters of Lake Talquin.

The water quality data collected at the sample stations during the field trip conducted by ESE on December 10, 1973, are summarized in Table V-2.

(a) Temperature - Temperature drops continuously from the discharge canal (23°C) to Station 3 where it is equivalent to the temperature observed in the open lake (11°C). The temperature of the Ochlockonee River is somewhat lower than the lake.

(b) Dissolved Oxygen (DO) - The observed DO concentration in the effluent canal was 12.4 mg/l which constitutes 143 percent of the saturation value at that temperature. DO remains at a relatively high level of saturation the length of the outfall creek and even near the mouth of the creek at sample Station 7. Concentrations in the river and the lake ranged from 6.8 to 8.5 mg/l or 65 to 77 percent saturation.

(c) pH - The observed pH in the outfall canal was 9.12. However, this value is not indicative of predicted pH values at Station 1, due to the fact that ion exchange regeneration backwash was being discharged from the plant during the time of the Station 1 sampling. The proposed plant expansion will incorporate a treatment facility for adjusting the pH of the regeneration backwash before discharge into the canal. Thus, values of pH which can be expected at the outfall will be equal to the pH of the cooling tower blowdown (no greater than 8.5). The maximum value of 8.5 is in compliance with standards established by the Florida Department of Pollution Control.

(d) Conductivity - The conductivity of the cooling tower make-up and blowdown waters indicates the tower was being operated at a concentration factor of approximately 2.6 on the sample date. Conductivity values downstream in the outfall creek indicate dilution of the blowdown water by the small stream entering the outfall just above Station 3. The small increase in conductivity between sample Stations 1 and 2 appears to be unusual. However, this trend is also observed for several other parameters (sulfate, chloride, nitrate, phosphate, and zinc). The impounding of discharge and natural stream flow water just above sample Station 2 will tend to average out shorter term fluctuations in conservative chemical parameters in the plant discharge. Hence, the slightly higher conductivity at Station 2 indicates that water of somewhat higher conductivity than that observed in the one-time grab sample has been discharged in the recent past. This is not unexpected since a grab sample only defines the chemical nature of the stream at one location at one point in time.

Conductivity in the river averages about 175 μmhos/cm. The three samples taken in the lake (Stations 12, 13, and 14) indicate a conductivity gradient increasing toward the western end of the lake. This trend probably reflects the inflow from small streams in the vicinity of sample Stations 12 and 13 and the increase in conductivity associated with evaporation from the lake's surface. This same trend is also noted for sulfate and chloride, which are two conservative chemical species.

The plant blowdown conductivity exceeds both the state standards of 500 µmhos/cm or not more than 100 percent increase above background levels if the point of discharge is considered to be the outfall. The permissable level isopleth of 360 µmhos/cm occurred approximately one mile downstream at the time of the winter survey.

(e) Sulfate - Sulfate is added to the cooling tower in the form of sulfuric acid to adjust the saturation index of the cooling water in order to avoid excessive formation of scale within the tower and cooling system. Sulfate is a conservative chemical species that may be used to trace the cooling tower blowdown, since concentrations in the blowdown water are well in excess of ambient concentrations. The observed sulfate concentration in the blowdown water is 52 mg/l. Concentrations are (see Exhibit V-4) seen to decrease downstream in the same manner as conductivity. Ambient levels in the Ochlockonee River were about 6.6 mg/l. Those in Lake Talquin were about 7.6 mg/l at the time these samples were taken.

These sulfate data may be employed to determine a gross approximation of streamflows in outfall creek. Two general assumptions must be made, these are:

(1) The A. B. Hopkins Generating Plant discharge averaged 0.41 cfs during the period of collection of these samples. This is the average discharge rate determined by Reynolds, Smith and Hills personnel between the hours of 8:00 a.m. and 4:00 p.m. on January 18, 1974.

(2) Ambient sulfate concentrations in area waters is 6.6 mg/l as observed for the Ochlockonee River.

Using the sulfate concentrations measured at Stations 1, 2, and 3 and at the cooling tower blowdown, and assuming simple dilution and mass conservation, flow rates within the outfall creek can be approximated. A schematic diagram of these flow rates is presented in Exhibit V-4.

The calculated flow rates indicate the natural flow in the outfall creek below the plant discharge is approximately one-fourth that of the plant discharge itself. The calculations also indicate the stream which enters the outfall creek above sample Station 3 has a flow approximately equivalent to that of the creek near the confluence.

Sulfate levels which are toxic to benthic invertebrates and fish range 1,000 mg/l and higher. The highest sulfate concentration during the winter survey was 52 mg/l which is below reported toxicity levels for *Tanytarsus* sp., *Procladius* sp., and snails, *Lepomis macrochirus*, and *Gambusia affinis*. Toxicity levels for indigenous species of periphyton and phytoplankton have not been reported in the available literature.

(f) Chloride - Chloride is another conservative chemical species, however it is not as useful in tracing plant discharge because concentrations in the discharge are expected to be highly variable. The periodic discharge of demineralizer regenerant would exert a large effect on the chloride concentrations. Ambient chloride concentrations are also not much lower than those in the plant discharge, at least at the time these samples were taken. The same downstream trends are noted in the chloride data as previously discussed for condictivity and sulfate. A chloride gradient increasing toward the west in Lake Talquin is also apparent.

Chloride toxicity levels for indigenous species were not available. The observed blowdown level during the survey was below the levels determined for the river. From these data no effect of chlorides would be postulated or anticipated. Demineralizer regeneration effects cannot be predicted from available data.

Shock applications of chlorine are used to control biological growth in the towers. Chlorine measurements were not taken during the winter survey but will be included during next scheduled sampling.

Although no chlorine residual is maintained in the tower, blowdown concentrations during shock treatments should approximate tower treatment levels. Therefore, some impact should occur in the stream. However, based on available data no impact is evident beyond Station 3.

(g) Total Organic Carbon (TOC) and Total Inorganic Carbon (TIC) - Organic carbon/concentration in the cooling tower blowdown water is less than 0.1 mg/l. The inorganic carbon concentration is much higher (47 mg/l), reflecting the concentration of carbonates in the cooling tower. As expected, TOC concentrations increase downstream in the outfall creek and TIC concentrations decrease toward ambient levels of approximately 14 mg/l and 10 mg/l, respectively.

The observed fourfold increase in TIC should produce no significant or abnormal environmental effect. The values observed are within the range expected during normal community metabolism.

(h) Nitrogen Species - A tertiary organic amine (Betz 403) of chemical formula $N(CH_2PO_3H_2)_3$ is added to the cooling tower as a dispersant. The presence of this compound and its degradation products may affect the nitrate and the ammonia concentrations in the plant discharge water. The observed concentration of nitrate in the discharge water is 0.116 mg N/l. The concentration at sample Station 1 is one-half that in the plant discharge. This lower nitrate concentration may be the result of the uptake of nitrate by aquatic vegetation in the outfall creek or it may be the result of the tertiary amine affecting the analytical results at high concentration. In either case, the observed nitrate concentration in the Ochlockonee River and Lake Talquin are well in excess of those in the outfall creek and even that of the plant discharge itself.

Ammonia concentrations are less than 0.03 mg/l in the outfall creek. Levels observed in the river and the lake range from 0.730 mg N/l to 1.20 mg N/l.

Organic nitrogen levels in the discharge water (1.63 mg N/l) reflect the concentration of nitrogen in the cooling tower makeup water and the addition of the organic tertiary amine. This concentration is lower than some of those observed in the river and in the lake where a range of 0.850 mg N/l to 1.76 mg N/l was determined. Approximately 6.5 lb/day as N is discharged in the effluent waters.

Assuming grab sample data is representative, it appears that the discharge of nitrogen species from the operating plant does not significantly increase nutrient nitrogen concentrations in the receiving waters. No significant effect is anticipated on primary productivity.

(i) Total Phosphorus and Dissolved Orthophosphorus - The tertiary amine dispersant compound which is added to the cooling tower is in the form of a phosphorous acid. Hence, total phosphorus and orthophosphorus concentrations in the blowdown water are affected by this chemical addition. Phosphorus concentrations in the blowdown water were 1.130 mg P/l and 0.148 mg P/l for total phosphorus and orthophosphorus, respectively.

A subsequent decrease in concentration of both forms is seen as the discharge passes down the outfall creek. By the time the effluent water has reached Station 3, the total phosphorus concentration is lower than that observed in Lake Talquin. Orthophosphorus concentrations show the same trend as shown by total phosphorus. In the plant discharge, soluble orthophosphorus constitutes 13 percent of the total phosphorus. The relative percentage of orthophosphorus to total phosphorus increases downstream until at sample Station 3 it comprises 60 percent of total phosphorus.

This relative proportion of orthophosphorus is near that observed for water samples from the river and from the open lake.

The data indicate a phosphorus discharge rate of approximately 4.6 pounds per day.

Total phosphorus levels remain well below the toxicity levels of the indigenous species presented in Table V-3 and well above levels considered limiting for algal bloom growth.

There are no specific state standards regarding phosphorus, nitrogen, and sulfate levels. However, under Section 17-3.04(3) on general water quality, a significant addition of nutrients or other salts to natural surface waters is considered as water quality impairment under Florida law. Sulfate at Stations 1, 2, and 3 were found to be 34.5, 58.5, and 30.5 mg/l above ambient. Total phosphorus levels were 0.46 mg/l and 0.40 mg/l above ambient at Stations 1 and 2, respectively (Table V-2). Based on the rationale discussed in the preceeding paragraph, elevations in the levels of sulfate and phosphorus are expected to occur downstream of Station 3. Estimates of the distance downstream in which significant increases in sulfate and phosphate concentrations are expected cannot be determined at this time.

(j) Heavy Metals - The only heavy metal for which analyses have been conducted and which may be of sufficient concentration to be of concern is zinc. The concentration of zinc in the cooling tower makeup water is 260 μg/l; in the blowdown water it is 610 μg/l, reflecting the cooling tower concentration factor. From the plant discharge downstream, the zinc concentration decreases as

Table V-3 Toxicity levels of various species of phytoplankton and periphyton collected during the winter survey (December 7-8, 1973) in the aquatic habitats near the A. B. Hopkins Power Plant for selected chemical parameters.

Taxa Collected	Stations Observed	Test[b]	Ref.	Zinc[c] (mg/l)	Phosphate (mg/l)	Copper (mg/l)	Nitrate (mg/l)	Ammonia (mg/l)
Periphyton								
Mougeotia spp.	2	SB,FW,LS	1	0.5 - 3.0 MNI 0.9 - 6.0 ML		0.60 - 0.50 MNI 0.29 - 0.45 ML		
Spyrogyra spp.	expected[a]	SB,LS	1	0.5 - 3.0 MNI 0.9 - 6.0 ML		0.06 - 0.50 MNI 0.18 - 0.70 ML		
Oedogonium spp.	expected[a]	SB,LS	1	0.08 - 0.46 MNI 0.22 - 0.62 ML		0.19 - 0.25 MNI 0.15 - 0.45 ML		
Ulothrix spp.	expected[a]		1	1.2 - 2.0 MNI 1.6 - 3.0 ML		0.22 - 0.45 MNI 0.29 - 0.53 ML		
Cladophora sp.	expected[a]		1	0.08 MNI 0.24 ML	10.0	0.12 MNI 0.30 ML		
Nitzschia linearis		SB,FW,LS	1	4.3				420
Nitzschia closterium	2,3,12	SW,LS	1	0.25, DRR				
Periphyton (general)		CB,FW,LS	1					
Phytoplankton								
Scenedesmus quadricauda	10,12,13	SB,FW,LS	1			0.15	<1,000	
Scenedesmus sp.	10,12,13	---	2				2.5	
Spyrogyra sp.	expected [a]							
Phytoplankton (general)		SB,FW,LS	1	0.1 - 0.5		0.1 - 0.3		

[a]Expected, but not observed.

[b]SB = Static Bioassay, CB = Constant Flow Bioassay, FW = Freshwater, LS = Lab Study, FS = Field Study.

[c]MNI = Maximum Inhibitory, ML = Minimum Lethal, DRR = Division Rate Reduced.

a result of both dilution and adsorption to particulate matter. Ambient river and lake zinc concentrations are less than 10 µg/l.

Iron concentrations are lower in the plant discharge and the outfall creek than those in the Ochlockonee River and Lake Talquin. Coppper and lead concentrations are well below water quality standards, however a somewhat higher concentration of copper is present in the cooling tower blowdown water than in the makeup water.

Tables V-3, V-4, and V-5 present data on the toxicity of several chemical components to benthos, fish, periphyton and phytoplankton. The chemical parameters of interest are the seven that are listed in Table V-6 since they were the only chemical parameters in the receiving waters resulting in a measurable increase above ambient levels. In addition, these seven parameters are expected to show significant elevations in concentration downstream in the outfall canal following a six-fold increase in blowdown.

The biotic and chemical parameters evaluated during the winter grab sample survey indicate a general trend. Station 1 is an obvious high stress area. Biotic recovery from the station state occurs with distance downstream. Recovery is essentially complete at Station 3 which is approximately 1.5 miles downstream. At the time of the survey, pH, conductivity, sulfate, and phosphorus at the outfall station were the detected parameters of potential regulatory concern.

Of these parameters, only pH approached or exceeded reported toxic levels for indigenous biota. However, the toxic pH levels are not

Table V-4 Toxicity levels of various species of macro-invertebrates and fish collected during the winter survey (December 7-8, 1973) in the aquatic habitats near the A. B. Hopkins Power Plant for selected chemical parameters

	Stations Observed	Test[a]	Ref.	Copper (mg/l)	Zinc (mg/l)	Lead (mg/l)	Iron (mg/l)	Phosphate (mg/l)	Ammonia (mg/l)	Nitrate (mg/l)
Benthos										
Campeloma sp.	12	--	4							
Chironomus sp.	3,7,9,10,11,12,13	SB,FW,LS	1						4.3	
Tanytarsus sp.	9,12,13	FS,FW	3				MLO[b] 0.1			
Chironomus attenuatus	3,7,9,10,11,12,13	FS,FW	3					MLO 26.2		MLO 43
Procladius sp.	2,11	FS,FW	3				MLO 0.1	MLO 26.2		MLO 43
Coelotanypus concinnus	9,12,13	FS,FW	3					MLO 26.2		MLO 43
Chironomids (general)	2,3,7,9,10,11,12,13	FS	2	7.0						
Tubificids (general)	13	SB,FW,LS	2			no effect			2.7	
Caddisflies (general)	12	FS,FW	3							
Fish										
Lepomis macrochirus	Lake Talquin	FW	1	.46					2.5	
Lepomis macrochirus	"	SB,FW,LS	1	1.25	4.2					
Lepomis macrochirus	"	CB,FW,LS	1							3,000
Gambusia affinis	"	CB,FW,LS	1						1.1	
Gambusia affinis	"	SB,FW,LS	1					720		421
Lepomis sp.	"	LS	2			1.4, 2.0				
Lepomis sp.	"	FS	4			23.8				
Fish (general)	"	--	2				50.0			
Fish (productivity)	"	--	1							

[a]SB = Static Bioassay, CB = Constant Flow Bioassay, FW = Freshwater, LS = Lab Study, FS = Field Study.

[b]MLO = Maximum level observed.

Table V-5 Tolerance levels of various species of macro-invertebrates and fish collected during the winter survey (December 7-8, 1973) in the aquatic habitats near the A. B. Hopkins Power Plant for selected physical and chemical parameters.

	Stations Observed	Test[a]	Ref.	pH	Thermal Tolerance (°C)	Supersaturated O_2 Effects	Sulfate (mg/l)	Chlorine (mg/l)
Benthos								
Tanytarsus sp.	9,12,13	FW,FS	3					
Chironomus attenuatus	3,7,9,10,11,12,13	FW,FS	3	9.1	32.8			
Polypedilum sp.	2,3	FW,FS	3	8.5	30.0			
Procladius sp.	2,11	FW,FS	3	9.1	30			
Coelotanypus concinnus	9,12,13	FW,FS	3	9.1	30			
Snails (general)	12,13	FW	1				1,000	
Clams (general)	3,9,10,11,12,13	FW,FS	2		40			
Chironomids (general)	2,3,7,9,10,11,12,13	FW	2		30-35			
Caddisflies (general)	12	FW,FS	3	9.0			no effect	
Worms & Mollusks	3,7,9,10,11,12,13							
Fish								
Dorosoma cepedianum	Lake Talquin		2					
Dorosoma petenense	"		4			Gas bubble disease		
Lepomis sp.	"	FW,FS	2	10.5				
Lepomis macrochirus	"	CB,FW,LS	4			Gas bubble disease		
Lepomis macrochirus	"	---	1				12,500	
Lepomis macrochirus	"		2		35.0			
Gambusia affinis	"	SB,FW,LS	1				24,000, 16,500	
Gambusia affinis	"	---	2		37.3			
Notemigonus crysoleucas	"	---	2		34.7			
Micropterus salmoides	"	---	2		28.9			
Micropterus salmoides	"	---	3		32.5			
Micropterus salmoides	"	SB,FW,LS	1					0.365
Ictalurus nebulosus	"	SB,FW,LS	1					0.5
Notemigonus crysoleucas	"	---	2					trace
Fish (general)	"	---	3	9.5				
Fish species diversity	"	FW,FS,stream	1					0.01

[a]SB = Static Bioassay, CB = Constant Flow Bioassay, FW = Freshwater, LS = Lab Study, FS = Field Study

Table V-6 Parameters affected by the A. B. Hopkins Generating Station cooling tower blowdown and comparison to ambient levels. Data collected in the outfall stream during Dec. 7-8, 1973.

Parameter	Station 1		Station 2		Station 3		Station 7
	level	Δ[a]	level	Δ	level	Δ	Ambient
Sulfate (mg/l)	41	34.5	65	58.5	37	30.5	6.5
Chloride (mg/l)	25.5	2.0	27	3.5	15	-8.5	23.5
Total Inorganic Carbon (mg/l)	42	31	42	31	19	8	11
Total Phosphorus (mg/l)	0.76	0.46	0.70	0.40	0.15	-0.15	0.30
Dissolved Oxygen (mg/l)	12.4	3.9	8.5	0	10.4	1.9	8.5
pH	9.12	1.75	8.2	0.80	7.86	0.49	7.37
Conductivity	600	420	650	470	315	135	180

[a]Δ - Outfall stream level minus ambient level.

expected to occur with the proposed expansion, due to additional treatment facilities which will be incorporated in the plant expansion.

The extent of downstream impact will be increased as a result of plant expansion. Two factors, the presence of the beaver pond which serves as a temporary retention basin and the absence of predictive study input for source to sink calculations, preclude a statement of the linear extent of impact after the proposed expansion is operational.

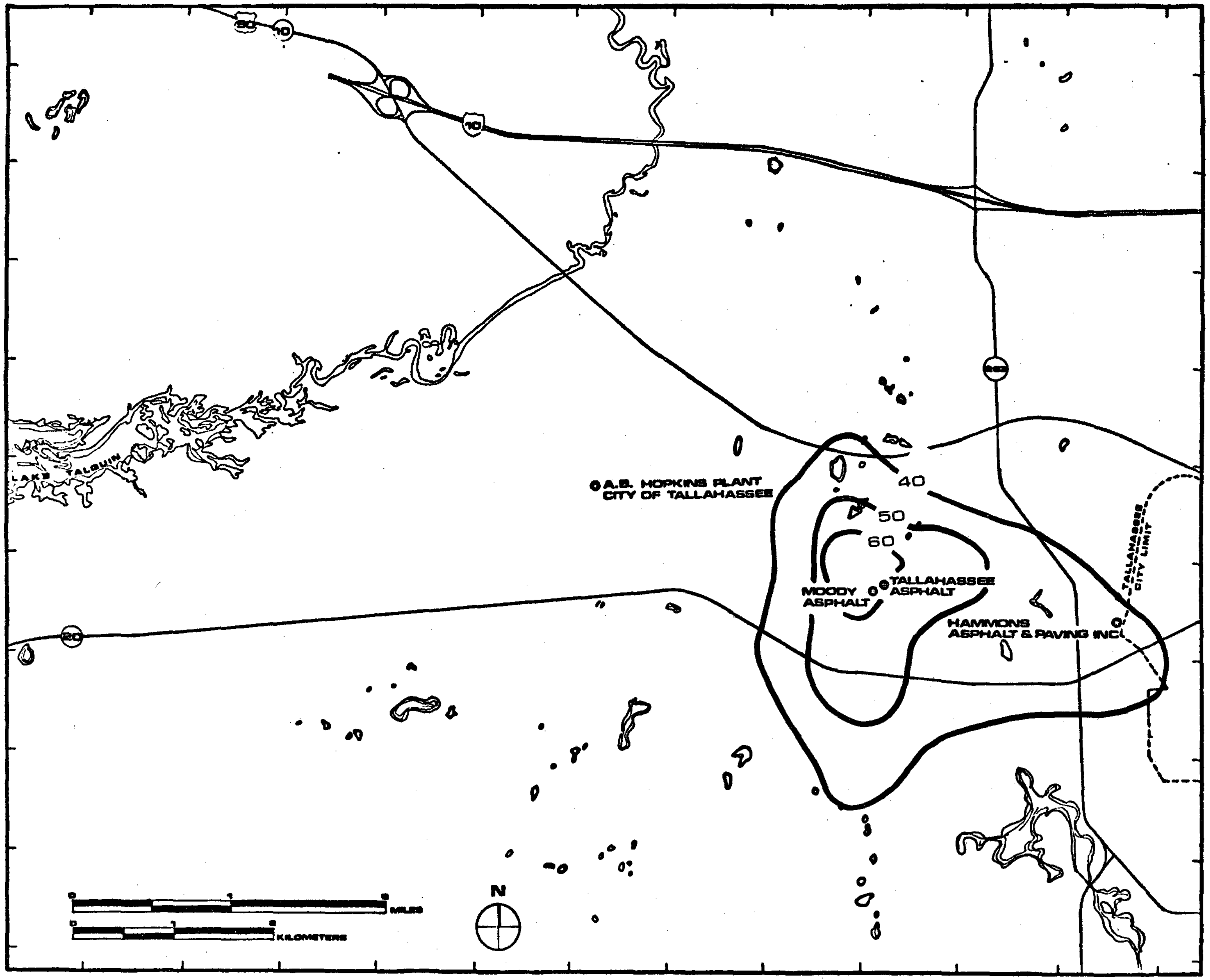
5.3 EFFECTS OF SANITARY AND OTHER WASTE DISCHARGE

The station sanitary system will use septic tanks for waste disposal. Solid waste will be disposed of at a landfill designated for such disposal.

5.4 EFFECTS OF AIR EMISSIONS

5.4.1 Results of the Air Quality Impact Evaluation

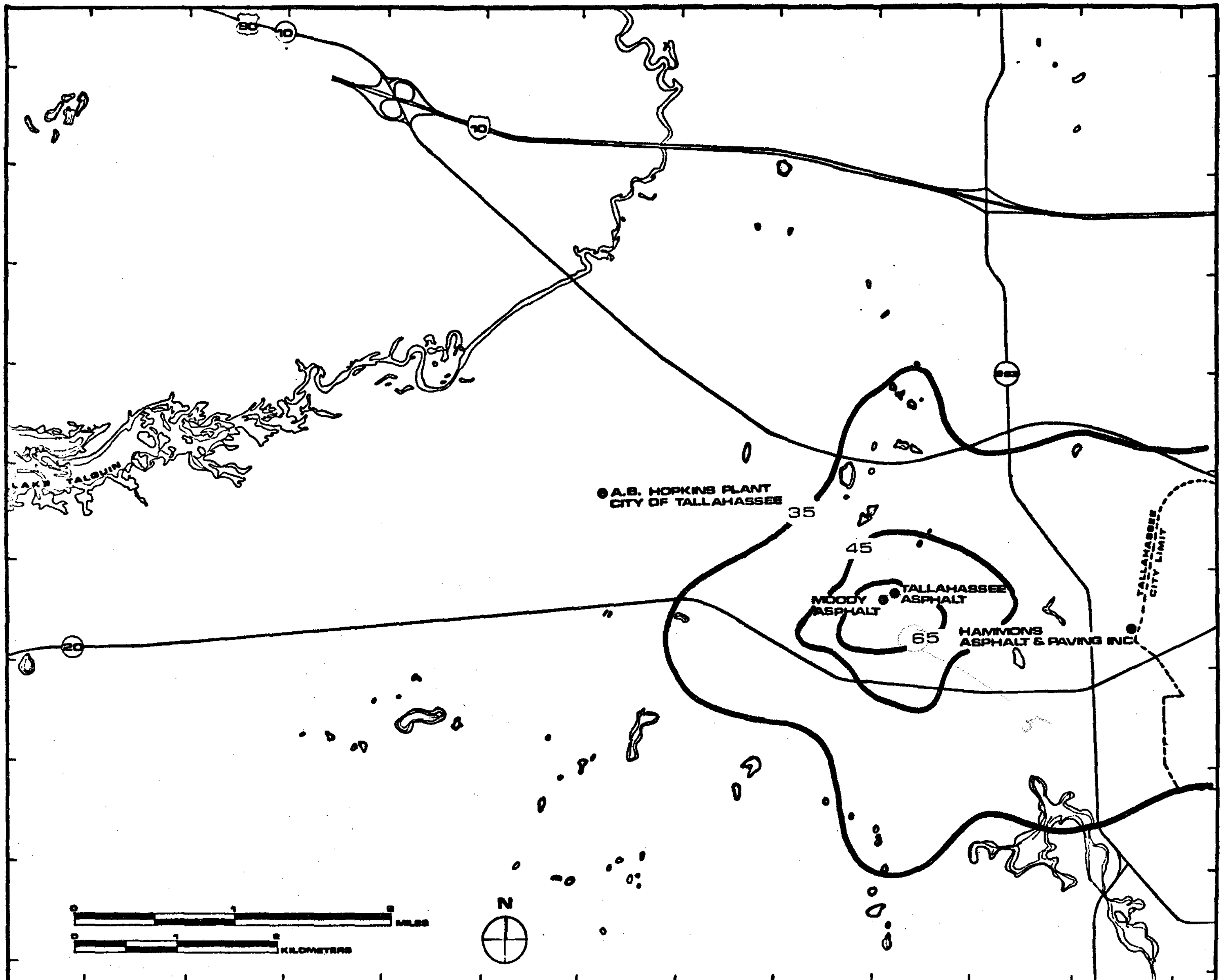
Exhibit V-5 indicates ground level concentrations of total suspended particulate matter for the year 1971 near the A. B. Hopkins Station. The emission inventory used to obtain these results reflect emission conditions for existing sources for that year. No diagram is included which reflects ground level concentrations of SO_2 for 1971 since the calculated concentrations over most of the area shown in the map were less than 2 $\mu g/m^3$. Exhibit V-6 shows ground level total suspended particulate matter concentrations predicted for 1975 with emissions from existing sources at the maximum permissible level for 1975. No corresponding diagram is shown for ground level SO_2 concentrations since none of the calculated concentrations



Ground-level concentrations of total suspended particulate matter near the site of the A. B. Hopkins Generating Station, Leon County, Florida, 1971 ($\mu g/m^3$).

EXHIBIT V-5

EXHIBIT V-6



Mr. Parrish 396-2011 ext 241

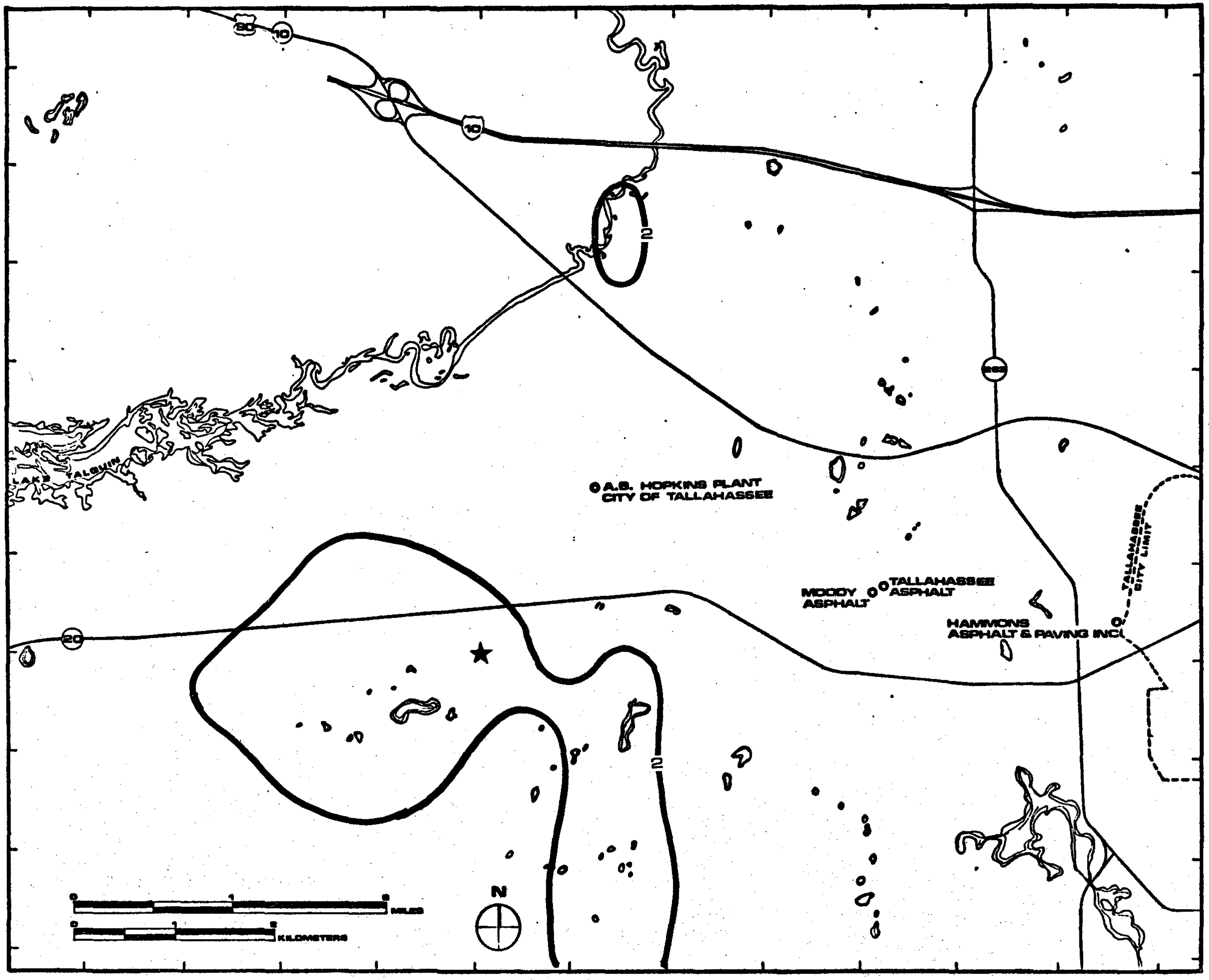
Expected ground-level concentrations of total suspended particulate matter near the site of the A. B. Hopkins Generating Station, Leon County, Florida, with existing sources emitting at maximum permissible levels for 1975 ($\mu g/m^3$).

exceeded 1 $\mu g/m^3$. The low SO_2 concentrations reflect reduced emission rates for 1975 for existing sources. Exhibits V-7 and V-8 show the incremental contribution of the A. B. Hopkins Units 2 and 3 to ground level concentrations of SO_2 and total suspended particulate matter, respectively. Similarly, Exhibits V-9 and V-10 show ground level concentrations of SO_2 and total suspended particulate matter for 1975 with existing sources and the Hopkins Units 2 and 3 emitting at maximum permissible levels for 1975.

The star on each exhibit marks the location where the annual average incremental contribution from the Hopkins Units 2 and 3 is a maximum. Exhibit V-11 shows the locations of the points of maximum incremental impact of Hopkins Units 2 and 3 on the 24-hour and 3-hour ground level concentrations of SO_2 and total suspended particulate matter and the predominant wind direction under which these maxima would occur.

Table V-7 summarizes the predicted ground level SO_2 and total suspended particulate matter concentrations at the points of maximum contribution by the Hopkins Units 2 and 3. Note that these levels are not necessarily the maximum concentrations in the entire study area. In order to more realistically evaluate the impact on air quality of the addition of Units 2 and 3 at the Hopkins Station, the point of maximum incremental impact of the new sources was chosen as a reference point instead of some other location where the concentrations might be higher, but the contribution from the new sources would be negligible. The locations of these maxima are shown in Exhibits V-7 through V-11 as indicated in Table V-7.

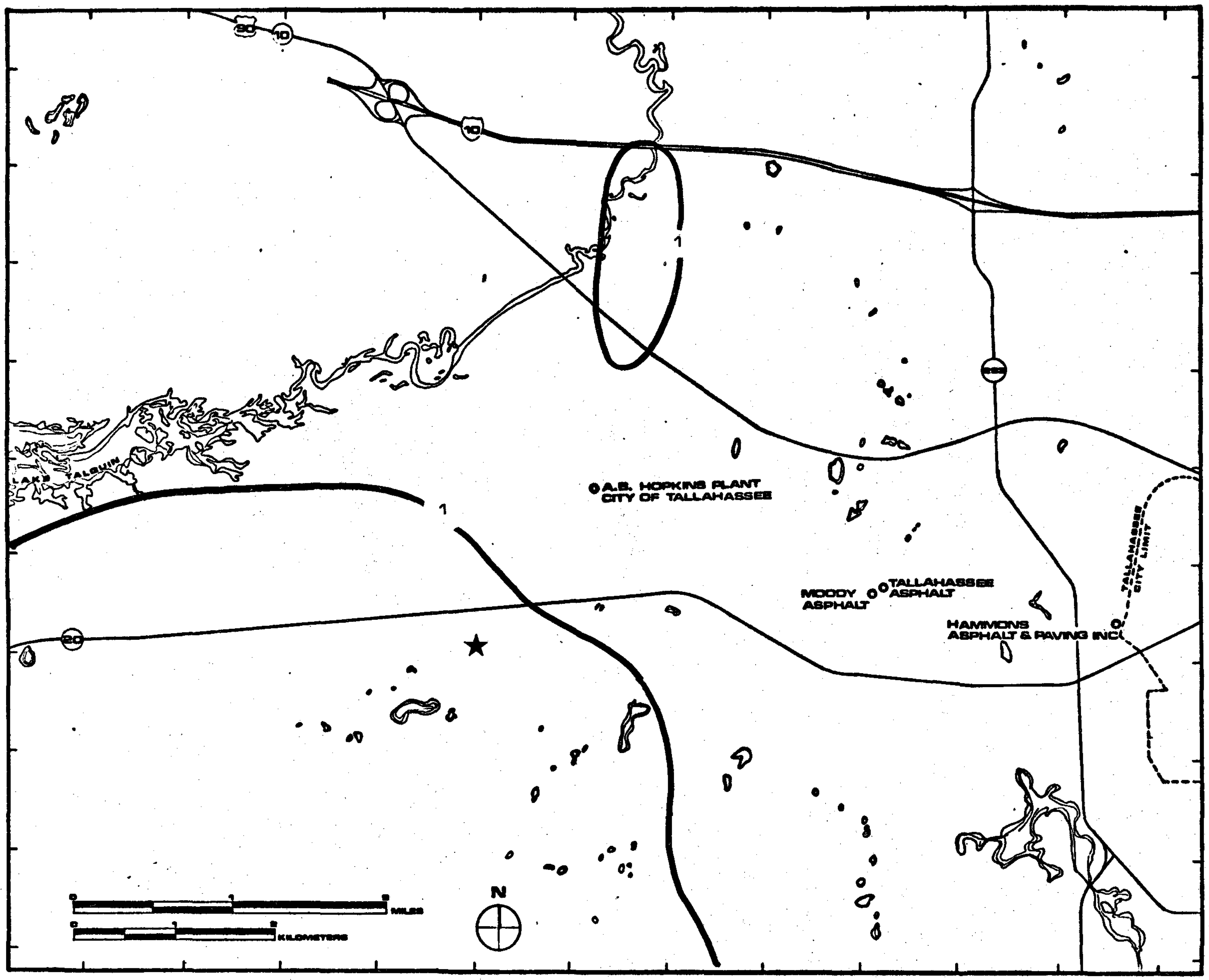
EXHIBIT V-7



Expected contribution of the proposed A. B. Hopkins Units 2 and 3 to ground-level concentrations of sulfur dioxide near the Hopkins site, Leon County, Florida, 1975 ($\mu g/m^3$).

★ Location of maximum incremental impact of Hopkins Units 2 and 3.

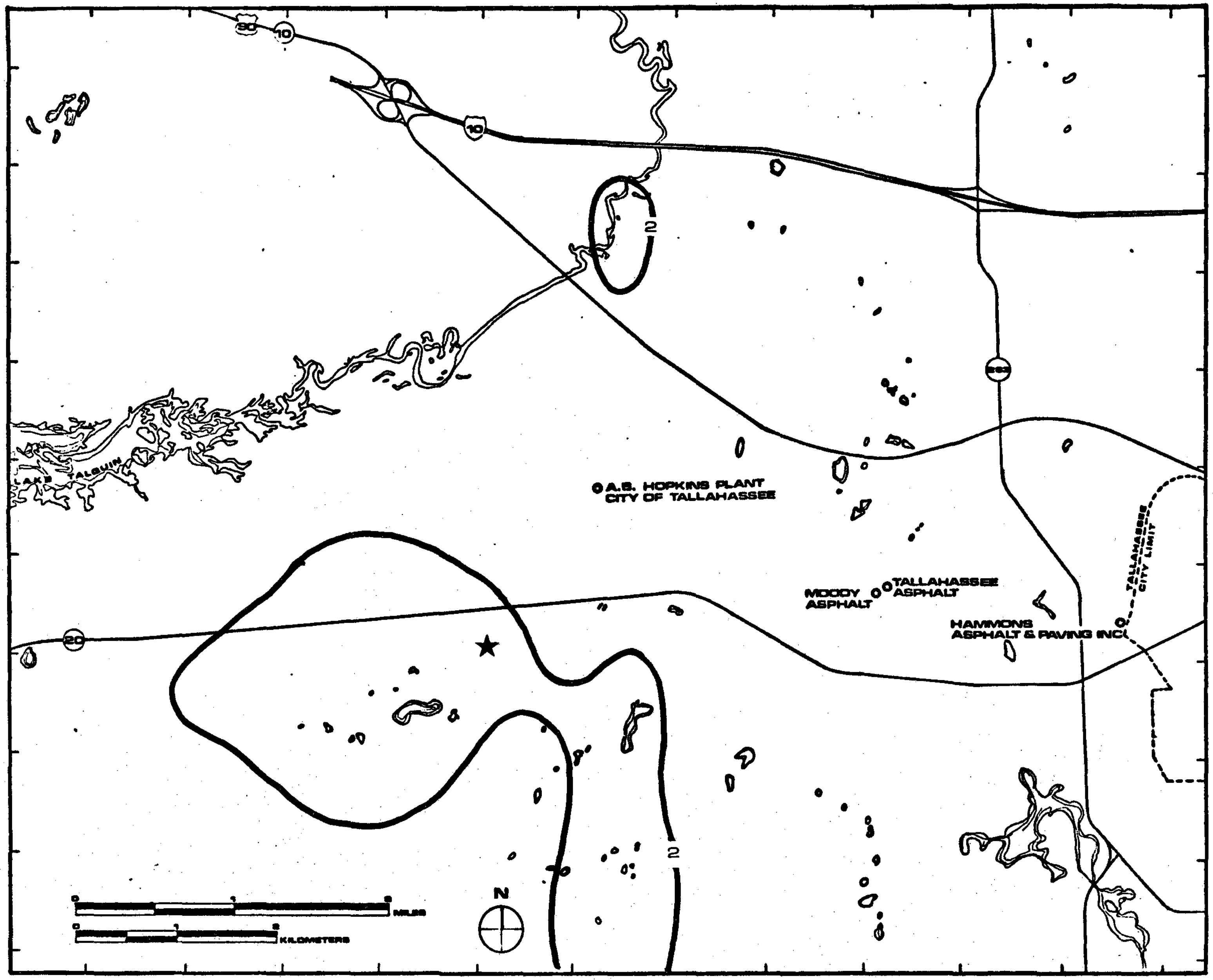
EXHIBIT V-8



Expected contribution of the proposed A. B. Hopkins Units 2 and 3 to ground-level concentrations of total suspended particulate matter near the Hopkins site, Leon County, Florida, 1975 (μg/m^3).

★ Location of maximum incremental impact of Hopkins Units 2 and 3.

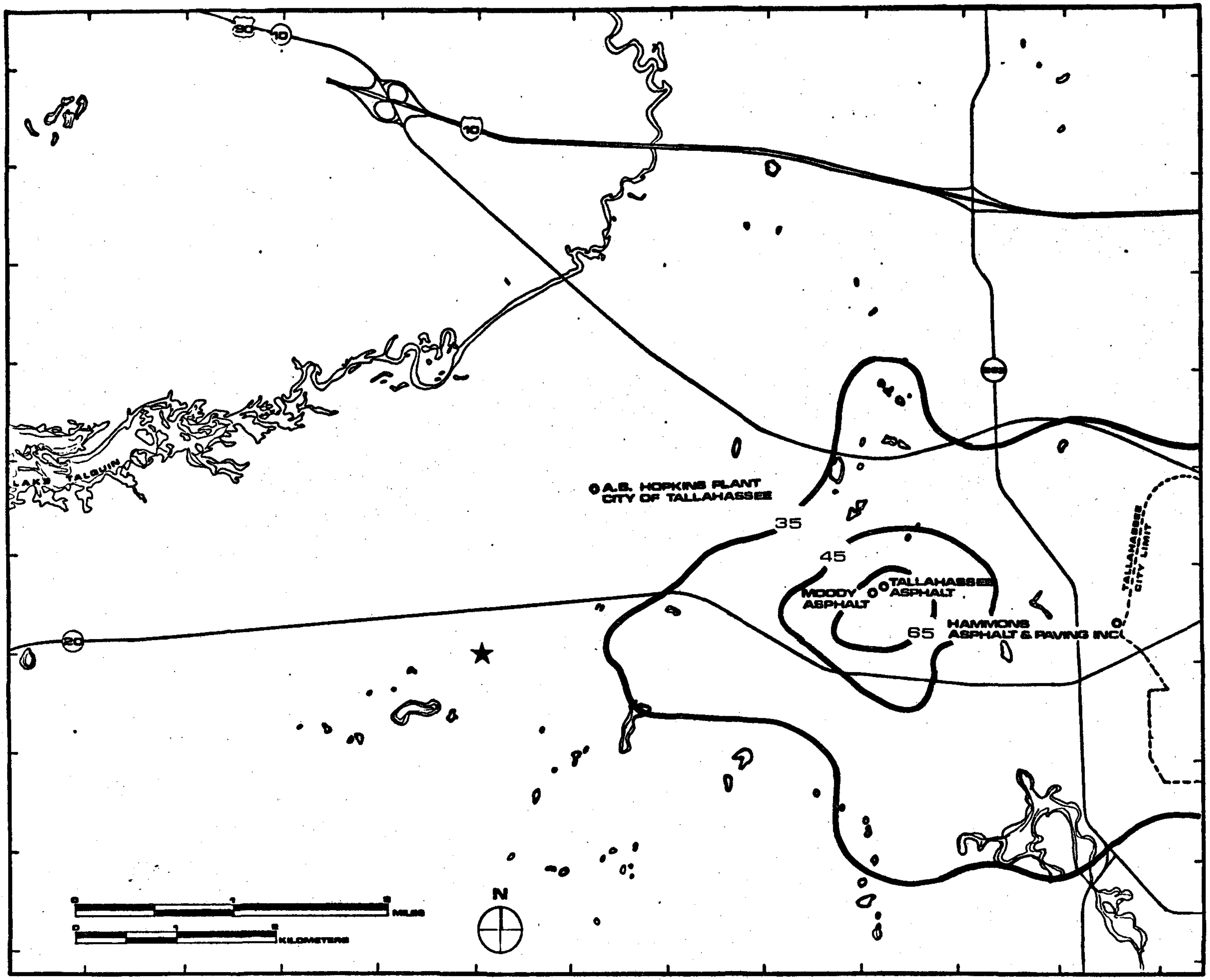
EXHIBIT V-9



Expected ground-level concentrations of sulfur dioxide near the site of the A. B. Hopkins Generating Station, Leon County, Florida, with existing sources and the proposed Hopkins Units 2 and 3 emitting at maximum permissible levels for 1975, ($\mu g/m^3$).

★ Location of maximum incremental impact of Hopkins Units 2 and 3.

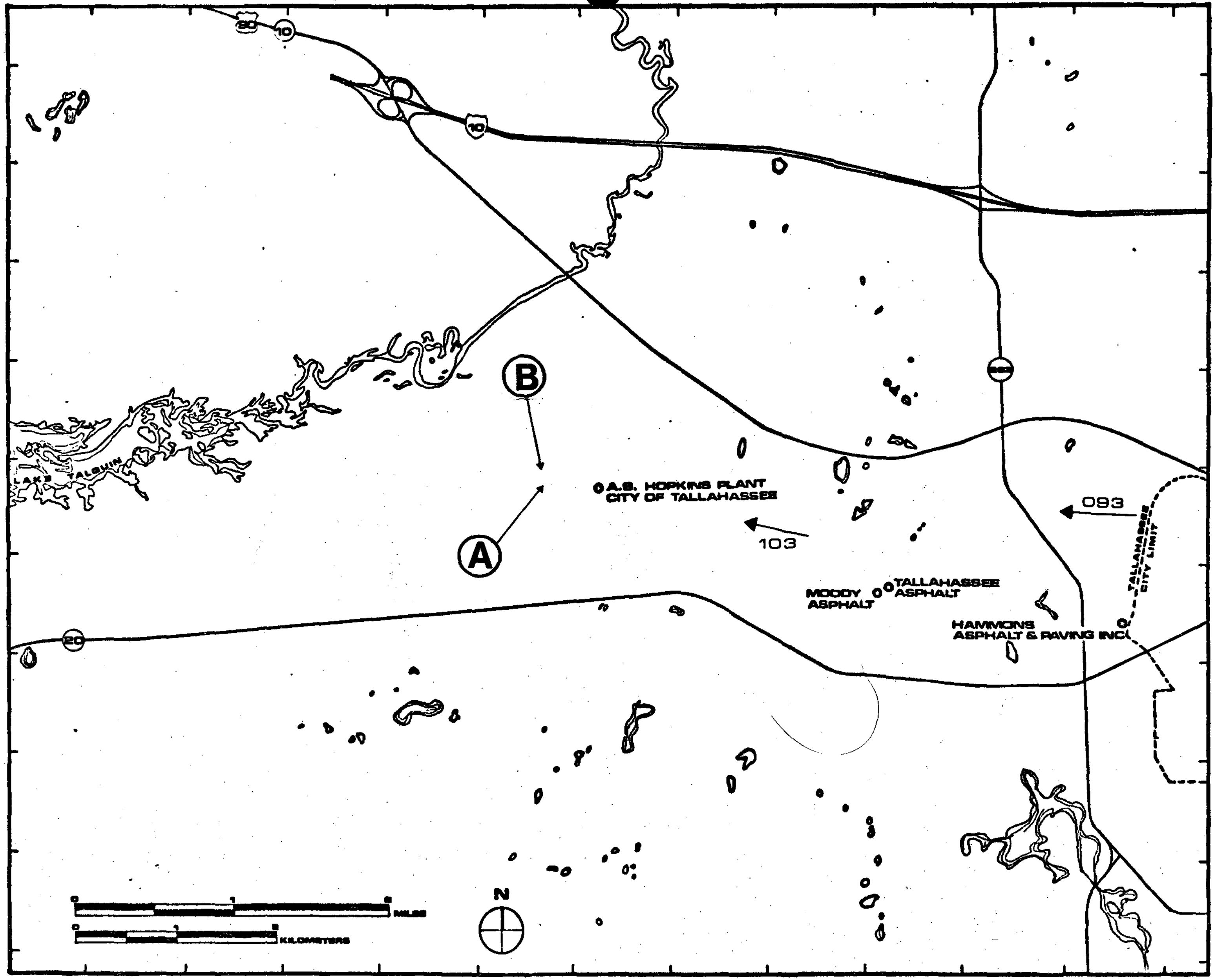
EXHIBIT V-10



Expected ground-level concentrations of total suspended particulate matter near the site of the A. B. Hopkins Generating Station, Leon County, Florida, with existing sources and the proposed Hopkins Units 2 and 3 emitting at maximum permissible levels for 1975, (μg/m^3).

★ Location of maximum incremental impact of Hopkins Units 2 and 3.

EXHIBIT V-11



Location of points of maximum incremental impact of Hopkins Units 2 and 3 on short-term pollutant concentrations.

A: SO_2 maxima. Wind direction = 093 degrees

B: Total suspended particulate matter maximum. Wind direction = 103 degrees

Table V-7 Ground-level concentrations of sulfur dioxide and total suspended particulate matter at the points of maximum contribution from the proposed A. B. Hopkins Units 2 and 3, ($\mu g/m^3$).

	Refer to Figure	Total Concentration ($\mu g/m^3$)	Increment From Hopkins 2 & 3 ($\mu g/m^3$)	Standard
<u>Sulfur Dioxide</u>				
Annual Average	5.4-3 & 5.4-5	2	2	60
24-Hour Average	5.4-7	26	24	260
3-Hour average	5.4-7	135	134	1300
<u>Total Suspended Particulate Matter</u>				
Annual Average	5.4-4 & 5.4-6	34	1	6~~5~~0
24-Hour Average	5.4-7	136	10	150

5.4.2 Discussion

The results shown in Table V-7 show that the impact of the proposed A. B. Hopkins Units 2 and 3 on the ambient air quality in Leon County would be minimal and that no violations of ambient air quality standards would occur as a result of their emissions. Since emission regulations for 1975 will reduce emissions of SO_2 from existing sources substantially, the Hopkins Station will be the major source of SO_2 in the area. However, the maximum annual average ground level concentration resulting from plant emissions will be only 2 $\mu g/m^3$. The maximum 24-hour average SO_2 concentration would be 26 $\mu g/m^3$ with the wind directed from other minor sources of SO_2 within the City of Tallahassee. Likewise, the maximum 3-hour average SO_2 concentration would be 135 $\mu g/m^3$. None of these concentrations exceed the ambient air quality standards for SO_2.

The maximum contribution of emissions of total suspended particulate matter from the Hopkins Units 2 and 3 to the annual average concentration of total suspended particulate matter is predicted to be only 1 $\mu g/m^3$. Note that the total concentration of 34 $\mu g/m^3$ shown in Table V-7 includes background. The 24-hour concentration near the site is predicted to be 136 $\mu g/m^3$ with the new sources contributing 10 $\mu g/m^3$.

As in the case for SO_2, none of the predicted concentrations of total suspended particulate matter near the site of the Hopkins Station exceed the ambient air quality standards for total suspended particulate matter.

5.4.3 Fogging Potential Impact Evaluation

Formation of fog in the atmosphere is caused by radiative or advective cooling of parcels of air. The atmosphere always contains some quantity of water vapor and at every temperature there is a definite limit to the amount of water vapor which the air will contain. The amount of water contained by the air divided by the amount it will contain at that temperature (expressed as a percent) is the relative humidity. As the air cools, the amount of water vapor present remains constant but the amount which the air will hold is decreased, and the relative humidity increases to the limit of 100 percent. Further decrease in temperature results in the removal of water vapor by condensation to liquid water droplets; fog formation. In fact, nature is not always constrained to follow the rules which men propose and condensation is possible at relative humidities less than 100 percent, and instances of supersaturation (relative humidity greater than 100 percent) occasionally are observed.

The exhaust from cooling towers is always warmer than the ambient air and is at or very near saturation. Therefore, when this exhaust is cooled by radiation to, or mixing with, the surrounding air some condensation occurs. As further mixing proceeds, re-evaporation of the initially condensed water vapor can occur if there is adequate water holding capacity (low relative humidity) in the surrounding air. The length of time and the geographic distance over which the plume will persist will depend on the relative humidity, temperature and wind speed of the surrounding air. Experience in the United States and Europe indicates that the plume rarely contributes to fogging and that it persists more than 100 yards downstream from the stack less than 15 percent of the time.

A qualitative classification of the potential for adverse cooling tower effects was made by EG&G, Inc., for the Environmental Protection Agency. The criteria selected are as follows:

(a) High Potential - Regions where heavy fog is observed over 45 days per year, where during October through March the maximum mixing depths are low (400-600m), and the frequency of low level inversions is at least 20-30 percent.

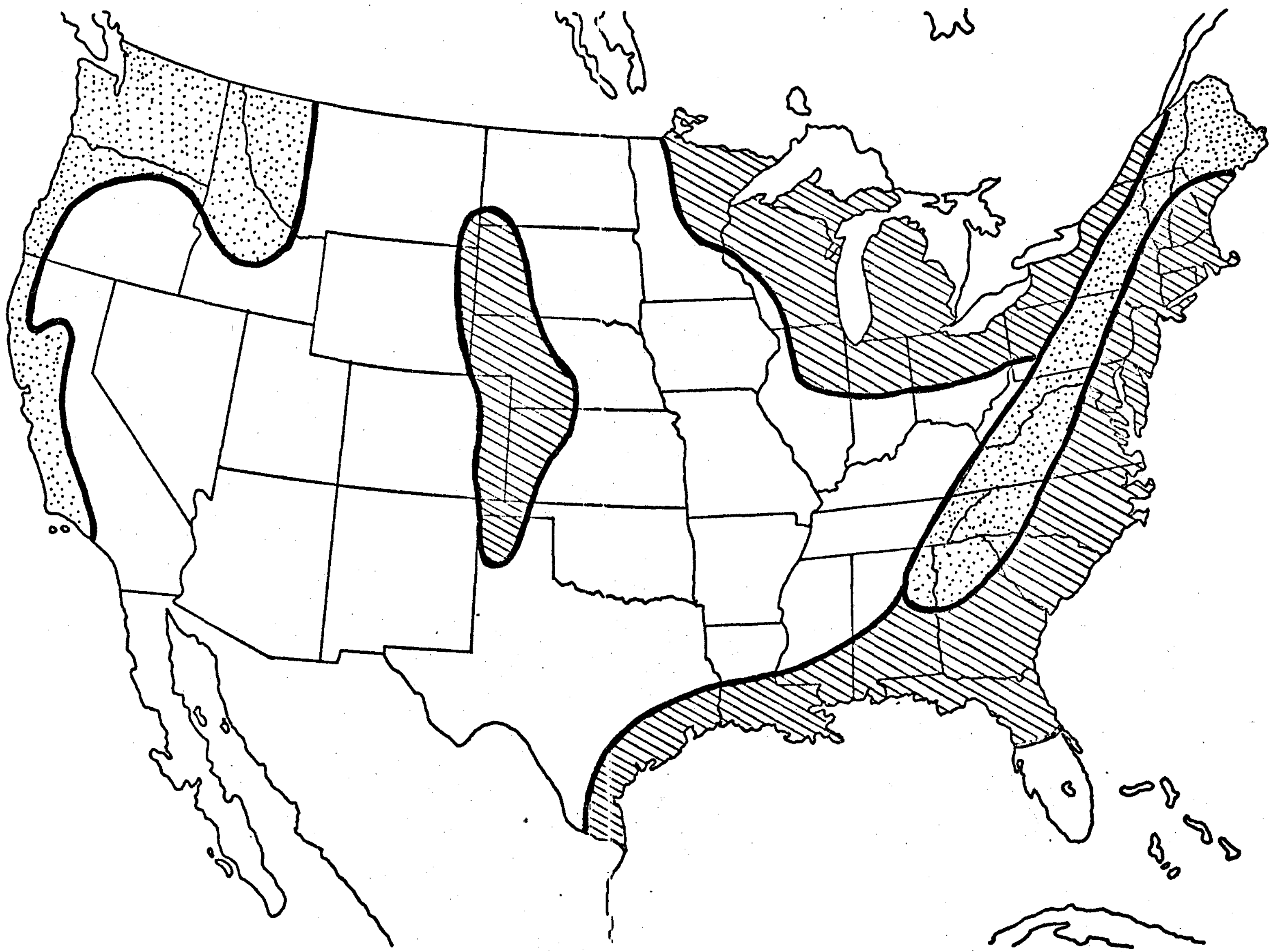
(b) Moderate Potential - Regions where heavy fog is observed over 20 days per year, where during October through March the maximum mixing depths are less than 600m, and the frequency of low level inversions is at least 20-30 percent.

(c) Low Potential - Regions where heavy fog is observed less than 20 days per year, and where October through March the maximum mixing depths are moderate to high (generally 600m).

The geographic regions in the United States which fall into these various classifications are shown in Exhibit V-12. Leon County, Florida is in a region of moderate fogging potential.

The gas which exits the cooling tower will be saturated with water vapor and have a temperature of about 100°F. During the initial stages of mixing with and dilution by ambient air, some condensation will occur; thus, there will

EXHIBIT V-12



High Potential

Moderate Potential

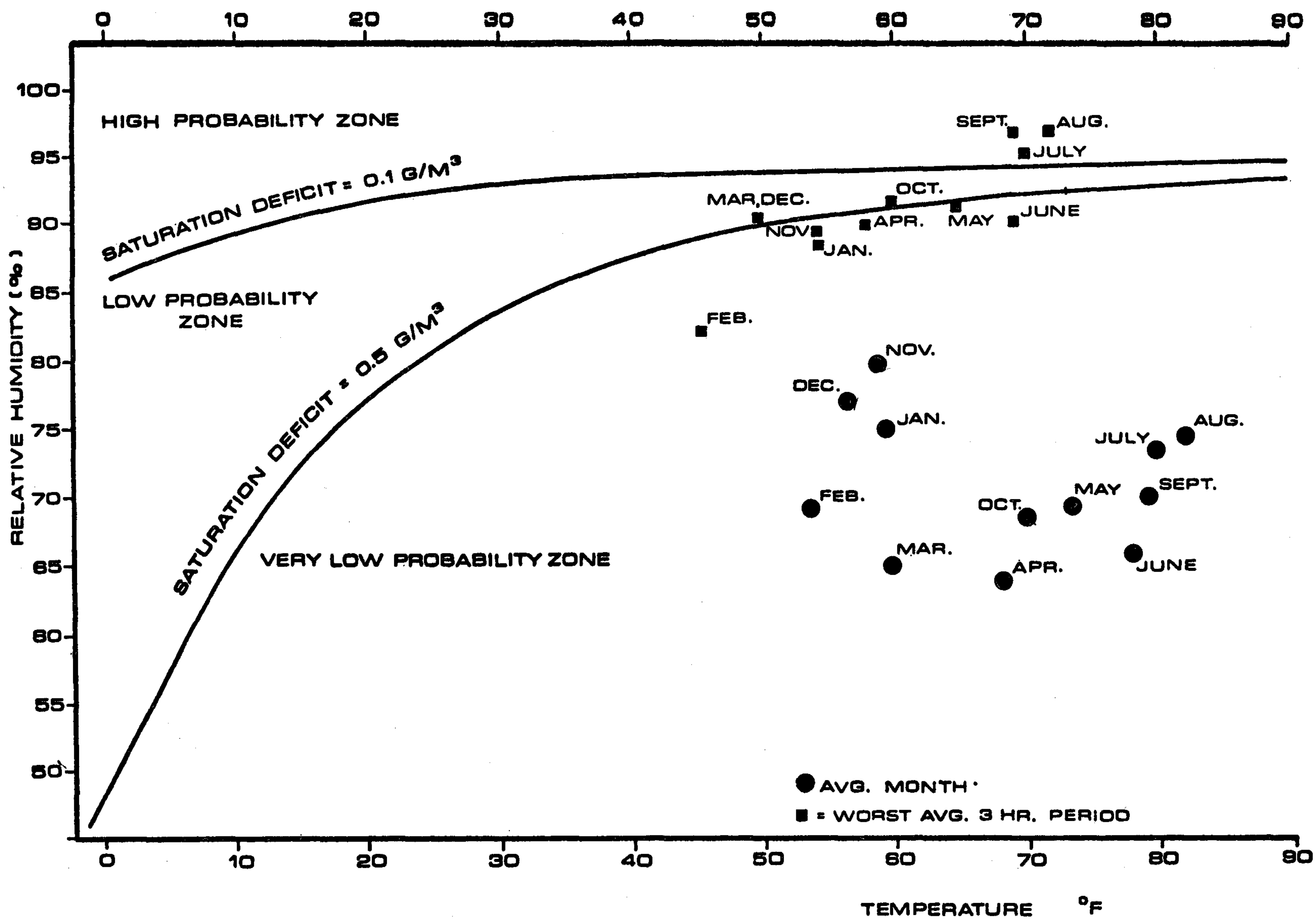
Slight Potential

Regions of fogging potential classifications in the United States. Geographical distribution of potential adverse effects from cooling towers based on fog, low-level inversion, and low mixing depth frequency.

usually be a visible plume at the cooling tower exhaust. As mixing and dilution continues, re-evaporation of the condensed water will begin and will continue until all of the moisture from the plume is re-evaporated. The amount of dilution required will depend on the saturation deficit of the ambient air. Saturation deficit is defined as the amount of water vapor the air will hold at saturation minus the amount it already contains. Therefore, when the saturation deficit is low (low temperature, high relative humidity), a large amount of dilution will be required before the ambient air will be able to absorb the moisture emitted from the cooling tower. This implies that the plume will occupy a large volume and cover a wide area before the re-evaporation is complete; and now we have a definition for a persistent, cooling tower induced fog.

It has been observed that there is a high probability of cooling tower induced ground fog formation when the saturation deficit of the ambient air is 0.1 g/m^3 or less. When the saturation deficit is 0.5 g/m^3 or more, the probability of fog formation is extremely low. Between these limits, there is a low probability of fog formation. The uppermost curve in Exhibit V-13 represents the relative humidity which results if 0.1 g/m^3 of water vapor is subtracted from saturated air at the temperatures shown. Thus, if a given condition of temperature and relative humidity fall on or above that line, the addition of water vapor by a cooling tower plume will very likely precipitate a fog. Conversely, if the temperature and relative humidity condition falls below the lower line (0.5 g/m^3 water deficit) a plume is very unlikely to precipitate a fog. The intermediate area (Zone B) represents the conditions for which a plume may precipitate a fog, but the probability is not high.

EXHIBIT V-13



Plot of saturation deficit versus temperature.

Also plotted are temperature and humidity data from 1972. The lower group of data are monthly averages. These data are all in the region of very low probability of fog formation. The upper group of points represent the worst average three-hour period (e.g. all data at 7:00 a.m. averaged over a month). All of these worst conditions fall between 4:00 a.m. and 10:00 a.m.

Table V-8 represents a summary of 3-hour averages of temperature and relative humidity from the Tallahassee weather station compared with Exhibit V-13. These data are grouped according to the existing weather conditions at the time of observation. The 217 cases of high fogging probability represent 7.43 percent of all hours during the year. Only 1.40 percent (41 cases) of the time would the cooling tower create a fog when no adverse weather condition existed. During 155 cases (5.31 percent) the tower would contribute to an existing fog, perhaps making it more persistent. Usually, fogs lift rather abruptly as solar heating breaks up the thermal stability of the atmosphere (about 9:00-10:00 a.m.) so this increased persistence would probably not be noticeable. The creation of a fogging potential during periods of rainfall would probably not result in the formation of fog because of the washing action of raindrops.

In addition to these hours of high fog potential there are 460 cases (15.75 percent) of relatively low fog potential. Only 209 cases (7.16 percent) of these times occur during times of clear weather. The cooling tower plume, because of its temperature and water vapor content, will in all cases be more buoyant than the surrounding air. This buoyancy will tend to keep the plume well elevated.

Table V-8 Probability of fog formation during periods of various weather conditions. Tallahassee, Florida, 1972. Numbers indicate occurrences of 3-hour averages.

	Clear		Rain		Rain and Fog		Ground-Fog and Haze		Drizzle and Fog		Fog		Ground Fog		Smoke and/or Haze		Total Occurrences	
Month	2[a]	3[b]	2	3	2	3	2	3	2	3	2	3	2	3	2	3	2	3
January	8	0	3	0	4	0	0	0	1	0	18	19	7	4	0	0	41	23
February	11	4	1	0	9	1	0	0	0	0	11	8	3	2	0	0	35	15
March	13	2	1	0	5	0	0	0	1	0	9	9	8	3	0	0	37	14
April	13	1	0	0	0	0	0	0	0	0	3	5	9	6	0	0	25	12
May	12	1	3	0	4	0	0	0	1	0	4	3	6	0	0	0	30	4
June	14	0	1	0	0	0	0	0	0	0	1	1	4	0	0	0	20	1
July	21	4	3	0	0	0	1	0	0	0	5	0	10	7	1	0	41	11
August	29	13	1	1	3	1	4	1	0	0	1	1	16	16	2	2	56	35
September	25	6	0	0	0	0	1	4	0	0	0	2	14	14	0	0	40	26
October	14	1	0	0	2	0	2	0	0	0	3	7	9	6	0	0	30	14
November	23	3	2	1	12	5	0	0	1	0	5	9	3	2	1	0	47	20
December	26	6	1	0	8	3	1	0	0	2	9	27	12	4	1	0	58	42
TOTALS	209	41	16	2	47	10	9	5	4	2	69	91	101	64	5	2	460	217

[a] 2-Low plume fogging potential

[b] 3- High plume fogging potential

It is expected that only a very small fraction of these cases will result in ground level fogging.

5.4.4 Conclusions

The results shown in the previous discussion indicate a minimal impact on ground level concentrations of SO_2 and total suspended particulate matter from the operation of Units 2 and 3 of the Hopkins Generating Station. The predicted concentrations near the station will be well below the ambient air quality standards for annual, 24-hour, and 3-hour averages. This would be the case even if a calibration factor of 1.0 were assumed for the prediction of SO_2 levels.

The evaluation of fogging potential near the site indicates that the cooling tower at the station would create a fog less than 2 percent of the time when no adverse weather conditions existed. And in these cases, the buoyancy of the plume from the tower would tend to keep it well elevated. Consequently, the effect of the cooling tower on fog formation near the station would only be slight.

5.4.5 Environmental Impact of Air Emissions on Terrestrial Plant Communities

Areas adjacent to the Hopkins plant were examined for signs of stunting, leaf blotching and reduced diversity according to the Air Pollution Control Association's publication on air pollution injury to vegetation (Berner, 1950). No impact could be observed in deciduous trees because leaf drop had occurred. No air pollution damage was noticed on coniferous species.

5.5 EFFECTS OF OPERATION AND MAINTENANCE OF THE ASSOCIATED TRANSMISSION SYSTEM

Effects of associated transmission lines are judged to be negligible.

5.6 OTHER EFFECTS

Increased road traffic resulting from plant personnel increases will cause an insignificant increase in vehicle induced wildlife deaths. Increased fogging potential should have no significant environmental impact.

Upstream river uses that may impact the lake were not evaluated.

Lake management practices such as scheduled drawdowns were not evaluated for impact or for their interaction with plant operational effects.

5.7 RESOURCES COMMITTED

Neither short-term nor long-term environmental losses associated with the project are regarded as involving a unique or ecologically significant structural or functional change to the regional environment. A zone in the vicinity of the blowdown outfall will be committed to natural treatment of the blowdown to make it compatible with the receiving system.

SECTION 6

SECTION 6 - ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 SURFACE WATERS

Flow measurements for the Ochlockonee River were obtained from historical flow records recorded at the gaging station near Havana as presented in 2.5.1 (a). To establish correlation between gaging station record flows and river flows at the point of discharge of the drainage ditch, a measurement of the river flow was made at the bridge on Highway 90. Measurement was made with a Price Model 667-E current meter, for suspended cable measurements.

Flow measurements on smaller streams for which historical records were not available were made using a Pygmy Model 625-D current meter.

Plant records were used to determine flow rate of discharge from the power plant.

Flow measurements of surface waters will be repeated at the time of the summer sampling period.

6.2 PHYSICAL AND CHEMICAL PARAMETERS

6.2.1 Water Collection

Ambient water samples were collected at mid-depth from the sample stations depicted in Exhibit II-17 by means of a Van Dorn water sampler. The cooling tower makeup and blowdown water samples were collected from the operating cooling system. All samples were returned to Environmental Science and Engineering, Inc. (ESE) laboratories in polyethylene containers. Preservatives were added as necessary. Samples collected for heavy metals analysis were acidified upon collection to a pH of approximately 2 by the addition of 2 ml sulfuric acid to 1 liter of water. Dissolved oxygen, pH and temperature were determined in situ.

6.2.2 Analytical Procedures

The analytical procedures used for the analysis of water samples are summarized in Table VI-1.

6.2.3 Scheduled Sampling Program

A water quality sampling excursion is scheduled for February, 1974. This excursion will be restricted to a concentrated study of the outfall creek. A downstream profile of temperature, dissolved oxygen concentration, pH, conductivity, sulfate concentration and residual chlorine concentration will be developed from the plant discharge downstream until ambient conditions are considered to have been attained. This sampling will be conducted during routine chlorination of the cooling tower and cooling system. Residual chlorine concentrations, both free and combined, will be determined on-site by the amperometric titration technique. Records will be obtained of the plant discharge rate and temperature during the study.

Another full-scale sampling excursion is scheduled for August, 1974. This excursion will be similar to that conducted on December, 1974. In situ water quality parameters will be determined and water samples will be collected from the 13 sample stations visited in December.

TABLE VI-1

PROCEDURES USED FOR WATER ANALYSIS

Analysis	Procedure/Instrumentation	Reference
Temperature	Mercury thermometer	-
DO	YSI[a] DO meter Model 54	Instrument Technical Manual
pH	Leeds and Northrup Model 7417 pH meter	Instrument Technical Manual
$SO_4^=$	Turbidimetric/Spectronic 20	SM[b] 156C
Cl^-	Mercuric nitrate	SM 112B
TOC/TIC	Bechman Model 915 TOC Analyzer	Instrument Technical Manual
NO_3^-	Brucine, sulfanilic acid	SM 213C
NH_3	Phenate	SM 132C
TON	Kjeldahl digestion/Orion ammonia electrode	SM 135
Total P	Persulfate digestion/ ascorbic acid method	SM 223C, 223F
Ortho P	0.45 μm filtration/ascorbic acid method	SM 223F
Zn,Fe,Cu	Atomic absorption spectrophotometry/Perkin-Elmer 503	Instrument Technical Manual
Hg	Flameless atomic absorption spectrophotometry/Perkin-Elmer 503	Instrument Technical Manual
Conductivity	Labline Conductivity Meter Model MC-1	Instrument Technical Manual

[a] Yellow Springs Instrument Company

[b] Standard Methods for the Examination of Water and Wastewater, 13th Ed., 1971, Method number indicated.

6.3 ECOLOGICAL PARAMETERS

6.3.1 Terrestrial Methods

Ground truthing of aerial photographs was used to delineate boundaries of various plant associations. Vegetation maps were prepared from these aerials and from the Midway quadrangle.

Plant transects were conducted to furnish quantitative data on the tree species composition of major associations. Fifty by 20-foot areas were randomly chosen and all tree species were recorded as well as their diameter at breast height (dbh). Importance values were calculated for each species by summing relative density, relative dominance (basal area), and relative frequency values (Bourelly, 1968). The maximum value for each of these components is 100. Three hundred is the maximum importance value and occurs only in monospecific stands.

Plant species were identified by recognized taxonomic keys (Brockman and Merrilees, 1968; Burt and Grossenheeder, 1964; Clewell, 1971; Conant, 1968; Conrad, 1969; Petrides, 1972; Radford, Ahles and Bell, 1968; Robins, Brunn and Zom, 1966; Sprunt, 1964) and listed for each association (Table II-10). Animal species sighted or expected are listed in Table II-7. Literature reviews (Conant, 1968; Robbins, Bruun and Zom, 1966; Sprunt, 1964; Whittaker, 1968) and field sightings were used to determine which animal species were important to the area.

6.3.2 Aquatic Parameters

Program parameters for collection and analysis during the winter survey on December 7 and 8, 1973, were periphyton, phytoplankton, and benthos. A second sampling period to survey the periphyton, phytoplankton, benthos and fish is planned during the summer.

The following procedures were utilized for sample collection, preservation, and analyses during the winter survey. During the summer survey, methods will remain the same although sampling sites 4, 5, 6, and 8 will be added and sampling sites 9, 10, 11, 12, and 13 will be deleted (Table VI-2, Exhibit II-17).

(a) Periphyton - Periphyton samples were collected in duplicate from natural substrates at three stations in the outfall canal (1, 2, and 3), four stations in Ochlockonee River (7, 9, 10, and 11) and two stations in Lake Talquin (12 and 13). Summer collection will be made at Stations 1 through 8. All samples will be preserved in three percent formalin. Samples are split into diatom and nondiatom fractions for analysis. The diatom fraction is cleaned using an oxidant of H_2O_2 and $K_2Cr_2O_7$ according to Van Der Werff (1955). This process allows identification of the siliceous frustules using oil emersion techniques at 1000X. Permanent Hyrax mounts of the cleaned diatoms are made for future reference. Each diatom species observed is counted and identified using standard toxonomic keys (Patrick & Reimer, 1966; Hustedt, 1928; Bacillariophyta (Diatomeae), 1930; Die Kieselalgen Deutschlands, 1961; Die Kieselalgen Deutschlands, 1962; Schmidt, 1959-1974; Van Heurck, 1880-1883; Whitford and Schumacher, 1969).

TABLE VI-2

PARAMETERS, STATIONS AND SAMPLING FREQUENCIES FOR THE A. B. HOPKINS STATION PRECONSTRUCTION AQUATIC ASSESSMENT

	Station No.												
	Outfall Creek						Ochlockonee River					Lake Talquin	
Study Element	1	2	3	4	5	6	7	8	9	10	11	12	13
Periphyton	W,S[a]	W,S	W,S	S	S	S	W,S	S	W	W	W	W	W
Phytoplankton		W			S	S	S	S	W	W		W	W
Benthos	W,S	W,S	W,S	S	S	S	W,S	S		W	W	W	W
Fish	S	S	S	S	S	S	S	S					

[a]W, winter collection (December 7-8, 1973); S, proposed summer sampling (August, 1974)

(b) Phytoplankton - Winter phytoplankton grab samples were collected in duplicate at Station 2 in the outfall canal, Stations 7, 9, and 10 in the river and Stations 12 and 13 in Lake Talquin. A sample volume of 950 ml will be preserved with 50 ml of 4 percent formalin and returned to the laboratory for processing. Summer samples will be collected at Stations 5 through 8.

Samples were split into diatom and nondiatom fractions for analysis. The diatom fraction was treated with the $H_2O_2/K_2Cr_2O_7$ reagent and permanently mounted.

Phytoplankton were identified to species and enumerated. The nondiatom fraction was concentrated according to the Utermohl (1952) settling technique. Identification and counts were made using an inverted microscope. Standard taxonomic keys were used in the identifications (Bourelly, 1968; Cocke, 1967; Drouet and Daily, 1956; Drouet, 1968; Hustedt, 1928; Bacillariophyta (Diatomeae), 1930; Patrick and Reimer, 1966; Prescott, 1962; Schmidt, 1959-1974; Smith, 1950; Tiffany, 1952; Whitford and Schumacher, 1969).

(c) Benthos - Winter benthic invertebrates were collected from three station locations in the outfall canal (1, 2, and 3), three stations in the Ochlockonee River (7, 10, and 11), and two stations in Lake Talquin (12 and 13). Summer samples will be collected at Stations 1 through 8. Samples are taken in duplicate using a Ponar dredge and strained through a No. 30 U. S. Standard Sieve (0.59 mm). Benthic invertebrates and detritus are stained with rose bengal, preserved in a 10 percent solution of formalin, and returned to the laboratory for further processing and analysis. Organisms were sorted by hand under low magnification and preserved in 95 percent ethylalcohol. Chironomids are permanently mounted on slides using Garr's polyvinyl lactophenol. Population densities and species determinations are made using standard techniques (Berner, 1950; Burks, 1953; Byers, 1930; Johannsen, 1934; Mason, 1968; Parrish, 1968; Pennak, 1953; Ross, 1944; Unsinger, 1963; Ward and Whipple, 1959; and Weber, 1973).

(d) Fisheries - Sampling of fish populations will be carried out at Stations 1 through 8 during the summer field survey.

Qualitative fish sampling will occur at eight stations. Sampling gear will include the use of various sized minnow seines and traps. Under special conditions, the use of rotenone may be employed. Field studies of collected fish will include: (1) species present, (2) relative and absolute abundance of each species, (3) size distribution, and (4) species diversity.

The methodology proposed herein conforms with the U. S. EPA's manual entitled Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents, 1956, which is the methodology suggested by the Department of Pollution Control. Collected data will be compared to available information obtained from the 1972-1973 Game and Freshwater Fish Commission study on Lake Talquin.

6.4 AIR

6.4.1 Introduction

The requirements of the air quality impact evaluation, as established by the FDPC and the Environmental Protection Agency (EPA), include both a long-term impact evaluation--that is, an annual average air quality impact evaluation--and a short-term impact evaluation--the impact averaged over a period of time from three hours to 24 hours. These requirements were met by this study and the assumptions that were used in doing so, while stringent, are the same assumptions that would be used by EPA or any other agency when reviewing this study. Predictions of ground-level pollutant concentrations were made for the year 1975 in order to reflect existing source emission regulations that become effective that year.

The evaluation of fogging potential for the area was approached from the standpoint of a percentage of time when a cooling tower at the site would create a fog or augment an existing fog. Local climatological data from the Tallahassee weather bureau were used for the fogging potential study.

6.4.2 Applicable, Regulatory Standards

The models described in Section 6.4.3 calculate arithmetic mean pollutant concentrations. In order to determine the effect of pollutant emissions on ambient air quality, these calculated concentrations are compared to state and federal ambient air quality standards. Since the Florida Department of Pollution Control standards are equally as, or more stringent than, Federal EPA standards, comparisons will be made to the Florida standards for SO_2 and total suspended particulate matter which are listed in Table VI-3. Note that the value of 60 μg/m^3 for the annual standard for total suspended particulate matter is a geometric mean. Reference is made in this report to the annual total suspended particulate matter standard as being 65 μg/m^3. This figure is an arithmetic mean concentration corresponding to the geometric mean of 60 μg/m^3 which is in accordance with the definition of the annual standard.

TABLE VI-3

FLORIDA DEPARTMENT OF POLLUTION CONTROL
AMBIENT AIR QUALITY STANDARDS FOR SULFUR DIOXIDE
AND TOTAL SUSPENDED PARTICULATE MATTER (μg/m^3)

	Sulfur Dioxide	Total Suspended Particulate Matter
Annual Standard	60	60[a]
24-Hour Standard	260	150
3-Hour Standard	1,300	None

[a] Geometric mean - corresponding to arithmetic mean of 65 μg/m^3.

6.4.3 Description of Models

The Air Quality Display Model (AQDM) was developed by the EPA and is an approved technique for computing annual average ground level concentrations of gaseous and particulate pollutants. The AQDM uses the Pasquill-Gifford diffusion equation and Holland's plume rise equation to simulate plume behavior. Using an annual average emission inventory, actual stack data and annual average meteorological data, ground level concentrations are calculated both at assigned receptor points and at points comprising a receptor grid network. The model may be used to predict ambient air quality for any annual time period, once calibrated, by adjusting the input data to correspond to the time period of interest.

The short-term models used in the modeling program were the PTMTP and the PTMAX, also developed by the EPA and available through the EPA UNAMAP system. The EPA 24-hour power plant model was not available for use during the time that this study was conducted.

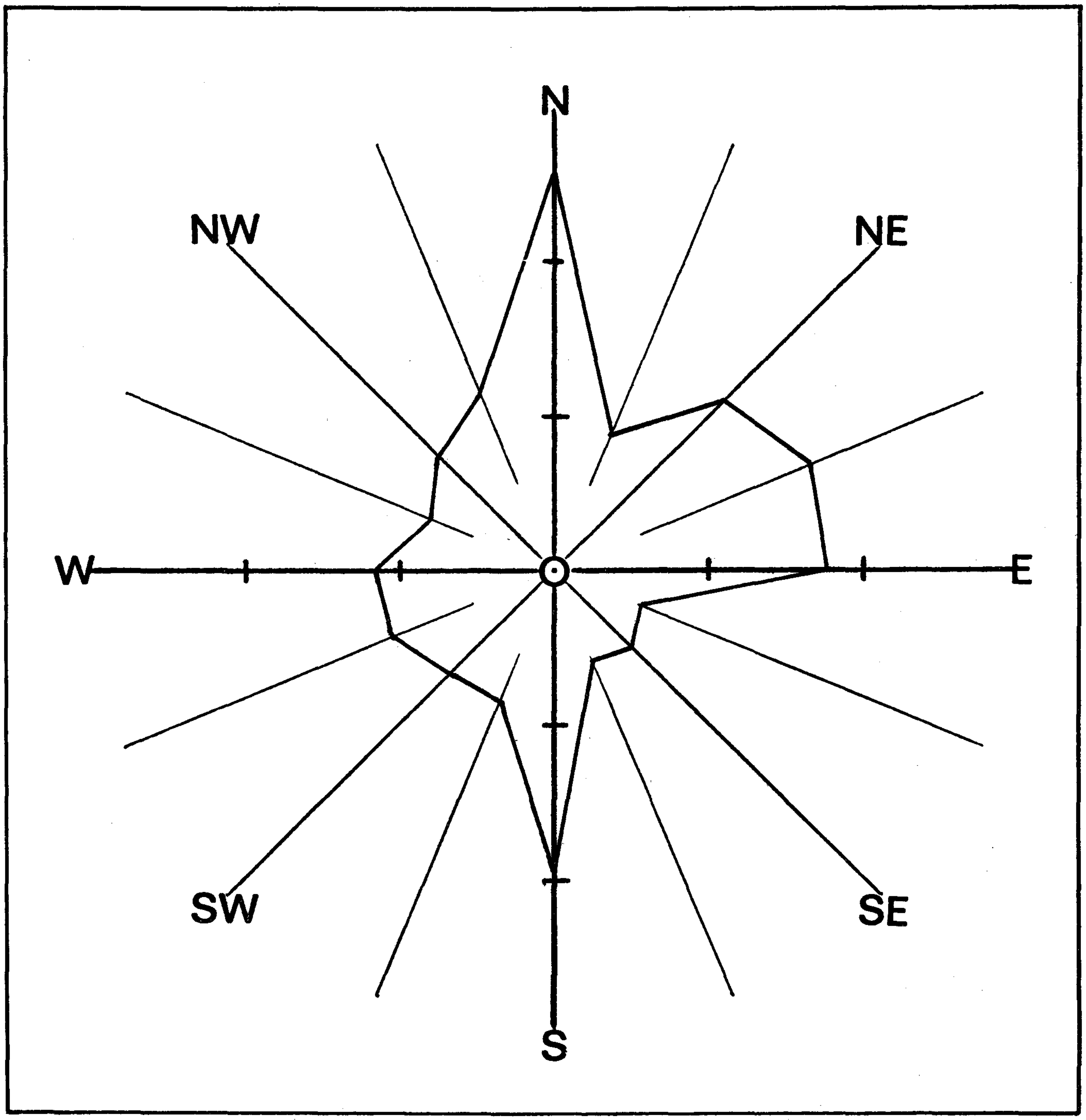
The PTMTP uses an hourly average emission inventory, stack data, and hourly meteorological data to calculate hourly ground level concentrations. These hourly ground level concentrations can, in turn, be averaged over a 3-hour or a 24-hour period to obtain averages for these periods of time. It is possible to use the PTMTP to calculate hourly concentrations for 365 days and average these in order to determine an annual average concentration. This latter approach was not used in this study because the cost would be prohibitive and because of time limitations.

The PTMAX uses input data similar to that used in the PTMTP to calculate maximum pollutant concentrations as a function of wind speed and stability class for emissions from a given stack. Output from the PTMAX was used to construct "worst case" meteorological conditions for use in the PTMTP.

Since annual average meteorological conditions do not vary appreciably from year to year, the maximum annual average concentrations for 1975 for the study area were obtained directly from the AQDM using annual meteorological data for Tallahassee for the year 1972. These meteorological data are reflected in the annual wind rose for Tallahassee which is shown in Exhibit VI-1. Since the meteorological conditions vary considerably from day to day, however, the maximum expected 24-hour concentrations were calculated with the PTMTP by assuming typical worst day conditions. The assumptions for worst day conditions are consistent with assumptions used by EPA and do represent conditions that could and probably do exist in Leon County on occasion. These conditions assumed that the winds are randomly distributed over a 10-degree sector for 24 hours and that the wind was directed in such a way that the maximum probable contribution from several stacks would combine to produce the maximum expected ground level SO_2 and total suspended particulate matter concentrations. Similar worst case conditions were assumed for the calculation of the 3-hour maximum concentration.

6.4.4 Calibration of the Models

The term "calibration of dispersion models" has been alluded to in this report and the question may arise, "What is calibration and why is it necessary?" Dispersion models, whether long-term or short-term models, are strictly a mathematical attempt to simulate the transport and dispersion of air pollutants between a source and a receptor. These models assume that steady-state conditions exist over a certain period of time, whether it be one hour, 24 hours, or even longer periods. This is a gross simplification since emission conditions and meteorological conditions vary continually and randomly. Since the dispersion model uses steady-state conditions to approximate or simulate the randomly varying meteorological and emission conditions, the predicted ground level concentrations generated by the dispersion model may



Annual wind rose for Tallahassee for 1972, including all stabilities.

Scale: 1 inch = 5%

EXHIBIT VI-1

over-estimate ground level concentrations of a pollutant. To compensate for this over-calculation but still retain a model that is feasible and practical to use, a calibration step is required. The calibration is accomplished by measuring ambient concentrations of the pollutant of interest under known meteorological conditions and emission conditions. These known meteorological conditions and emission conditions are then used as input to a dispersion model and ground level concentrations are calculated. The calculated ground level concentrations are then compared with measured ground level concentrations and a ratio between the two is obtained. For example, if it assumed that the calculated ground level concentration is five times the observed concentration, the calibration factor would be one-fifth or 0.2. This calibration factor is then used as another input to the dispersion model and all calculated ground level concentrations are multiplied by this calibration factor in order to obtain a realistic simulation of conditions as they would exist. This example is an oversimplification since actual calibration factors are usually obtained by applying a mathematical regression analysis to several sets of calculated and observed concentrations.

Calibration factors may differ from location to location, from one pollutant to another, and between long-term and short-term models. ESE has experienced long-term calibrations which vary from 0.5 to 1.0 for suspended particulate matter and from 0.15 to 0.25 for SO_2. Short-term calibrations for SO_2 have been found to vary from 0.2 to 0.3. No short-term calibration has been made for suspended particulate matter. In order to be conservative, ESE has assumed long-term calibrations of 1.0 for total suspended particulate matter and 0.25 for SO_2, and short-term calibrations of 1.0 for total suspended particulate matter and 0.3 for SO_2.

No measurable background concentration for SO_2 exists in the state of Florida. However, background levels for total suspended particulate matter will range from 20 to 30 $\mu g/m^3$. Since no significant sources of fugitive dust exist near the site, a background concentration of 30 $\mu g/m^3$ was assumed for total suspended particulate matter. No background concentration was assumed for SO_2.

BIBLIOGRAPHY

Air Pollution Control Association, 1970. Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas. Air Pollution Control Association, Pittsburgh, Pennsylvania.

Berner, L., 1950. The Mayflies of Florida, University of Florida. University of Florida Press, Gainesville, Florida, 267 p.

Bourelly, P., 1966-1968. Les alques d'eau doce, Tome I-III, Boubee and Al, Paris, 434 p.

Brockman, C. F., and R. Merrilees, 1968. Trees of North American, Golden Press, New York, New York.

Burks, B. D. The Mayflies or Ephemeroptera of Illinois, Bulletin 111, Natural Hist. Surv. 26:1-216.

Burt, W. H. and R. P. Grossenheeder, 1964. A Field Guide to the Mammals, Houghton Mifflin Company, Boston, Massachusetts, 284 p.

Byers, C. F., 1930. A Contribution to the Knowledge of Florida Odonata, Univer-sity of Florida Biological Science Service, 1(1):1-327.

Cairns, J., Jr., 1956. Effects of Increased Temperature on Aquatic Organisms, Ind. Wastes. 1(4):150-152.

City of Tallahassee Electric Power Production Department, 1973. Long-Range Fuel Oil Supply Report.

Clewell, A. F., 1971. The Vegetation of the Appalachicola National Forest: An Ecological Perspective, U. S. Department of Agriculture/Forest Service Publication, 152 p.

Cocke, E. C., 1967. The Myxophyceae of North Carolina, Wake Forest University, Winston-Salem, 201 p.

Conant, R., 1968. A Field Guide to Reptiles and Amphibians, Houghton Mifflin Company, Boston, Mass., 365 p.

Conard, H. S., 1969. Plants of Central Florida, Ridge Audubon Society, Lake Wales, Florida, 143 p.

Craighead, F. L., Sr., 1971. The Trees of South Florida, University of Miami Press, Coral Gables, Florida, 212 p.

Drouet, F. and W. A. Dailey, 1956. Revision of the Cocoid Myxophyceae, Butler University Bot. Stud., Volume 12, 218 p.

Drouet, F., 1968. Revision of the Classification of the Oscillatoriaceae, Academic Natural Science, Philadelphia, Penn., 340 p.

Fasset, N. C. and E. C. Odgen, 1957. A Manual of Aquatic Plants, University of Wisconsin Press, Madison, 405 p.

Harrar, E. S. and T. G. Harrar, 1972. Guide to Southern Trees, Dover Publications, Inc., New York, New York, 709 p.

Heath, R. C. and E. T. Wimberly, 1971. Selected Flow Characteristics of Florida Streams and Canals, Information Circular No. 69, Florida Department of Natural Resources, Tallahassee, Florida.

Hendry, C. W. and Sproul, C. R., 1966. Geology and Ground-Water Resources of Leon County, Florida, Bulletin No. 47, State of Florida, State Board of Conservation, Division of Geology, Florida Geological Survey.

Hitchcock, A. S., 1971. Manual of the Grasses of the United States, Dover Publications, Inc., New York, New York, 1051 p.

Hustedt, F., 1928. Die Kieselalgen Deutschlands, Osterreichs und der Schweiz unter Berucksichtingung der ubrigen Lander Europas sowie der angrenzenden Meersgebiete. In L. Rabenhorst, ed. Kryptogamenflora von Deutschland, Osterreich und der Schweiz. Band 7, Teil 1, Lieferung 2. Akademische Verlagsgesellschaft Geest und Portig K.-G., Leipzig, Deutschland, 191 p.

1930. Bacillariophyta (Diatomeae). In A. Pascher, Ed. Die Susswasser-Flora Mitteleuropas. Heft 10. Gustav Fischer Verlag, Jena., 466 p.

1961. Die Kieselalgen Deutschlands, Osterreichs und der Schweiz unter Berucksichtigung der ubrigen Lander Europas sowie der angrenzenden Meersgebiete. In L. Rabenhorst, ed. Kryptogamenflora von Deutschland, Osterreich und der Schweiz. Band 7, Teil 3, Lieferung 1. Akademische Verlagsgesellschaft Geest and Portig K.-G. Leipzig, Deutschland, 160 p.

1962. Die Kieselalgen Deutschlands, Osterreichs und der Schweiz unter Berucksichtigung der ubrigen Lander Europas sowie der angrenzender Meersgebiete. In L. Rabenhorst, ed. Kryptogamenflora von Deutschland, Osterreich un der Scweiz. Band 7, Teil 3, Lieferung 2. Akademische Verlagsgesellschaft Geest and Portig K.-G., Leipzig, Deutschland, 187 p.

Hynes, H.B.N., 1972. The Ecology of Running Waters, University of Toronto Press, 518 p.

Johannsen, O. A., 1937. Aquatic Diptera, Part III. Chironomidae: Subfamilies Tanypodinae, Diamesinae, and Orthocladiinae, Me. Cornell University of Agricultural Exp. Sta. 205:1-84.

1937. Aquatic Dipera, Part IV, Chironomidae: Subfamily Chironomidae, Ibid, 210:1-56.

Kendeigh, S. C., 1961. Animal Ecology, Prentice-Hall Inc., Engelwood Cliffs, New Jersey, 468 p.

Kurz, H. and R. K. Godfrey, 1962. Trees of Northern Florida, University of Florida Press, Gainesville, Florida, 311 p.

Long, R. W. and O. Lakela, 1971. A Flora of Tropical Florida, University of Miami Press, Coral Gables, Florida, 962 p.

Mason, W. T., Jr., 1968. An Introduction to the Identification of Chironomid Larvae, FWPCA, U. S. Dept. of Interior, Cincinnati, Ohio

McKee, J.E. and H. W. Wolf, 1971. Water Quality Criteria, (2nd Edition) State Water Resources Control Board, California, 548 p.

Muenscher, W. C., 1944. Aquatic Plants of the United States, Comstock Publishing Company, Inc., Ithaca, New York, 374 p.

Odum, E. P., 1971. Fundamentals of Ecology, 3rd Edition, W. B. Saunders Company, Philadelphia, p. 149, 574 p.

Parrish, F. K. (Ed.), 1968. Key to Water Quality Indicative Organisms (Southeastern United States), FWPCA, Department of Interior, Atlanta, Georgia.

Patrick, R. and C. W. Reimer, 1966. The Diatoms of the United States, Volume 1, Academy of Natural Sciences of Philadelphia Monograph No. 13, 688 p.

Pennak, R. W., 1953. Fresh Water Invertebrates of the United States, Ronald Press Co., New York, 769 p.

Petrides, G. A., 1972. A Field Guide to Trees and Shrubs, Houghton Mifflin Company, Boston, Mass., 428 p.

Prescott, G. W., 1962. Algae of the Western Great Lakes Area, (2nd Edition), W. C. Brown, Dubuque, 963 p.

Prosser, C. C., and F. A. Brown, Jr., 1961. Comparative Animal Physiology, (2nd Edition), W. B. Saunders Company, Philadelphia, 688 p.

Radford, A. E., H. E. Ahles, and C. R. Bell, 1968. Manual of the Vascular Flora of the Carolinas, University of North Carolina Press, Chapel Hill, North Carolina.

Rickett, H. W., 1967. Wildflowers of the United States. McGraw-Hill Book Company, New York, New York, 688 p.

Ross, H. H., 1944. The Coddisflies or Trichoptera of Illinois, Bull. Ill, Nat. Hist. Surv. 23:1-326.

Rossie, J. P., 1972. Dry Cooling Towers, Lecture at M.I.T. Summer Session, June 26-30, 1972, Engineering Aspects of Heat Disposal From Power Generation.

Robbins, C. S., B. Bruun and H. S. Zom, 1966. A Guide to Field Identifications: Birds of North America, Golden Press, New York, New York, 340 p.

Schmidt, A., et. ag., 1974-1959. Atlas der Diatomaceen-Kunde. R. Reisland, Leipzig. Heft 1-120, Tafeln 1-480. (Tafeln 1-212, A. Schmidt, 1874-1897; Tafeln 213-216, M. Schmidt, 1899; Tafeln 217-232, Fr. Fricke, 1899-1902; Tafeln 233-240, M. Schmidt and Fr. Fricke, 1902; 241-244, H. Heiden, 1903; Tafeln 245-246, O. Muller, 1904; Tafeln 247-248, M. Schmidt and Fr. Fricke, 1904; Tafeln 249-256, Fr. Fricke, 1904-1905; Tafeln 257-264, H. Heiden, 1905-1906; Tafeln 265, Fr. Fricke, 1906; Tafeln 266, M. Schmidt and Fr. Fricke, 1906; Tafeln 267-268, Fr. Fricke, 1906; Tafeln 269-274, Fr. Hustedt, 1911; Tafeln 275-277, Fr. Fricke and Fr. Hustedt, 1911-1912; Tafeln 278-283, Fr. Hustedt, 1912; Tafeln 284, Fr. Fricke and Fr. Hustedt, 1912; Tafeln 285-290, Fr. Hustedt, 1913; Tafeln 291, Fr. Fricke and Fr. Hustedt, 1913; Tafeln 292-420, Fr. Hustedt, 1913-1958; Tafeln 421-432 not issued; Tafeln 433-480, Fr. Hustedt, 1940-1959).

Schumacher, F. X., and R. A. Chapman, 1949. Sampling Methods of Forestry and Range Management. Duke University School of Forestry Bulletin.

Smith, G. M., 1950. The Freshwater Algae of the United States, (2nd Edition), McGraw-Hill Book Company, New York, 704 p.

Sprunt, A., Jr., 1954. Florida Bird Life, National Audubon Society and Coward-McCann, Inc., New York, New York, 545 p.

Strickland, J.D.H., and T. R. Parsons, 1960. A Manual of Sea Water Analysis, Bull. Fish. Res. Bd. Can., 125:1-85.

Tiffany, L. H., 1952. The Algae of Illinois, University of Chicago Press., Chicago, 383 p.

Usinger, R. L., Ed. 1963. Aquatic Insects of California, University of California Press, Berkely and Los Angeles, 508 p.

U.S.A.E.C., 1973. Toxicity of Power Plant Chemicals to Aquatic Life, Battelle Pacific Northwest Laboratories, Richland, Washington.

U. S. Department of Interior, Bureau of Sport Fisheries and Wildlife, 1973. Threatened Wildlife of the United States, Resource Publication 114, 289 p.

United States Geological Survey, 1960. Compilation of Records of Surface Waters of the United States through September 1950, Part 2-B, Water Supply Paper 1304, U. S. Government Printing Office, Washington, D. C.

United States Geological Survey, 1963. Compilation of Records of Surface Waters of the United States, October 1950 to September 1960, Part 2-B, Water Supply Paper 1724, U. S. Government Printing Office, Washington, D. C.

United States Geological Survey, 1961-1970, Water Resources Data for Florida, Part 1, 2, 3, U. S. Geological Survey District Office, Tallahassee, Florida.

Utermohl, H., 1959. ZurVervollkommung Der Quantitativen Phytoplankton - Methodik, Mitt. int. Verein, Limnol. 9, 1-38.

Van Heurck, H., 1880-1883. Synopsis des Diatomees de Belgique, Atlas. Ducaju and Cie., Anvers. 132 Pl. (Planche 1-30, 1880; Planche 31-33, 1881; Planche 34-77, 1881; Planche 78-103, 1882; Planche 104-132, 1883).

Ward, H. B. and G. C. Whipple, 1959. Fresh Water Biology, John Wiley and Sons, New York.

Ware, F., and S. L. Smith, 1973. Annual Progress Report for Investigations Projects, State of Florida, Game and Freshwater Fish Commission.

Weber, C. I. (Ed.), 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents, Program Element 1BA027. National Environmental Research Center. Office of Research and Development, United States Environmental Protection Agency, Cincinnati, Ohio.

Whitaker, J. O., Jr., 1968. Keys to the Vertebrates of the Eastern United States, Burgess Publishing Company, Minneapolis, Minn.

Whitford, L. A. and G. J. Schumacher, 1969. A Manual of the Freshwater Algae In North Carolina, North Carolina Agricultural Experiment Station, Tech. Bul. No. 188, 309 p.

Wilhm, J. L., and Dorris T. C., 1968. Biological Parameters for Quality Criteria, Bioscience, 18:477-481.

ADDENDUM NO. 2

APPLICATION FOR POWER PLANT SITE CERTIFICATION

TO: FLORIDA DEPARTMENT OF POLLUTION CONTROL

ARVAH B. HOPKINS GENERATING STATION

CITY OF TALLAHASSEE, FLORIDA

INTRODUCTION

This interim report is the result of a water quality survey conducted at the A. B. Hopkins Generating Station of the City of Tallahassee, Florida, on March 21, 1974. The results of the first full-scale field trips associated with this project have been previously reported in the Application for Power Plant Site Certification to the Florida Department of Pollution Control for the A. B. Hopkins Generating Station, prepared jointly by Reynolds, Smith and Hills and Environmental Science and Engineering, Inc. in February, 1974. The principal purpose of this survey was to determine the water quality effects of cooling tower chlorination and was, therefore, conducted during a period of cooling tower chlorination. Another full-scale field survey is scheduled for the summer season.

This report is to be considered an addendum to Section 5 - ENVIRONMENTAL EFFECTS OF PLANT OPERATION - of the original application and hence, subsections are numbered according to the original application.

5.2.1 (j) Heavy Metals - The analytical results for nickel, total chromium, and mercury in each of the water samples collected on December 10, 1973 are reported in the Addendum to Table V-2. All observed concentrations of these metals are below levels of concern from the standpoint of adverse effects on water quality or toxicity to aquatic organisms.

(k) Chlorine - A field sampling program was conducted on March 21, 1974 to assess the water quality effects of chlorination of the cooling tower and cooling system. The measurement of various additional water quality

Table V-2 (Addendum)

HOPKINS GENERATING STATION

Water Quality Data

December 10, 1973

Sample Station	Ni (ug/l)	Cr (ug/l)	Hg (ug/l)
Cooling Tower Makeup	4	<5	<1
Cooling Tower Blowdown	7	<5	<1
1	2	<5	<1
2	5	<5	<1
3	4	<5	<1
7	2	<5	<1
8	2	<5	<1
9	2	<5	<1
10	2	<5	<1
11	2	<5	<1
12	2	<5	<1
13	2	<5	<1
14	2	<5	<1

parameters was included in this survey to assist in the assessment of the effects of chlorination.

Chlorination was in progress during the period 0730 to 1600 on March 21, 1974. The initial indicated chlorine addition rate was 35 lb/24 hours and the final indicated rate was 65 lb/24 hours. An average chlorine addition rate of 50 lb/24 hours will be assumed. The average rate of water supply from on-site wells was 51,550 gal/hour (1.24 MGD) and the average cooling tower blowdown rate was observed to be 14,630 gal/hour (0.35 MGD).

A cold front passing through the area resulted in heavy rainfall on March 20 and the morning of March 21. Rainfall had ceased by 1200 on March 21, 1974 (the sampling date).

During the morning (0700-1300) of March 21, 1974, samples were taken from Stations 1, 2, 2a, and 3 in addition to the plant effluent. These stations are depicted in Exhibit II-12. They are the same stations sampled by ESE and RS&H personnel on previous occasions.

The afternoon sampling program (1300-1700) was confined to the reach of the outfall creek between the plant effluent and Station 1. This reach includes approximately 1200 feet, all of which is within the plant site property. Stations 1a, 1b, and 1c are located at equal intervals between the plant effluent and Station 1.

Dissolved oxygen (DO), temperature and pH were determined <u>in-situ</u>. Water samples were collected and returned to the laboratory for subsequent analysis of sulfate and chloride. Chlorine analyses were conducted at each site by amperometric titration immediately after collection in brown glass containers.

The results of the analyses conducted are presented in Table V-9. These results are also shown in Exhibits V-14 and V-15. Exhibit V-14 depicts the downstream profile of temperature, DO, ph, sulfate and chloride in the outfall creek during the morning sampling period. The downstream profiles of temperature, DO, ph, and total residual chlorine during the afternoon sampling period are shown in Exhibit V-15. The values of these parameters observed at Station 2a (the influent stream) are also shown in Exhibits V-14 and V-15 for reference purposes.

The plant cooling water effluent temperature is seen to decrease (Exhibit V-14) from an initial value of 32°C to the ambient temperature of 19°C before Station 3 is reached (1.4 miles downstream). The temperature of the discharged water is lowered by heat loss to the atmosphere and by dilution by cooler groundwaters and runoff waters.

Referring to Exhibits V-14 and V-15, it can be seen that DO concentrations in the outfall creek being high (96-109 percent saturation) at the plant effluent as would be expected for cooling tower blowdown. Concentrations in the drainage canal just below the outfall are seen to increase (Exhibit V-15), resulting in slight supersaturation (104 percent). This effect is probably the result of the plunging action of the saturated effluent water as it leaves the plant discharge where it undergoes a two-foot drop. DO concentrations decrease slowly downstream

Table V-9 WATER QUALITY PARAMETERS

A. B. Hopkins Generating Station

March 21, 1974

Sample Station	Sample Time	Temp (^{o}C)	DO (mg/l)	% DO Saturation	pH	Cl^- (mg/l)	$SO_4^=$ (mg/l)	Free Residual Chlorine (mg/l)	Combined Residual Chlorine (mg/l)
Plant Effluent	0915	32	8.1	109	8.5	69	146	0.54	0
1	0935	27	6.8	84	8.1	59	94	0	0
2	1215	22	6.7	76	7.2	43	89	0	0
2A	1135	19	7.2	77	4.9	4	<5	0	0
3	1050	19	6.6	78	6.6	17	32	0	0
Plant Effluent	1400	31	7.2	96	8.2	67	119	0.83	0
1A	1420	33	7.6	104	8.1	62	95	0.54	0
1B	1445	32	7.7	104	7.9	53	98	0.22	0
1C	1510	31	7.6	101	8.4	54	98	0.02	0
1	1545	29	6.7	89	8.2	51	88	0	0

Exhibit V-14 A. B. Hopkins Generating Station water quality parameters, March 21, 1974.

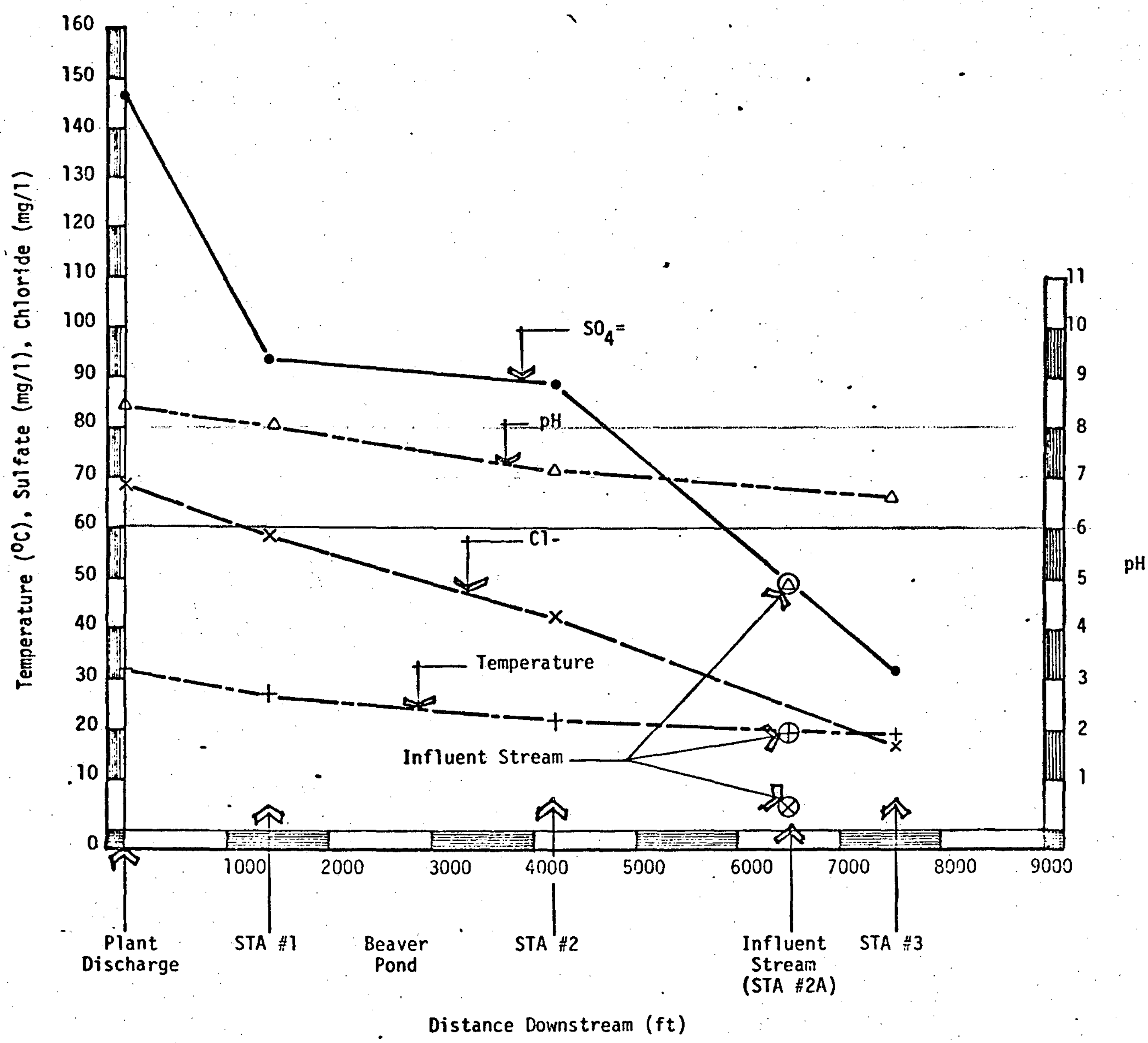
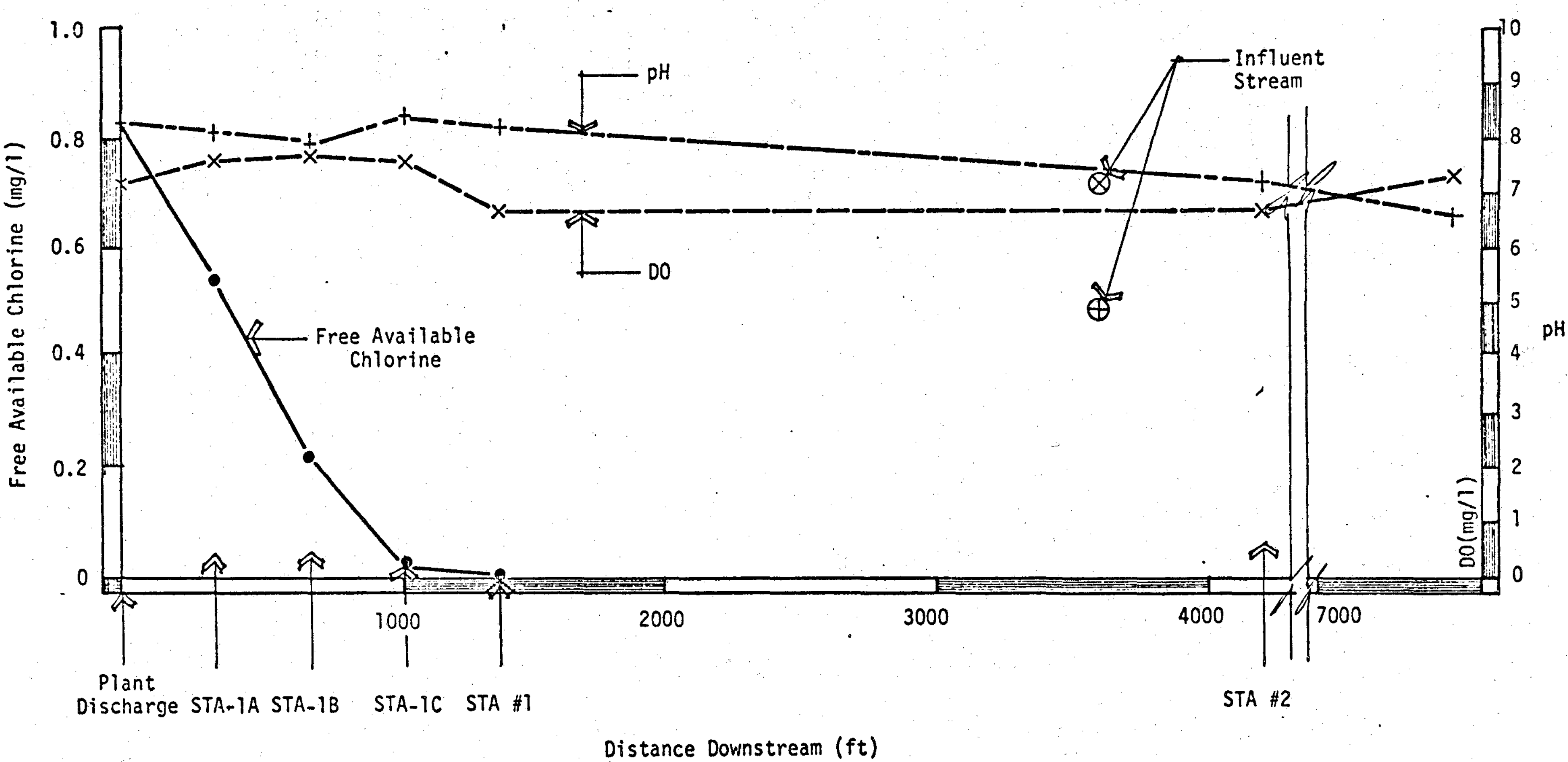


Exhibit V-15 A. B. Hopkins Generating Station water quality parameters, March 21, 1974.



due to the loss of oxygen to the atmosphere during the period of supersaturation, by dilution and by biochemical oxygen demand. The lowest DO concentration observed was 77 percent of the saturation concentration.

The initial pH of discharge water is 8.2 and 8.5. A continuous decrease in pH downstream reflects the influence of lower pH ambient waters. Ambient waters such as at Station 2a are acidic in nature (4.9) because of their relatively high concentration of organic acids and low buffer capacity. A pH of 6.6 was attained at Station 3.

Chloride concentrations show a continuously decreasing trend downstream reflecting dilution by rainfall, rainfall runoff and groundwaters. Concentrations are well below the FAC 17-3 standard of 250 mg/l, although effluent concentrations are much higher than those observed on the previous sampling excursion (69 mg/l versus 29.5 mg/l on December 10, 1973).

The rate of decrease in sulfate concentration can be most clearly seen in Exhibit V-14. This figure provides an indication of the rate of dilution of the plant discharge water by groundwater seepage and surface runoff. The discharge water is diluted by a factor of 4.6 by the time Station 3 is reached. This is slightly greater than the dilution factor at this point reported by RS&H, based on flow measurements (factor of 3.39). The greater dilution in this case can be attributed to the increased runoff subsequent to rainfall in the area just prior to sampling.

Effluent sulfate concentrations, like chloride concentrations, are much higher than those observed on the December 10, 1973 sampling excursion (146 mg/l versus 52 mg/l), however, they are still well below any levels that may be toxic to organisms.

The residual chlorine concentrations observed are reported in Table V-9 and depicted in Exhibit V-15. Only free available chlorine was detected (i.e., HOCl). Combined residual chlorine (i.e., monochloramine, dichloramine, etc.) was not detected at any time. This is reasonable, since it is known from the previously reported field analysis that the ammonia and organic carbon concentrations in the plant discharge water are extremely low. Therefore, there is little chlorine demand in this water and little combined residual chlorine is formed.

It is apparent from mass calculations, based on the chlorine addition rate and the cooling water flow rate, that a large proportion of the chlorine added to the cooling tower makeup water is subsequently lost to the atmosphere while circulating through the tower. At a chlorine addition rate of 50 lb/24 hours and a cooling tower makeup rate of approximately 51,500 gal/hour (1.24 MGD) as recorded during this study, the concentration of chlorine in the blowdown water should be approximately 4.8 mg/l. The maximum observed concentration was 0.83 mg/l.

The residual chlorine in the effluent water rapidly decreases after it leaves the plant. Chlorine was not detected at Station 1 or any others further downstream. Degradation by light and the chlorine demand of creek sediments rapidly depletes concentrations after the effluent water leaves the plant.

The impact on aquatic life is, therefore, limited to the discharge ditch on the plant site itself.

Brungs (1973) has suggested that total residual chlorine not exceed 0.01 mg/l for continuous chlorination and that 0.002 mg/l should protect most aquatic organisms. For intermittent chlorination, he suggests that for a dose period of up to 2 hours per day, up to, but not in excess of, 0.4 mg/l should protect most species of fish.

Basch and Truchan (1973) have stated that warm water fish species are protected when continuous chlorination values do not exceed 0.02 mg/l and intermittent dose rates of 0.1 mg/l are limited to no more than 30 minutes per day.

Chlorination of the recirculating cooling systems will be in the form of intermittent shock treatment. The existing cooling tower utilizes a fully covered deck area, which has greatly reduced the need for chlorination. The cooling towers for the proposed Units 2 and 3 will also utilize covered decks, which will reduce possible photosynthetic activity, thus reducing the need for frequent chlorination.

It is proposed that the chlorination procedure for the cooling towers for Units 1, 2, and 3 follow the guidelines presented in the EPA Proposed Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source (Federal Register, March 4, 1974), which are as follows: "Concentrations of free available chlorine in wastewater discharged fron nonrecirculating and recirculating cooling water systems shall not exceed average concentrations of 0.2 mg/l and maximum concentrations of 0.5 mg/l at the outlet corresponding to an individual unit during a maximum of one 2-hour period a day. No discharge of total residual chlorine is otherwise allowed. No discharge of total residual chlorine is allowed from one unit while another unit at the same plant is being chlorinated."

These maximum free available chlorine concentrations will be as measured at the point at which the plant discharge ditch crosses the plant site property line (Station 1). In this manner, the blowdown from any one cooling tower being chlorinated will be diluted by the blowdown from the other cooling towers.

It is observed that all detectable residual chlorine was in the free available state in the plant discharge water. This free residual chlorine was rapidly lost both in the cooling tower, and after discharge of the water. If a significant proportion of the residual chlorine had existed in the combined state, the rapid drop in concentration after discharge may not have been realized. Combined residual chlorine species are generally more persistent than free residual chlorine. However, they are equally as toxic to aquatic organisms.

The reason very little combined residual chlorine was formed during chlorination is that the cooling waters are extremely low in ammonia and organics. These waters are taken directly from on-site wells. If waters from the Ochlocknee River were used for cooling, which is one of the suggested alternatives for the new facilities, the combined residual chlorine concentrations in the plant effluent may be much greater and persist much further downstream because the river waters are high in ammonia and organics. Under these conditions, the impact on water quality would be increased.

REFERENCES

Brungs, W. A. 1973. Effects of Residual Chlorine on Aquatic Life. JWPCF. 45: 1558

Basch, R. E. and Trauchan, J. G. 1973. Calculated safe residual chlorine concentrations safe for fish. Interim Report, Michigan Water Resources Commission, Bureau of Water Management, Department of Natural Resources, Lansing, Michigan

ADDENDUM NO. 3

APPLICATION FOR POWER PLANT SITE CERTIFICATION

TO: FLORIDA DEPARTMENT OF POLLUTION CONTROL

ARVAH B. HOPKINS GENERATING STATION

CITY OF TALLAHASSEE, FLORIDA

INTRODUCTION

This interim report addresses alternative means of air pollution control for Units 2 and 3 at the Arvah B. Hopkins Generating Station in Tallahassee, Florida. In the previously submitted "Application for Power Plant Site Certification," control for sulfur dioxide and particulates was assumed to be effected by use of low sulfur fuel oil and/or use of natural gas in combination with fuel oil to "dilute" the sulfur dioxide emissions.

This report will be an addendum to Section 3.6 AIR EMISSIONS of the "Application for Power Plant Site Certification," which was submitted to the Florida Department of Pollution Control on February 18, 1974.

3.6.3 Alternative Sulfur Dioxide Control Systems

The below alternative sulfur dioxide control systems are listed in order of preference established by economic considerations and projected delivery schedule. Particulate control will not be addressed specifically, due to the fact that oil and natural gas will be the only fuels used, and it is anticipated that fuel with an ash content required to meet the particulate emission standards set forth in 17-2.04 will be readily available.

The alternative SO_2 control systems are as follows:

1. Purchase additional natural gas in quantities which may be burned in combination with 1.8 percent sulfur fuel oil to maintain the sulfur dioxide emission rate within standards.

2. Build tall stacks for enhanced dispersion of sulfur dioxide and incorporate secondary control through meteorological monitoring.

3. Purchase low sulfur ($\leq$ 0.75%) fuel oil.

4. Purchase flue gas scrubbers.

5. Purchase fuel oil hydrodesulfurization system.

(a) Use Of Additional Natural Gas - The Hopkins Generating Station has facilities for receiving natural gas and all boilers are capable of firing both natural gas and/or oil. At present, the quantities of natural gas which are delivered to the site vary from month to month. This is due to the fact that industrial users are low priority customers for the available supply of natural gas.

Current trends show the quantities of natural gas available for firing boilers at the Hopkins site are diminishing. However, the natural gas is much more economical to use than fuel oil, and if additional quantities should become available, this would be the most economical means of SO_2 control. The scarcity of natural gas is probably due in some degree to government price controls which limit the price on gas. If these price controls were to become less stringent, it is possible that natural gas may be available to the Hopkins Station in greater quantities.

At present, low sulfur content No. 6 fuel oil cost is approximately 3.6 times the cost of natural gas on an equivalent heat basis. Thus, higher priced natural gas would have to more than triple in price to become economically unfeasible for use in Units 2 and 3.

Thus, the most attractive alternative for SO_2 control is use of natural gas, which would be cheaper and cleaner than any fuel oil. However, this alternative is not promising at present, due to the scarcity of additional natural gas.

(b) Use of the Sulfur Dioxide Emission Limitation System – As an alternative to costly and sometimes unreliable flue gas scrubbing systems, the Tennessee Valley Authority has proposed the Sulfur Dioxide Emission Limitation (SDEL) system to assure that ambient sulfur dioxide concentrations do not exceed the ambient air quality standards. The SDEL program consists of two control methods:

(1) Use of very tall boiler stacks to provide greater dispersion of stack effluents; and

(2) Use of extensive meteorological monitoring and ambient air quality monitoring in order to detect atmospheric conditions which may result in unacceptable ground level concentrations of SO_2. The meteorological conditions being monitored will be fed continuously to computers, which will also receive plant operational data and determine conditions which merit a reduction of SO_2 emissions from the stacks. The plant SO_2 emissions may be reduced by either switching to low sulfur fuel oil, or reducing the plant generating rate.

The City of Tallahassee currently has an ambient SO_2 monitoring program at the Hopkins Generating Station, which will run for a year. The ambient data collected will be analyzed and correlated with site meteorological conditions to determine dispersion characteristics existing at the site. By use of computer modeling, optimum stack heights can be determined to assure that ground level SO_2 standards will be acceptable.

The SDEL program will not involve changing the sulfur content of the fuel oil at the Hopkins site from the presently used 1.8 - 2.0 percent sulfur oil. Thus, the plant will be in violation of the Department of Pollution Control's SO_2 emission standards and the EPA's "Standards of Performance for New Stationary Sources." However, the TVA has proven the SDEL system to be very reliable in controlling ambient SO_2 concentrations.

In the event the SDEL system becomes acceptable to the regulatory agencies concerned, it is the second preference for SO_2 control at the Hopkins site.

(c) Use of Low Sulfur Fuel Oil - Emission data given in paragraph 3.6.1 was based on use of No. 6 fuel oil with a sulfur content of 0.75 percent or less. The availability of the low sulfur oil for use in Hopkins Units 2 and 3 is questionable to a degree. However, some utilities in Florida are currently burning the low sulfur oil, and it is assumed that quantities will be available for use at the Hopkins plant. Economically, the premium which use of low sulfur oil will entail ranks this alternative lower than other alternatives. However, use of low sulfur oil is judged to be the most feasible alternative since it will require no additional design or equipment purchase, and there is no question of the reliability of SO_2 emission control.

(d) Flue Gas Scrubbers - There has been a great deal of controversy over the utilization of flue gas scrubber systems designed to remove sulfur dioxide from oil- and coal-burning boiler flue gas. Although the reliability of such systems is questionable with regard to application on full size fossil fuel generating units, it is not the intent of this report to determine the state-of-the-art of scrubbers. For the purpose of this report, it is assumed that flue gas scrubbers can be fitted on Units 2 and 3 and that these systems can reliably maintain the SO_2 emission rate of these units at permissable levels. At present, flue gas scrubbers are adjudged to be the best available control technology by the Environmental Protection Agency.

For the purposes of evaluation of flue gas scrubbers at the Hopkins site, two types of scrubbers are considered: a wet limestone "throw-away" system, and a wet "recovery" system.

(1) Wet "throwaway" Scrubber - The term "throwaway" refers to a system in which the by-product of the flue gas scrubbing is disposed of rather than being processed for sulfur recovery. The throwaway system is currently being used in a number of full-scale installations throughout the country. The advantages of this system are its simplicity and the fact that the reactants used to remove SO_2 are readily available in large quantities, the most common of these reactants being lime (CaO) and limestone ($CaCO_3$). Thus, for purposes of evaluating a possible throwaway scrubber system for the Hopkins site, a wet limestone tail end scrubber is assumed. Such a system is manufactured by Babcock and Wilcox Company, and this particular system will be used for purposes of this analysis.

The system consists of five major operations:

1. Particulate Collection - This operation, which is implemented by venturi scrubbers, quenches

the flue gas and scrubs out fly ash.

2. SO_2 Absorption - The SO_2 is absorbed by a limestone slurry to form $CaSO_3$.

3. Reheating of Flue Gas - After SO_2 absorption and subsequent demisting, the flue gas is reheated to protect ducts and fans, and to promote buoyancy for dispersion of the gas.

4. Limestone Preparation - This operation entails milling the raw limestone to a desired fineness and mixing into a slurry.

5. Sludge Disposal - The resulting mixture of $CaCO_3$-$CaSO_3$-$CaSO_4$ and fly ash must be discarded, usually after treatment.

Scaling and corrosion have been the greatest problems involved in operation of scrubber systems of this type. These problems may be alleviated to some degree by careful pH control in the scrubber operation.

At the Hopkins site, transportation of limestone and disposal of sludge present further problems. Limestone will be required at the rate of approximately 145 tons/day for Unit 2 and 290 tons/day for Units 2 and 3, assuming 75 percent SO_2 removal efficiency and 3 percent sulfur content fuel oil. The limestone would need to be transported approximately 100 miles to the plant site.

Sludge produced by the scrubber system would amount to approximately 380 tons/day for Unit 2 alone, assuming dewatering to a 50 percent solids sludge composition. This amount of sludge would necessitate 9,000 cubic feet of storage each day. The plant site would not provide adequate area as required for sludge disposal for the life of Units 2 and 3. Therefore, the sludge would require transportation to some disposal area.

(2) "Recovery" Scrubber - The term "recovery" refers to recovery of sulfur, usually in the form of sulfuric acid or elemental sulfur, from the reactant which scrubs SO_2 from the flue gas. There are several types of recovery systems, varying in the reactants used and the method by which sulfur is recovered. Full scale installations of recovery scrubber systems are few at present, but extensive pilot plant research is taking place.

The main advantages of the recovery system as compared to the throwaway system is the reduction in the waste products which require disposal, and the production of a saleable by-product. However, the recovery scrubbers are more complex, due to a greater number of operations and, in some cases, the recovered sulfur product would have to be produced at a chemical plant apart from the power plant.

For purposes of cost analysis, a recovery system similar to a pilot plant operated by Stauffer Chemicals at Connecticut Light and

Power's Norwalk Harbor Plant will be assumed. This plant uses sodium phosphate, made up from sodium hydroxide and phosphoric acid, to reduce SO_2 in the flue gas. In general, the process consists of the following steps:

1. Particulate Collection - Similar to Step 1 in the throwaway system.

2. SO_2 Absorption - The gas is passed to an absorber column where the addition of sodium phosphate reduces the SO_2.

3. Reheating of Flue Gas - Similar to Step 3 of the throwaway system.

4. Sulfur Recovery - The solution from the absorber column is fed to the reactor section, where it contacts a concentrated stream of hydrogen sulfide, and the sulfur is precipitated out. The sulfur slurry is then processed in a recovery unit to yield pure sulfur, some of which is recycled to the hydrogen sulfide generator.

5. Disposal of Sodium Sulfate - Sodium sulfate is the only waste product from the reactant, and exists in the form of a salt cake. The production of sodium sulfate is claimed to be low. Estimated production

of sulfur sulfate for Unit 2 is 2,200 tons/year and 4,400 tons/year for Units 2 and 3.

6. Recycle and Addition of Reactant - The liquor from the sulfur recovery unit is recycled to the column, with only sodium hydroxide needed for makeup. Over 6,800 pounds/day of sodium hydroxide would be needed for Unit 2.

The pilot plant operation indicates that the waste product from the recovery system is approximately 75 times less than the volume created by a comparable throwaway system. This would indicate that the production of sodium sulfate wastes from the recovery system would amount to approximately 12.2 tons/day for both Units 2 and 3 operating at the Hopkins Station. This amount of waste could be disposed of on site in an impoundment area, or could possibly be sold.

One major drawback of this recovery system is the sodium hydroxide requirement. At present, sodium hydroxide is in high demand, and a supply of the magnitude needed for scrubber operation may be an impossibility.

It should be noted that this type of recovery scrubber system has not been operating as a full-scale installation, but only as a pilot plant. However, the manufacturer is encouraged with the results and is considering going directly to a unit for a 100 MW steam electric generating unit.

(e) Use of Fuel Oil Desulfurization Process - A final alternative of fuel oil hydrodesulfurization was examined and found to be very expensive for an installation to serve Hopkins Units 2 and 3.

The process of hydrodesulfurization involves the following operations:

(1) The fuel oil is mixed with hydrogen, heated, and sent to the hydrodesulfurization reactor. The reactor operates at 1,500-2,000 psig and 600°-800°F.

(2) The reaction products from the reactor are next sent to a vapor-liquid separator and then to fractionation. The fractionation has a vapor and two liquid products, the bottom product being desulfurized fuel oil. About one percent of the total charge will come off as light naptha, which could be sold "as is" or used for fuel. Off the top of the fractionator and the separator, a mixture of hydrogen sulfide, hydrogen, and light hydrocarbon gases is taken.

(3) The light gases are taken to an amine unit to separate hydrogen sulfide from the light gases. The gases then go for use as fuel, and the hydrogen sulfide is sent to a sulfur plant for conversion to liquid sulfur. Hydrogen is generated in a hydrogen-steam reformer.

The hydrodesulfurization process requires a residual fuel oil which is the product of an atmospheric crude fractionation tower, rather than a vacuum tower. The fuel oil is further restricted in the metals content (vanadium plus nickel content less than 150 ppm) and the asphaltene content (less than 3.5 percent). These restrictions are necessary to protect the desulfurization catalyst.

However, new developments are taking place which may allow use of fuel oil with higher metals content.

The high capital expenditure required for a hydrodesulfurization system and the restrictions on the fuel oil which may be used with the process make this alternative the least desirable. The hydrodesulfurization system becomes more feasible on a larger scale installation.

(f) Cost Comparison of Alternatives - Capital and operating costs for all alternatives were compiled for cost comparison, based on 1974 dollars. These costs are presented in Table III-6, using present operating costs as a baseline. For purposes of the cost analysis, a load factor of 60 percent was assumed, and the baseline operating costs are based on use of 1.8-2.0 percent sulfur fuel oil.

Economic comparison of the alternatives can be made with the total annual costs from Table III-6, which includes annual operating costs and amortized capital costs, where applicable. Capital expenditures will require bond issues by the City of Tallahassee, and at present, the interest situation is uncertain. For purposes of amortization, a sinking fund is assumed using a 10 percent rate of return.

(1) Cost of Additional Natural Gas - At present, natural gas is delivered to the Hopkins site at a cost of \$.58 per million BTU. Assuming use of fuel oil with 1.8-2.0 percent sulfur content, a fuel mix of 60 percent natural gas-40 percent fuel oil would be required to maintain legal SO_2 emission rates (See Table III-4). Present fuel oil costs are \$1.72 per million BTU for 1.8 percent sulfur oil. Thus, fuel cost with additional natural gas would be

$1.036 per million BTU, a savings of $.684 per million BTU over the present fuel cost.

No additional capital cost would be incurred for use of additional natural gas, assuming the present gas handling facilities at the Hopkins site are adequate to deliver the extra gas required.

(2) Cost of Low Sulfur Fuel Oil - The cost for 0.75 percent sulfur content fuel oil in Table III-6 is based on a $1.70/barrel premium over the cost of presently used 1.8-2.0 percent sulfur content fuel oil.

(3) Cost of Tall Stacks and SDEL - The costs for installation and operation of a system similar to the TVA's proposed Sulfur Dioxide Emission Limitation (SDEL) system at the Hopkins Station were determined using costs projected for the TVA generating system and assuming a proportional relationship between the TVA system and Hopkins Units 2 and 3. It is assumed that the presently used 1.8-2.0 percent sulfur fuel oil would be used in conjunction with an SDEL system, with lower sulfur content fuel oil used if meteorological conditions warranted. The capital cost for an SDEL system is amortized over the life of the plant or 40 years.

(4) Cost of Scrubber Systems - The capital cost of the wet limestone "throwaway" scrubber was obtained from the Babcock and Wilcox Company and was placed at $30/KW. Operating costs include cost of limestone delivered to the site; electrical cost to run the system; sludge disposal cost, assuming off-site disposal; maintenance and labor cost; insurance on the equipment, assuming a 10-year life; and a $1/barrel credit for oil, assuming use of 3 percent sulfur oil

with the scrubber. Capital costs are amortized over a 10-year period, assuming zero salvage value.

The capital cost of the sulfur recovery scrubber system was obtained from estimated costs given by Stauffer Chemical Company and was placed at $35/KW. Operating costs were also estimated by Stauffer and are based on 1.46 mills/kwh, assuming a $15/long-ton credit for sulfur recovered from a 1,000 MW unit burning 3.5 percent sulfur fuel. These operating costs were adjusted for application to Hopkins Units 2 and 3 and a $1/barrel credit was made for oil, assuming use of 3 percent sulfur oil with the scrubber system. Capital costs are amortized over a 10-year period, assuming zero salvage value.

(5) Cost of Hydrodesulfurization System - A preliminary cost estimate of a hydrodesulfurization system with a capacity of 4,000 barrels per day was made by Frantz Chemical Consultants, in Houston, Texas. The 4,000 BPD unit would be adequate capacity for Unit 2 only. Capital costs were estimated to be $11-$14 million, which includes equipment, installation and catalyst. Operating costs were not determined. Capital costs are amortized over 15 years, assuming zero salvage value.

(g) Equipment Delivery - Construction of Hopkins Unit 2 is scheduled to begin in early 1975 with start-up scheduled for 1977. Therefore, any equipment which would be required for an SO_2 control system for Unit 2 would have to be designed and constructed within the scheduled construction period, to assure that Unit 2 start-up would not be delayed.

Use of low sulfur fuel oil or additional natural gas will require no additional equipment purchase. Construction of tall stacks and installation of a meteorological monitoring network could probably be completed by the scheduled start-up date, if the regulatory agencies involved with plant permitting would approve the control concept. Design and erection of a scrubber system as estimated by the Babcock and Wilcox Company would require 38-47 months. Installation of this system would then delay start-up of Unit 2 for 1-2 years. Design and construction of a hydrodesulfurization system would require 24-30 months. Thus, of the five alternatives, low sulfur oil is the most feasible alternative for implementation in time for Unit 2 start-up, assuming that additional natural gas will probably not be available in the required quantities by the scheduled start-up date. The SDEL concept will have to gain approval before implementation, which could involve lengthly legislative processes. Finally, installation of a scrubber system would be the most unfeasible alternative for Unit 2, due to the long delivery times.

TABLE III-6

COST OF SO_2 CONTROL ALTERNATIVES

System		Capital Cost	Additional Annual Operating Cost (Present Cost as Baseline)	Total Annual Cost (Amortized + Operating Costs)
Additional Natural Gas	Unit 2	--	-$ 8.54 million	-$ 8.55 million
	Units 2 & 3	--	-$17.10 million	-$17.10 million
Tall Stacks and Meteorolog-ical Monitoring Network	Unit 2	$ 1.5 million	$ 0.25 million	$ 0.41 million
	Unit 2 & 3	$ 2.5 million	$ 0.50 million	$ 0.76 million
Low Sulfur Oil	Unit 2	--	$ 3.32 million	$ 3.32 million
	Unit 2 & 3	--	$ 6.64 million	$ 6.64 million
Flue Gas Scrubber (Throwaway System)	Unit 2	$ 7.5 million	$ 0.38 million	$ 1.60 million
	Unit 2 & 3	$15.0 million	$ 0.76 million	$ 3.20 million
Flue Gas Scrubber (Recovery System)	Unit 2	$ 8.75 million	-$ 0.13 million	$ 1.30 million
	Unit 2 & 3	$17.5 million	-$ 0.26 million	$ 2.59 million
Fuel Oil Hydro-desulfurization	Unit 2	$14.0 million	undetermined	$ 1.84 million + operating
	Unit 2 & 3	$25.0 million	undetermined	$ 3.3 million + operating

ADDENDUM NO. 4

APPLICATION FOR POWER PLANT SITE CERTIFICATION

TO: FLORIDA DEPARTMENT OF POLLUTION CONTROL

ARVAH B. HOPKINS GENERATING STATION

CITY OF TALLAHASSEE, FLORIDA

INTRODUCTION

This report constitutes Addendum 4 to the "Application for Power Plant Site Certification" of the Arvah B. Hopkins Generating Station. The purpose of this addendum is to clarify several items previously addressed in the "Application for Certification". Specifically, these items are: (a) phosphorus and sulfate levels in the cooling tower blowdown discharge, and (b) groundwater drawdown.

This addendum is to be considered a part of Section 5 entitled Environmental Effects of Plant Operation.

5.2.1(e) Sulfate ($SO_4^=$) levels in the cooling tower blowdown discharge result from the concentration of the groundwater used for cooling tower makeup and from the addition of sulfuric acid (H_2SO_4) to the recirculating cooling water for scale control. (Para. 3.4.2 (b)).

Sulfate concentrations in the groundwater at the Hopkins plant site are typically 7.0 mg/l (see paragraph 3.3.7 and Table V-2). Sulfate is a conservative parameter in the recirculating cooling water system. Therefore, the sulfates in the cooling tower blowdown atrributable to sulfates from the makeup water are directly proportional to the number of cycles of concentration for the recirculating cooling system.

The proposed Unit 2 cooling tower will operate at 4 - 6 cycles of concentration; therefore, sulfate concentrations in the blowdown will be 28 - 42 mg/l without addition of sulfuric acid.

At present, values for sulfates in the Unit 1 cooling tower blowdown reach 250 mg/l with approximately 220 mg/l resulting from the use of sulfuric acid for scale control.

Continued use of sulfuric acid to aid in scale control in Units 1 and 2 would result in an additional flux of approximately 557Kg $SO_4^{=}$/day into the plant discharge stream. This value is based on a recorded 1973 usage rate of 9500 gallons of 66° Be H_2SO_4 for Unit 1 cooling tower. This additional sulfate represents approximately 6.6% of the average daily flux of sulfate in the Ochlockonee River as determined by Dr. Edward Laws, Department of Oceanography, Florida State University.

In lieu of using sulfuric acid for cooling water treatment, two alternatives are available:

1. Use of hydrochloric acid (HCl) for pH control in the cooling water. This alternative would increase chloride flux from the cooling tower blowdown at the average rate of 412 Kg/day. Use of hydrochloric acid would involve a 45% increase in chemical cost for acid water treatment.

2. A second alternative for sulfate reduction would involve decreasing of the amount of sulfuric acid used to treat the recirculating cooling water. However, the attendant elevation of pH values in the blowdown discharge may prove to be objectionable.

The pH value of the recirculating cooling water is dependent upon the alkalinity of the water. The groundwater used for cooling water makeup at the Hopkins Station typically has a methyl orange alkalinity of 100 ppm as $CaCO_3$, and this alkalinity will increase in proportion to the number of cycles of concentration which the recirculating cooling water experiences. If no acid is introduced into the recirculating cooling water, the pH of the water will increase, due to the increase in alkalinity. Thus, the number of cycles of concentration in the cooling system will be limited by the desired pH value of the blowdown discharge.

Table V-9 presents pH values for different cooling water cycles of concentration and the corresponding blowdown rates required to maintain the cycles of concentration.

TABLE V-9
COOLING TOWER PERFORMANCE
WITH NO ACID FEED

Cycles of Concentration	Blowdown pH	Average Blowdown Units 1 & 2 (GPM)
1.0	8.0	Once Through
2.0	8.43	2368
2.5	8.58	1578
3.0	8.72	1184
3.5	8.82	947
4.0	8.9	790

It is evident from Table V-9 that by eliminating the acid which is presently used to treat the cooling water, greater volumes of makeup water will be required for the cooling system operation as the result of increased blowdown volumes. The increased cooling tower blowdown also represents an increase in the total phosphorus loading from the plant attributable to the phosphorus present in the scale inhibitor used in the cooling system.

Elimination or reduction of the sulfuric acid used for cooling water treatment will effectively lower the cycles of concentration allowable in the cooling system and cause the pH of the blowdown to increase. Thus, it is proposed to continue acid treatment of the cooling water, preferably using sulfuric acid.

The proposed Unit 3 cooling tower will be of a design similar to Unit 2 cooling tower. However, the source of makeup water and thus, the chemical treatment of the makeup water, has not been ascertained. It is proposed that the effects of Unit 3 operation be evaluated at some future date when design is finalized.

5.2.1(i) Phosphorus concentrations in the cooling tower are attributable to the phosphates in the makeup water (0.017 mg/l, P) and to the organic phosphonate compound added for scale control. As discussed in paragraph 3.4.2(a), the concentration of the Betz 403 additive is maintained at 3 - 5 ppm of PO_4, or a maximum of 1.65 mg/l P. At this concentration, the average daily flux of total phosphorus from the cooling tower blowdown from Units 1 and 2 will be approximately 6.1 Kg/day, assuming an average plant load factor of 60%.

The state in which this phosphorus exists in the blowdown is uncertain. A survey of three manufacturers of cooling water treatment chemicals has indicated that the commonly used phosphorus-bearing scale inhibitors, phosphonates and polyolesters, were developed specifically to prevent reversion of the additives to orthophosphates. The phosphonates and polyolesters are stable at elevated temperatures and low pH values. However, these compounds are also biodegradable, indicating a possibility of biological breakdown of the organic molecules containing phosphorus. The manufacturers surveyed were unable to assess the possible mechanism or rate that the phosphorus-bearing additives would convert to nutrient form of phosphate.

Orthophosphate levels presented in Table V-2 indicate that the blowdown orthophosphate concentrations are comparable to those found in Lake Talquin, while total phosphorus concentrations in the blowdown exceed the concentrations found in the lake. However, total phosphorus concentrations tend to decrease downstream of the plant discharge, while orthophosphate levels remain relatively constant.

The maximum value of 1.65 mg/l P present in the cooling tower blowdown is well below the 5 mg/l P allowed by the Environmental Protection Agency for power plant effluents. If the present chemical treatment program is continued for Unit 2, the average daily total phosphorus loading from Unit 1 and 2 of 6.1 Kg/day represents only an 0.8% increase in an average daily total phosphorus flux of 760 Kg/day from the Ochlockonee River, as determined by Dr. Edward Laws, Department of Oceanography, Florida State University.

As stated above, the source of makeup water for Unit 3 cooling system is yet to be established, as Unit 3 construction is not scheduled to start until 1979. Thus, it is proposed that Unit 3 cooling tower operation be evaluated at a later date, in order to assess any possible new developments in chemical treatment in recirculating cooling systems.

5.6 OTHER EFFECTS

5.6.1 Groundwater General Information

Principal source of groundwater supply in Leon County is the Floridan aquifer, a regional system extending over a major portion of the State of Florida. Literature research and personal communications with the U. S. Geological Survey indicate that in the Tallahassee area, all major production wells penetrate the Crystal River and Hawthorn Formations within this aquifer.

Presently, the City of Tallahassee operates 17 wells penetrating the aforementioned formations. Information supplied by them indicates the current withdrawal rates to be 12.6 million gallons per day (MGD) average and 15 MGD peak.

The Crystal River Formation is the oldest geologic unit penetrated by wells in Leon County. Well logs indicate that the top of this formation may be highly solutioned, and the top 50 to 60 feet of the formation is highly permeable. In the Tallahassee area, this formation characteristically has a hard relatively impermeable zone about 60 feet below the top of the formation. Due to abundance of water and relatively low withdrawal rates, the U. S. Geological Survey has to date, not conducted in-depth studies to assess the hydrogeologic characteristics of the Crystal River Formation.

In the absence of detailed hydrogeologic information on the Crystal River Formation, an in-depth literature research was conducted (see application report) to assess the amount of available groundwater, the use needed for the Hopkins plant, and the impact on resource. This brief document summarizes and amplifies the discussion from the applicant's report.

(a) Water Demands - Groundwater usage will be primarily for industrial use. Following is a summary of total water demands as indicated in Table III-2 of the application report.

	Maximum		Minimum		Average	
	GPM	MGD	GPM	MGD	GPM	MGD
Unit 1	1422	1.54	394	0.76	908	1.15
Units 1 & 2	4450	4.94	1119	2.27	2785	3.60
Units 1, 2 & 3	7500	8.30	1845	3.80	4673	6.05

(b) Aquifer Model - A groundwater model was used to determine the effect of groundwater development on the Floridan aquifer in the vicinity of the site.

The aquifer coefficients for this model were 250,000 GPD/FT for transmissivity and 5×10^{-4} for storage coefficients. These values were verified by Mr. N. D. Hoy of the U. S. Geological Survey, Tallahassee Office, as being close to the values published in literature for the Floridan Aquifer. Furthermore, he indicated that the aforementioned values probably are conservative, and that the aquifer characteristics would be higher if field data were available for a thorough hydrogeologic analysis. Therefore, it should be kept in mind that the aquifer model as used in this analysis is conservative.

Utilizing the aforementioned criteria, it was possible to construct the distance-drawdown and time-drawdown model indicated in Exhibits II-14 and II-15 of the applicant's report. Construction of the distance-drawdown and time-drawdown exhibits allows an estimate of the change in water levels at any point in the vicinity of a well for any time after pumping begins.

The distance-drawdown and time-drawdown exhibits shown do not account for local recharge from shallow or underlying strata. The boundary condition for the model was considered a nonleaky artesian aquifer. Once again, this assumption is conservative, as the U. S. Geological Survey publications do indicate the existence of solution channels, cracks, fissures, and recharge throughout the Floridan aquifer system.

The pumping rate assumed to generate the distance-drawdown and time-drawdown curves was 1,500 GPM. This withdrawal rate was used because it corresponds with the proposed capacity for each well. Drawdowns for other pumping rates can be calculated by multiplying the values shown with the corresponding factor.

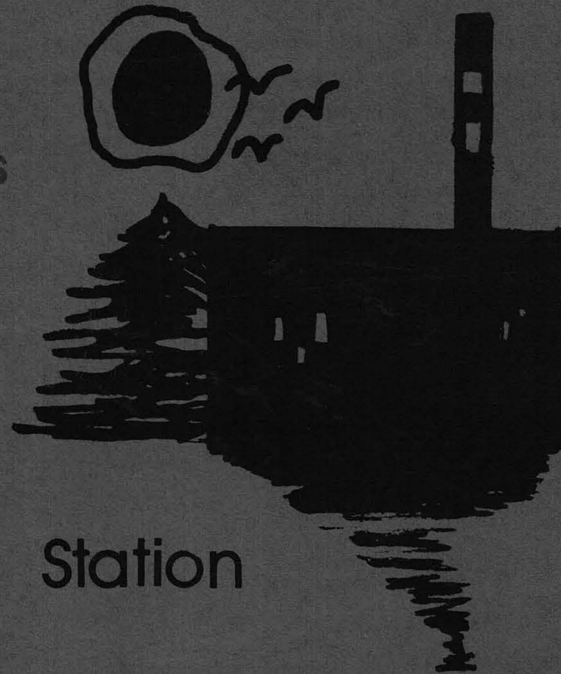
(c) Withdrawal Impact - In order to meet water demands for Units 1 and 2, two new 1,500 GPM wells are proposed, spaced no closer than 1,000 feet center-to-center. As mentioned earlier, the proposed number of wells (three wells at 1,500 GPM each and one standby well at 1,500 GPM) have been specified to meet maximum water demand of 4,500 GPM. From past experience with Unit 1, the maximum demand is experienced within about 100 days during a given year, but only lasting for 12 to 16 hours within any day. Under normal operating conditions for Unit 2, water demand is approximately 62 percent of maximum or 2,800 GPM.

Therefore, it can be seen from the distance-drawdown and time-drawdown curves that continuous pumping of the well for 100 days would result in a drawdown at the well of approximately 16 feet. Assuming the two new pumping wells are placed at diagonals of the property (1,000 feet apart) continuous pumping of these wells for 100 days would result in a drawdown at each well of approximately 8 feet of drawdown at each well due to interference from adjacent wells. The maximum composite drawdown effect at each well, therefore, would be approximately 24 feet. In actuality, the aforementioned drawdown levels would be considerably less when local recharge is considered, and more site specific values of aquifer characteristics were available. Drawdowns away from the pumped wells would be less than these maximum values. For example, 1,000 feet away from a pumped well the drawdown using conservative aquifer characteristics and no local recharge and pumping continuously at 1,500 GPM for 100 days would only be about 8 feet.

(d) Conclusions - From literature research, personal communication with the U. S. Geological Survey and model analysis of the groundwater in the vicinity of the site, it is apparent that sufficient quantity of water is available to sustain the proposed Unit 2 expansion. However, due to paucity of information, development of wells for Unit 3 is not proposed at this point in time.

Drawdown in the groundwater levels from Unit 2 will not adversely impact the natural resource. The proposed use of water is for a reasonable beneficial use and in the public interest.

FILE COPY



Review of Application for Site Certification

Arvah B. Hopkins Generating Station
Tallahassee, Florida

by the

Power Plant Siting Group
Florida State University

Robert C. Glassen, **coordinator**

John W. Winchester, **principal investigator**

Department of Oceanography and
Florida Resources and Environmental
Analysis Center
Florida State University
Tallahassee, Florida 32306

November 1974

REVIEW OF
APPLICATION FOR SITE CERTIFICATION
ARVAH B. HOPKINS GENERATING STATION
TALLAHASSEE, FLORIDA

by

Power Plant Siting Group

Florida State University

Robert C. Glassen, Coordinator

John W. Winchester, Principal Investigator

Department of Oceanography
and
Florida Resources and Environmental
Analysis Center

15 November 1974

POWER PLANT SITING GROUP

1. Staff

Robert C. Glasssen, Coordinator

Research Staff:	Support Staff:
Thomas E. Ahlfeld	R. Craig Starns
Robert Crider	Barbara R. Barnes
Robert P. Eganhouse	Patti M. Boyd
Manuel H. Johnson	Daniel J. Kelly
Selvakumaran Mahadevan	Beth A. Smoker
Hugh Mitchell-Tapping	Glenda B. Trefcer

2. Faculty Review Committee

Thomas Burton	Robert J. Menzies
George W. DeVore	J. Kenneth Osmond
Loretta C. Ellias	Donald Patton
Edward A. Fernald	Mildred W. Ravenell
Robert C. Harriss	Steven Schamel
Charles L. Jordan	Philip E. Sorensen
Robert A. Kromhout	William F. Tanner
Edward A. Laws	Robert G. Turner
Robert J. Livingston	Robert H. Weller
Harold L. McConnell	David C. White
Jeff B. Meeker	John W. Winchester, Chairman
Thomas J. Vickers	Sherwood W. Wise, Jr.

REVIEW OF APPLICATION FOR SITE CERTIFICATION
ARVAH B. HOPKINS GENERATING STATION
TALLAHASSEE, FLORIDA

Contents

POWER PLANT SITING GROUP 2

List of Figures 5

List of Tables 6

I. CONCLUSIONS AND RECOMMENDATIONS.................... 7

II. INTRODUCTION...................................... 12

A. Need for Review of Site Certification 12

B. Methodology 16

III. STATEMENT OF NEED................................ 21

IV. THE QUESTION OF FUEL.............................. 39

V. THE SITE.. 45

A. Site Geology 45

B. Socio-Economic Aspects of the Present Site 46

VI. HEAT DISSIPATION TECHNIQUES........................ 49

VII. DIRECT IMPACTS FROM INCREASED GENERATING CAPACITY... 51

A. Cooling Tower Effects 51

B. Water Quality Effects of Blowdown Discharge 58

1. Concentrated salts 59

2. Additives 61

3. Boiler blowdown 68

4. Ion exchange regeneration wastes (IERW) 68

5. Future water quality problems 68

C. Air Pollution Potential 72

1. Oxides of sulfur 73

2. Oxides of nitrogen 76

3. Atmospheric particulates 77

D. Impact on the Ground Water System 79

1. Hydrology 79

2. Surface water 79

3. Groundwater 80

4. Water demands for ABH 82

5. Effects of future water demands on water supply 83

E. Effects of Increased Water Demands 86

F. Ecological Impact 91

1. Critique of biological survey methodology 93

2. Critique of biological data analysis 94

3. Environmental impact - potential problems 103

4. Summary 107

VIII. INDIRECT IMPACTS....................................109

IX. REFERENCES CITED....................................115

APPENDIX I.

Selected Bibliography....................................119

APPENDIX II.

Comments From the Faculty....................................133

APPENDIX III.

Other Agency Comments....................................171

LIST OF FIGURES

Figure		Page
1.	Potential impacts from the ABH Generating Station	19
2.	Price and quantity of KWH demanded for Tallahassee	34
3.	Measure of total consumer's surplus	35
4.	Theoretical drawdown	87
5.	Plot of species diversity (H'), rarefaction values (at the 45 individual level) for ESE benthic stations	97
6.	Plot of species diversity (H'), equitability (J') and species richness for ESE benthic stations	98

LIST OF TABLES

Table		Page
1.	Comparison of Demand Forecast	26
2.	Computer Printout of Demand Function	31
3.	Operating Costs 1978	36
4.	Cost of Pollution Abatement	37
5.	Costs of Plant and Operation (1975-2008)	38
6.	Cooling Water Quality Parameters	59
7.	Chemical Treatment Levels	62
8.	Further Analysis of Benthic Species Diversity Data Provided by Environmental Sciences and Engineering Incorporated	96
9.	Morista's Index of Faunal Affinity Values for ESE Stations	100

I. CONCLUSIONS AND RECOMMENDATIONS

During the past five months, the City of Tallahassee's application for expansion of the Arvah B. Hopkins (ABH) Generating Station was reviewed by the Power Plant Siting Group (PPSG) at Florida State University. This analysis has led to the following conclusions:

1. Forecast modeling conducted by the PPSG indicates that if present trends in the growth of demand continue, expansion of the City's generating capacity is needed to meet future electrical demands.
2. Primarily because the ABH facility already exists, it seems reasonable for the city to satisfy the demand for increased generating capacity at this site. However, the proximity of this location to environmentally sensitive areas with high economic and recreational value (the Lake Talquin - Ochlockonee River system and the Apalachicola National Forest) necessitates that care must be taken to achieve minimal environmental impact.
3. Specifically, analysis of the ABH Site Certification Application has shown that problems exist in the following areas:

   a. The proposed treatment of cooling tower water with sulfuric acid will lead to unacceptable levels of sulfates in Lake Talquin.

b. The question of phosphate discharge into Lake Talquin remains unresolved.

c. The drawdown model presented in Addendum 4 of the application shows that sufficient make-up water will be available for Unit 2 but does not present enough information to enable certification of Unit 3.

d. The method proposed for transporting the large amount of fuel oil needed for Unit 3 - by truck from St. Marks - is not feasible along existing roads.

e. Serious questions exist concerning the availability of natural gas and oil, particularly low-sulfur oil.

f. Due to the scarcity of low-sulfur fuels, the applicant proposes that air pollution control be accomplished by means of very tall stacks but no information is given on the stack height or its anticipated adverse effects on operations at the Tallahassee Municipal Airport or of its visibility in the surrounding area.

g. There is a general deficiency of baseline biological data in the application.

h. Potential damage to historical artifacts by plant construction is inadequately evaluated.

4. For these reasons, the PPSG recommends that:

a. Hydrochloric acid be considered as a substitute for sulfuric acid in cooling water treatment.

b. More data on the anticipated effects of phosphate discharge into the Lake Talquin - Ochlockonee River system should be presented by the applicant.

c. More accurate data on transmissivity and storage coefficients must be collected before certification is extended for Unit 3. At this time, since this information does not exist, field investigation is necessary.

d. Fuel transportation to ABH involves transfer from tanker to barge in Port St. Joe or Tampa and transfer from barge to truck in St. Marks. Spillage during these operations is a possibility and close surveillance is recommended.

e. Because of the uncertainty concerning the supply of fuel oil and natural gas, other fuels should be considered before certification is advanced.

f. More information on the environmental effects of the high stack pollution control alternative should be presented. This information would include a monitoring design.

g. In order to forestall any unanticipated ecological impact arising from plant expansion it is imperative that a monitoring program be designed which should include frequent sampling and analysis of Lake Talquin's water and sediments for sulfates, phosphates and chlorides. In addition, this program should include a quantitative biological sampling design for monitoring of both micro and macro fauna. This program will have the added advantage of providing base-line data for a later application for the certification of Unit 3.

h. Because of the moderately high probability of encountering heretofore unrecorded cultural resources, it is recommended that the applicant arrange for a professional on-site evaluation of the project area to insure that construction of the generating facility will not adversely impact presently unrecorded cultural resources.

5. The PPSG recommends that the points noted above be satisfied by the applicant before certification is extended for Unit 2. However, due to complexities of the problems which are involved with the construction of a third unit, the PPSG does not recommend certification of Unit 3 at this time.

II. INTRODUCTION

A. Need for Review of Site Certification

In the last ten years, Tallahassee's population has increased 40 percent. During the same period the demand for electric power has risen over 200 percent. To meet present and projected future electric power demands the City of Tallahassee plans to increase the generating capacity at the Arvah B. Hopkins power station with the addition of a 235 MW unit in 1977 and a similar unit in 1982. Even these increases will come too late, and, until the first new unit comes on line, the City will have a power deficit.

Tallahassee's sharply rising demand for electric power is not unusual. Statewide and nationwide we have experienced ever increasing energy demands and the race to keep up has begun.

Supply and demand for electric power leaves only two options: a) meet demand or, b) limit demand to meet supply. By law, a utility is limited to the first choice, and this is the one that is the hardest on the environment. The decision to meet demand has led to one of the major problems of the day - to increase electric generating capacity in order to keep abreast of the mounting demand for energy while trying to protect the environment.

One of the most troublesome aspects of this situation is the tendency for the solution to the problem to be counter-productive. It seems, for example, that an excess in electrical supply creates demand and stimulates growth, which, in turn, places added pressure on the ecological system. What may be even worse, environmentally, is that the kind of growth which is encouraged often represents a shift from previous patterns of light industrial and residential to heavy industrial.

The City of Tallahassee in an effort to satisfy short term goals and provide a quick response to energy demand, may be adding to the long-term problem. It may, for example, be expedient to use oil to avert today's shortages but, as oil supplies dwindle and prices rise, this may prove to be a costly decision. Alternative fuels may have been a better choice for the future, but in many cases, they are rejected in an effort to get new plants on line as rapidly as possible. Policy changes such as energy conservation by some allocation strategy are even more cumbersome and are often rejected because of time constraints, even though this type of planning may have proven more effective in the long run.

Tallahassee must strike a balance between short term and long term interests. While recognizing the importance of an adequate power supply, it should also be noted that the solutions of today may be the problems of the future.

Our point is this: we now face a dilemma. This dilemma which has been called the "energy-environment dilemma"

(COPPS, 1972), is a result of the energy crisis. On one hand, there is an unprecedented public and industrial demand for electric power while, on the other hand, there is outrage in an era of environmental awareness. Public utilities, like the City of Tallahassee, are caught in the middle of this controversy.

The consumer, while enjoying a standard of living which is possible only in an energy intensive economy, has identified the power companies as one of the leading villains in the age of pollution. Partly because of their visibility, partly because they are monopolies, and partly because of past depredations, power companies have been restricted by the public in their ability to meet their responsibility to furnish adequate power. Yet, through it all, and in spite of himself, the consumer has demanded more and more cheap electricity.

Obviously, there is no clear-cut solution to the energy-environment dilemma. Both needs are crucial and careful planning can be our only logical response. It must be remembered that satisfaction of both long-term and short-term planning goals lies in maintaining compatibility between people and their environment. This is the key consideration and this report has been prepared with this principle in mind.

It is the opinion of the PPSG that the resolution of the energy-environment dilemma lies in careful planning and enlightened engineering. We must recognize that it is possible to build a clean, economical power plant in a logical place. This should be our goal in the State of Florida. This is a goal which can be achieved.

A major step in this direction was taken by the Legislature with the passage of the Florida Electrical Power Plant Siting Act (House Bill 149, Regular Session 1973) which requires power companies to submit a site certification to the Florida Department of Pollution Control (DPC) for approval before construction can begin.

The Site Certification is essentially equivalent to what is usually referred to as an Environmental Impact Statement (EIS). As such, it provides the basis for any planning-management procedure. Without an accurate and complete EIS, environmental planning is impossible.

The question then arises as to what constitutes an accurate and complete EIS. Some clarification of this question came when the passage of the National Environmental Policy Act of 1969 (NEPA) (Public Law 91-190) made the EIS a subject of Federal concern. For the purposes of law, definition was provided by the Council on Environmental Quality established by NEPA. Although formulated for Federal law, the information provided by the Council (Federal Register, Vol. 30, no. 147) is often applicable at the state level. According to this information the EIS should (may) include:

1. Description of the proposed action.
2. Statement of purpose (and need).
3. Description of the environment which may be affected (as it exists prior to the proposed action).

4. The relationship of the proposed action to land use plans, policies, and controls for the affected area.
5. The probable impact of the proposed action on the environment (including secondary or indirect impacts).
6. Alternatives to the proposed action, including alternative design details.
7. Summary of probable adverse environmental effects which cannot be avoided.
8. Summary of adverse environmental effects which will be controlled in such a way as to render them insignificant.
9. Any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented. (Resources <u>also</u> means natural and cultural resources).

In this state, the Florida Electrical Power Plant Siting Act provides the procedure for review of site plans by the DPC. Florida State University has been subcontracted by the DPC to assist in its evaluation and this document represents the final report on that review.

B. <u>Methodology</u>

From the outset, the PPSG has proceeded under the assumption that the data contained in the EIS were presented in good faith and with no intention of misleading the reviewers. This assumption seems to have been true, but, nevertheless, was necessary because the alternative would have been to test numerous data points contained in the certification. With the resources, personnel and time available this course of action was impossible. Instead, the reviewers believed that erroneous data would probably surface when examined by an expert in the corresponding field. Many experts assisted in the review, and errors in the data were noted in some cases, but none of these errors seemed intentional on the part of the applicants.

As a first step, the EIS was read by the Principal Investigator and the Research Associate. To delineate deficiencies and/or detrimental impacts rapidly with as much accuracy as possible and to gain a point of departure for simplification of review of the myriad complex and interrelated man/environment factors involved at this site, matrix analysis was employed. This analysis was performed as prescribed in U.S.G.S. circular No. 645: "A Procedure For Evaluating Environmental Impact". That procedure consists of constructing a two dimensional matrix with the ordinate axis being divided into equal units wherein proposed actions are listed.

The abscissa is divided into the same equal units for the listing of existing characteristics of the environment. A grid of squares is thereby generated by the intersection of lines drawn parallel to those axes. A slash is placed in each square of intersection indicating an impact relevant to the project under review. Then in the upper portion of each marked square the magnitude of the impact it represents is subjectively rated by placing a numeral between one and ten inclusive, a one being the lowest magnitude of impact and a ten being the highest. In the lower portion of the same marked square the importance of that impact is rated in the same manner. Thus the relative environmental impacts produced by given actions of the proposed project can be readily seen where high indices of magnitude/importance appear in the matrix.

This procedure led to the identification of four major areas of environmental impact associated with the ABH generating station (Fig. 1). These are:

1. Atmospheric impact due to water vapor discharge at the cooling towers.
2. Atmospheric and terrestrial impact from stack gases.
3. Hydrological impact caused by drawdown of the groundwater table.
4. Thermo-chemical impact on the aquatic ecosystem stemming from discharge of the blowdown effluent.

In addition, it was decided the statement of need embodied in the City's Ten Year Plan should be reviewed along with the ABH Site Certification since such information is normally considered an essential part of an EIS. This section of our review includes (a) a cost benefit model, as well as (b) an analysis of the City's projection of electric power demand.

Once the major problem areas for the ABH plant were identified, the PPSG was staffed with these needs in mind.

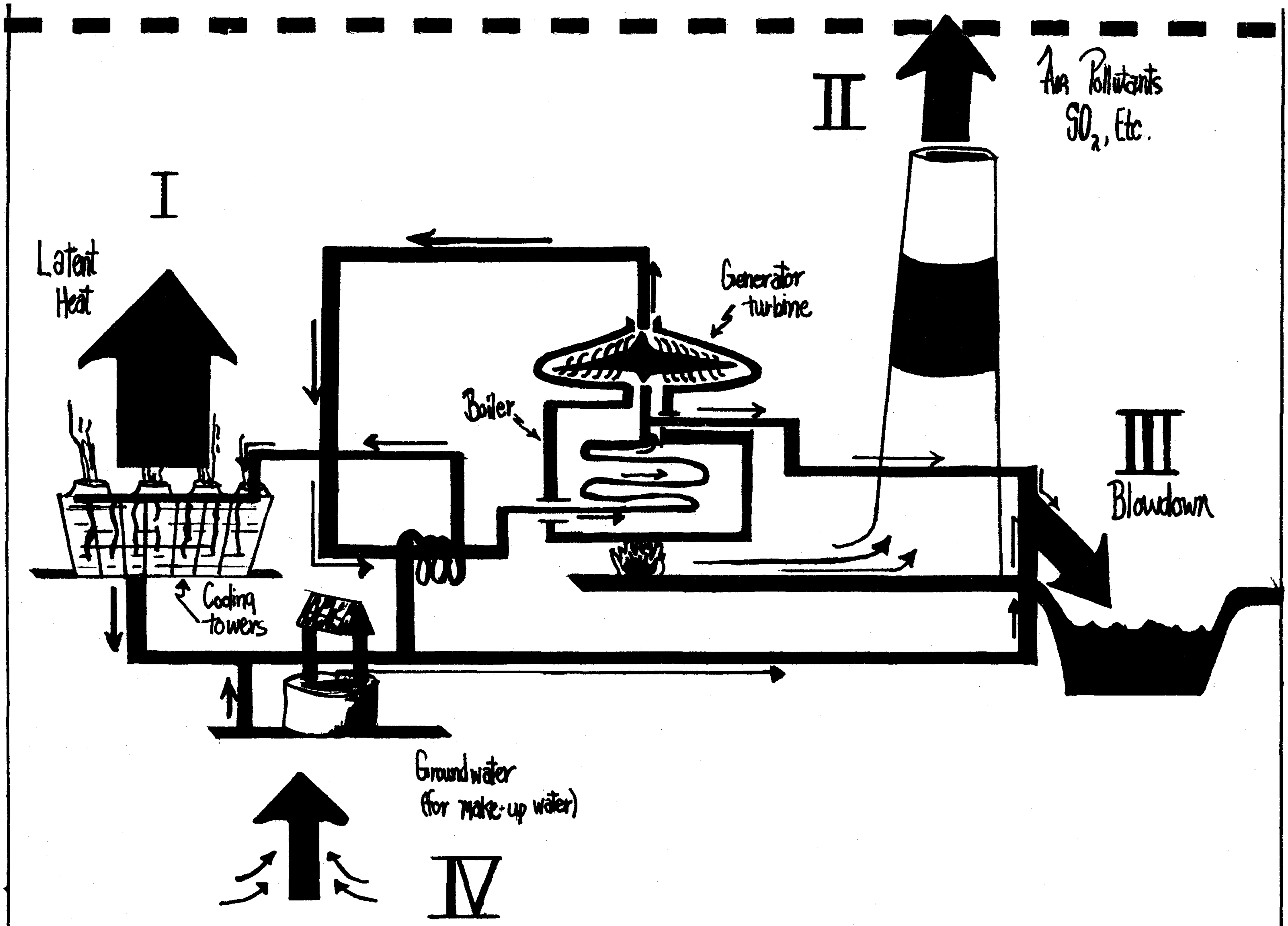


Fig. 1. Potential impacts from the ABH Generating Station

To this end, a geologist, a chemical oceanographer, and an economist were added to the group. Analysis of the atmospheric impacts was supervised by the Principal Investigator.

Since the biological impacts on the ecosystem provide the integrator which ties all the other impacts together, it was decided that expertise in this area was critical to the success of the review and two aquatic biologists were added to the staff. These specialists were experienced in sampling procedures and thermo-chemical effects on aquatic ecosystems. Their responsibility was to review the biological data and sampling procedures contained in the EIS, as well as to evaluate the accuracy of the Site Certification as regards the total ecological impact of plant expansion.

Each of the professional staff members was assigned the task of writing a complete and detailed report in his area of expertise. The direction, organization, and general thrust of these reports was the responsibility of a full-time Research Associate who worked closely with the individual investigators.

During the course of the project, a library search was conducted so that a basic bibliography on power plant siting techniques and the environmental effects of fossil-fueled electric generation could be compiled. Because a large volume of information exists, this review was selective and by no means exhaustive. The bibliography which was compiled, broken down by subject, is presented in Appendix I.

As part of the review process, and while the staff reports were being written, the Site Certification was read again by the Research Associate. This time the objective was to divide the EIS into segments which would be distributed to faculty experts throughout the Florida State University for their review. Part of this process included a thorough and extensive search of the University to identify experts in diverse disciplines who were interested in environmental problems. When this was accomplished, these faculty were asked to read a section of the EIS. Each was then interviewed by the Research Associate or one of the Graduate Research Assistants on the staff of the PPSG. In addition to these verbal comments, many of the faculty members also transmitted a written memorandum to the Research Associate detailing their observations and this material has been included in Appendix II.

The following sections of this report present a compilation and analysis of the comments of all those involved in the review of the ABH Site Certification.

III. STATEMENT OF NEED

The Site Certification submitted by the City of Tallahassee does not include any statement of the need for the requested increase in generating capacity. In our opinion, a statement of need is an essential part of any EIS. It is problematical whether or not an EIS is the same as a site certification. The PPSG feels that it should be. As the process now stands, the Public Service Commission (PSC) has the major responsibility in reviewing what amounts to a statement of need contained in the Ten Year Plan submitted by the power company (See PSC review for ABH in Appendix III). Separately and at another time the PSC is asked by the DPC for comments on various site certifications. It is difficult for the PSC to relate the rather general information contained in the Ten Year Plan to the Site Certification approval which necessitates very specific data. Either the Ten Year Plans must provide more information or the Site Certification should provide this information. The latter course of action appears to be more logical and appropriate.

For analysis of the need for increased generating capacity at ABH, the PPSG went to the City's Ten Year Plan. It was decided the approach was first to verify or reject Tallahassee's forecast of future demand for electric power in the service area and to outside customers. Secondly, although not required by House Bill 149, it was felt that there should be a definite consideration of the social costs and benefits generated by the construction of the facility.

State document (DSP-BCP-T-4-13-73), initiated by the Division of State Planning, in conjunction with House Bill 149, clearly states that each utility is required to provide documentation of the procedures used in forecasting energy consumption. Specifically, the documentation should include a detailed description of the methodology used in preparing the forecast as well as a description of specific analytical techniques employed, their purpose, and the portion of the forecast to which they apply. The instructions further state that statistical forecasting techniques shall be supported by the presentation of typical computations, including computer printouts and formulas, and any appropriate statistical tests to indicate confidence levels and accuracy ranges. Also, data sources used in preparing the forecast should be identified explicitly.

The City of Tallahassee's Ten Year Plan does not satisfy these guidelines. There is no statement of methodology and no presentation of statistical computations whatsoever. Nevertheless, the city does present a table of forecasted values of electric energy consumption. As part of the PPSG's review these figures were tested for accuracy and dependability.

An exponential trend line is probably the most accurate method of testing the City's data. If a time series tends to increase geometrically, which Tallahassee's does, the trend can often be described by the exponential equation

$$Y^*=ab^x$$

where a and b are constants and the time variable x appears as an exponent. If b is greater than 1, the trend value Y* will grow by increasingly larger amounts in each time period. Written in its logarithmic form, the exponential trend line becomes

$$\log Y^*=\log a + x\log b$$

which is linear in log Y* and x.

The method of least squares can be used to estimate the constants a and b in logarithmic form, then using antilogarithms their true values may be approximated.

Y* represents total electric power consumption in Tallahassee and x represents the time variable with the origin at 1969, selecting the origin so that $x=0$ the normal equations are reduced to:

$$\log Y = n \log a \text{ and } x \log Y = (\log b)\ x^2$$

A reproduction of the computer printout concerning the exponential trend applied to Tallahassee utilities consumption data is presented in Chart 1. Column 2 is identified historical time series of total electric energy use from 1965 to 1973. Column 3 represents the time variable with the origin at 1969. Column 4 is the log transformation of Column 2. Applying least squares results in the regression coefficients listed on the printout

$$\log Y^* = \log a + x \log b$$

$$\log Y^* = 13.1626 + .1325\ x$$

Goodness of fit of the regression equation or of the coefficient of determination (R^2) is listed as 0.9889.

Taking the antilogarithm of the regression coefficients gives

$$Y^* = ab^x$$

$$Y^* = (520528.54)\ (1.141)^x$$

The average annual rate of growth of energy consumption during the period from 1965 to 1973 was found to be

EXPONENTIAL TREND LINE ECONOIC FLORIDA STATE UNIVERSITY (JULY 1

2	3	4	5	6	7	8	9	10	11
1309450.0000	-4.0000	12.6426	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2339972.0000	-3.0000	12.7366	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3380669.0000	-2.0000	12.8497	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
4461768.0000	-1.0000	13.0428	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5535625.0000	0.0000	13.1912	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6637212.0000	1.0000	13.3649	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7593309.0000	2.0000	13.4492	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8755376.0000	3.0000	13.5356	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9848823.0000	4.0000	13.6516	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

NUMBER OF OPERATION COMPLETED = 27
SEQUENCE COMPLETED-OPERATION COUNT = 6

EXPONENTIAL TREND LINE ECONOIC FLORIDA STATE UNIVERSITY (JULY 1

****
EQUATION NUMBER 1 9 OBSERVATIONS 3 VARIABLES 1 3 4
****

ADJ. COEFFICIENT OF DETERMINATION .9873
UNADJ. COEFFICIENT OF DETERMINATION .9889
UNADJ. MULTIPLE CORR. COEFFICIENT .9944

F-RATIO 623.6201

ADJ. STD. ERROR OF ESTIMATE .0411
UNADJ. STD. ERROR OF ESTIMATE .0363

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARES
DUE TO REGRESSION............	1	1.0540	1.0540
DEVIATION ABOUT REGRESSION...	7	.0118	.0017
TOTAL...	8	1.0658	

VARIABLE NO.	MEAN	REGR. COEFF.	STD.ERROR OF REG.COE.	COMPUTED T-RATIO	UNADJ.PARTIAL CORR.COEFF.	UNADJ.PARTIAL COEFF. OF DET.	ADJ.PARTIAL COEFF. OF DET.
1	1.0000	1.3162610+01	1.3703820-02	960.5071	0.0000	0.0000	0.0000
3	0.0000	1.3254010-01	5.3074660-03	24.9724	.9944	.9889	.9873

(Y)= 13.1626 VAR(Y)= .1164

SPC= .275 SPCBAR= .312 DETERM= 1.00000+00

DW= 1. 342 CH= 1.4468 RHO= .9157 FER= 0.0000 RHOFO= 0.0000 INRHO= .5599

EXPONENTIAL TREND LINE ECONOIC FLORIDA STATE UNIVERSITY (JULY 1

EQ RSQBAR F	SCT R	SEEB SPCB	VARIABLES				REGRESSION COEFFICIENTS T-RATIOS 1	2	3	4	5	6	7	8
1 .987	1.034	.041	1	3	4	0	13.1626	.1325	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
623.62	.994	.312	0	0	0	0	960.5071	24.9724	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

NUMBER OF OPERATION COMPLETED = 13

Chart 1

$$g = b-1$$

$$g = 1.141 - 1.0 = 0.141 = 14.1\%$$

Applying the 14.1% annual growth rate to the forecast period enables comparison of this method of prediction to the projection offered by the City of Tallahassee. The exponential trend estimation procedure was selected for comparison specifically because of the characteristics of the operation.

It seems doubtful, however, that power consumption would continue to increase at the derived rate for an extended period of time. Thus, the estimated trend line is likely to produce exaggerated forecasts of future consumption even though it fits the data on past sales extremely well.

One hypothesis is that if the city utilities forecast is at all accurate its estimates for the projected years should consistently fall below those derived by our method.

TABLE 1

COMPARISON OF DEMAND FORECAST (KWH)

CITY OF TALLAHASSEE FORECAST	YEAR	EXPONENTIAL TREND LINE
874,000	1974	968,507.4
971,000	1975	1,105,066.8
1,071,000	1976	1,260,881.2
1,366,000	1977	1,438,665.4
1,415,000	1978	1,641,517.2
1,458,000	1979	1,872,971.1
1,616,000	1980	2,137,060.0
1,793,000	1981	2,438,385.4
1,989,000	1982	2,782,197.7
2,206,000	1983	3,174,487.5

A quick study of TABLE I shows that the city's estimates do fall below those projected by the trend line and are probably reasonable forecasts of future power consumption (no matter how ambiguous their approach might be).

It must be recognized, however, that goodness of fit criteria are not adequate in themselves for deciding whether or not to use an estimated trend equation for making forecasts. There may be technical or theoretical reasons for not using the closest fitting trend line as a forecasting tool. The investigator may be aware of changes in other variables which, in his judgment, may affect the future values of the time series he is trying to forecast. Such information should not be ignored even if it cannot be incorporated into a mathematical function.

One consideration that might cause both forecasts to overestimate future power demand would be the probability of a drop in Florida's migration rate. It is known that Florida, and also Tallahassee which is not atypical of the state, has one of the lowest birth rates and one of the highest death rates in the nation. The overbalancing factor is the area's inward migration rate. Florida ranked first in the nation, not only in terms of net migration as a percent of 1970 population (9.6%), but also in terms of the absolute number of net migrants (574,000). If no migration had occurred into or out of the state between 1960-1970 Florida's population growth would have increased only 10% over this period rather than the 37% observed.

There are two possible factors involving migration that could cast serious doubts on the prediction of exponential power consumption in the Tallahassee area. First, several studies have hypothesized that Florida will become disadvantaged as a result of migration. On the basis of previous data, these studies concluded that those persons who left the state were superior, in terms of both educational attainment and income level, to those persons migrating into Florida. Since disposable income is directly associated with consumption and square footage of living space, there is a possibility that immigrants will consume, on the average, less power than the present citizens. Secondly, there is a distinct possibility that climbing interest rates, high construction costs, and shortage of mortgage money, will put a lid on future migration and also force many of Florida's present citizens into multi-family apartment complexes. In fact, these factors have already reduced construction activity in many areas. This supports the theory that power needs for the surrounding area will not be as great as those forecasted using historical time series data.

Although time constraints do not allow a rigorous determination of costs and benefits involved with the decision to invest in an electric power plant, a method of approach will be considered along with a strong recommendation that these measures be followed.

In calculating the benefits incurred by construction of A. B. Hopkins unit #2, some estimation of consumer's surplus must be taken into account. This involves developing a demand curve, such as the City of Tallahassee's, which might possess the same general properties as the industry demand curve for a perfectly competitive market. It is an aggregate of the demand curves of individual consumers and is assumed to be negatively sloped.

It is hypothesized that the City's demand function for power is represented by

$$Q_t = \alpha - \gamma P_t + \delta Y_t + \lambda Q_{t-1}$$

where the amount of electric power consumed by the average family in Tallahassee is determined by the price he has to pay for electricity, his net income, and some level of habit persistence based on past consumption.

Q_t -- is quantity of power demanded (KWH)

α -- has the same units as the dependent variable and shows the amount of power that would be purchased if both price and income were zero.

P_t -- price per kilowatt hour

γ -- is the regression coefficient that indicates on average, the amount of the decline in KWH purchased for every fractional increase in price (with income held constant).

Y_t -- aggregate disposable income

δ -- shows the change in the numbers of kwh purchased if income increases while price is held constant.

Q_{t-1} -- quantity of power demanded (KWH) lagged one period

λ -- shows the change in quantity demanded due to the level of previous demand (habit persistance) with price and income held constant.

To estimate this demand function, monthly data were collected and assembled on the above mentioned variables over the period January, 1970 to May, 1974. Consistent figures on total revenue and amount of KWH's sold were provided by the City Utilities Department. Price was derived by dividing revenue by amount of KWH's sold to obtain price per KWH. Only annual statistics for disposable income were available, so in estimating monthly income a least squares linear trend line was determined to be the best approach.

The equation,

$$Y^* = a + bx = 12.51 + 0.115x$$

indicated the annual growth rate of income to be 11.5 percent. In order to derive the monthly rate of growth, this figure is divided by 12 which gives .0096 as the proper increase.

With consistent monthly data available for all variables, a multiple regression was performed to determine the coefficients of the demand function. Included on the next two pages are a printout of the relevant regression statistics and a list of the data used. Column 2 on the printout represents price per KWH while column 3 is quantity of KWH sold in millions. The 4th column is disposable income (in thousands of dollars) and the 7th column lists lagged quantity.

From the printout our demand function is represented by,

$$Q_t = \alpha - \gamma P_t + \delta Y_t + \lambda Q_{t-1}$$

TABLE 2

FUNCTION TALLAHASSEE CITY UTILITIES — ECONOMIC FLORIDA STATE UNIVERSITY

EQUATION NUMBER 1* 52 OBSERVATIONS 5 VARIABLES 1 2 4 7 3

ADJ. COEFFICIENT OF DETERMINATION	.7832
UNADJ. COEFFICIENT OF DETERMINATION	.7959
UNADJ. MULTIPLE CORR. COEFFICIENT	.8922
F-RATIO	62.4 7?
ADJ. STD. ERROR OF ESTIMATE	5.5213
UNADJ. STD. ERROR OF ESTIMATE	5.3.47

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	D.F.	SUM OF SQUARES	MEAN SQUARES
DUE TO REGRESSION............	3	5707.4220	1902.47[illegible]
DEVIATION ABOUT REGRESSION...	48	1463.2572	30.4845
TOTAL...	51	7170.6792	

VARIABLE NO.	MEAN	REGR. COEFF.	STD.ERROR OF REG.COE.	COMPUTED T-RATIO	UNADJ.PARTIAL CORR.COEFF.	UNADJ.PARTIAL COEFF. OF DET.	ADJ.PARTIAL COEFF. OF DET.
1	1.0000	4.4271950+01	1.1171560+01	3.9629	0.0000	0.0000	0.0000
2	.0221	-2.4691000+03	6.3562820+02	-3.8845	.4891	.2392	.1916
4	3.4.8692	1.0858110-01	3.0777620-02	3.5279	.4538	.2059	.1563
7	59.8934	6.2245040-01	9.0640730-02	6.8672	.7040	.4956	.4641

(Y)= 60.5962 VAR(Y)= 137.8977

SPC= 8.827 SPCHAR= 9.187 DETERM= 1.71120-06

DW= .8923 DH= 5.2772 RHO= .3187 FER= 0.0000 RHOFO= 0.0000 TNRHO= .5631

		3	4	5	6	7	8	9	10	
1	.0280	45.8000	233.9000	2.0100	.0260	49.0000	1.0000	-4.9871	-6.1393	-5.6556
2	.0210	40.2000	236.3000	1.9900	.0250	45.8000	2.0000	-6.3868	-7.7314	-12.2345
3	.0190	47.6000	238.7000	1.9700	.0210	40.2000	3.0000	-.6999	-9.9673	-1.2935
4	.0190	50.9000	241.0000	2.0400	.0190	47.6000	4.0000	-2.2557	-7.7061	-6.5994
5	.0190	54.5000	243.4000	2.0600	.0190	50.9000	5.0000	-.9704	-4.7239	-3.6454
6	.0190	61.5000	245.9000	2.0600	.0190	54.5000	6.0000	3.5173	1.6324	2.7793
7	.0180	63.8000	248.3000	2.5600	.0190	61.5000	7.0000	-1.2695	-1.3112	4.5308
8	.0190	62.6000	250.8000	2.7800	.0180	63.8000	8.0000	-1.7035	1.2578	-1.3309
9	.0190	63.4000	253.3000	2.7800	.0190	62.6000	9.0000	-.4280	1.6273	2.9572
10	.0210	51.6000	255.9000	2.7900	.0190	63.4000	10.0000	-8.0701	-1.5905	-9.4175
11	.0220	46.1000	258.4000	3.0900	.0210	51.6000	11.0000	-4.0275	-2.0822	-7.2947
12	.0220	43.6000	261.0000	3.0900	.0220	46.1000	12.0000	-3.3864	-5.6385	-5.3045
13	.0220	47.2000	263.6000	3.1700	.0220	43.6000	13.0000	1.4874	-2.7079	-3.2992
14	.0220	47.8000	266.2000	3.3300	.0220	47.2000	14.0000	-.4357	-2.7773	-3.2939
15	.0240	43.8000	268.9000	3.4500	.0220	47.8000	15.0000	-.1641	1.7792	-7.9115
16	.0240	47.0000	271.6000	3.4500	.0240	43.8000	16.0000	5.2325	4.7102	2.6515
17	.0230	57.1000	274.3000	3.4500	.0240	47.0000	17.0000	10.5784	9.4893	[illegible]
18	.0220	64.1000	277.1000	3.4500	.0230	57.1000	18.0000	8.5185	10.9296	[illegible]
19	.0220	66.5000	279.8000	3.5700	.0220	64.1000	19.0000	6.2682	12.4214	12.2953
20	.0230	65.5000	282.6000	3.6500	.0220	66.5000	20.0000	5.9394	15.3263	[illegible]
21	.0230	65.4000	285.4000	3.6500	.0230	65.5000	21.0000	6.1578	14.7185	14.0043
22	.0230	59.8000	288.3000	3.6500	.0230	65.4000	22.0000	.3052	8.3719	7.7409
23	.0240	51.2000	291.2000	3.6400	.0230	59.8000	23.0000	-2.6549	3.6511	-1.5224
24	.0240	46.7000	294.1000	3.6400	.0240	51.2000	24.0000	-2.1167	-1.3825	[illegible]
25	.0220	54.6000	297.0000	3.6400	.0240	46.7000	25.0000	3.3312	-3.4807	[illegible]
26	.0230	56.2000	300.0000	3.4600	.0220	54.6000	26.0000	-3.8428	-4.4534	-6.6251
27	.0230	48.3000	303.0000	3.3400	.0230	56.2000	27.0000	-3.3297	-6.9127	-7.1214
28	.0220	53.9000	306.3000	3.3400	.0230	48.3000	28.0000	.6581	-6.7108	-2.2075
29	.0220	57.5000	309.1000	3.2300	.0220	53.9000	29.0000	.4358	-4.1220	[illegible]
30	.0210	67.5000	312.2000	3.1100	.0220	57.5000	30.0000	5.3892	.4592	[illegible]
31	.0210	74.2000	315.3000	3.1000	.0210	67.5000	31.0000	5.5281	6.1433	[illegible]
32	.0200	78.9000	318.5000	3.1000	.0210	74.2000	32.0000	3.2412	5.3934	11.7535
33	.0210	77.5000	321.6000	3.1000	.0200	78.9000	33.0000	1.9481	7.6000	5.5545
34	.0220	66.8000	324.9000	3.1000	.0210	77.5000	34.0000	-6.5696	.8972	-1.5104
35	.0220	60.7000	328.1000	3.0600	.0220	66.8000	35.0000	-6.4559	-5.8135	[illegible]
36	.0220	56.6000	331.4000	3.0600	.0220	60.7000	36.0000	-7.1163	-10.7631	[illegible]
37	.0220	69.2000	334.7000	3.1100	.0220	56.6000	37.0000	7.5755	.9473	[illegible]
38	.0220	63.8000	338.1000	3.3400	.0220	69.2000	38.0000	-5.9306	-5.2581	-3.7548
39	.0230	57.2000	341.4000	3.4600	.0220	63.8000	39.0000	-7.8646	-8.1119	[illegible]
40	.0230	57.9000	344.8000	3.6600	.0230	57.2000	40.0000	-2.6256	-8.0741	[illegible]
41	.0220	69.2000	348.2000	3.7000	.0230	57.9000	41.0000	4.4004	-3.2753	[illegible]
42	[illegible]	81.9000	351.8000	3.7800	.0220	69.2000	42.0000	11.2983	[illegible]	11.2255
43	.0220	90.2000	355.3000	3.8000	.0220	81.9000	43.0000	10.6507	16.5535	15.7250
44	.0220	88.4000	358.8000	3.8100	.0220	90.2000	44.0000	3.3443	13.9527	15.1254
45	[illegible]	86.4000	362.4000	3.8100	.0220	88.4000	45.0000	2.0739	11.0559	13.5020
46	[illegible]	[illegible]	366.1000	3.8100	.0220	86.4000	46.0000	-7.1139	2.2291	-.0443
47	[illegible]	[illegible]	369.7000	4.3300	.0230	73.9000	47.0000	-11.9242	-10.5847	-5.9779
48	[illegible]	[illegible]	373.4000	4.7000	.0230	61.7000	48.0000	-5.4529	-10.2115	-13.5242
49	[illegible]	[illegible]	377.2000	4.9400	.0240	58.5000	49.0000	-3.5455	-5.3252	[illegible]
50	[illegible]	[illegible]	[illegible]	6.4400	.0250	53.9000	50.0000	.6469	-7.2774	-2.5702

$$Q_t = 44.3 - 2469.1\ P_t + .12\ Y_t + .623\ Q_{t-1}$$

where Student's t ratios of the parameters are,

(3.963) (-3.884) (3.528) (6.867)

The multiple correlation coefficient of dependent and independent variables is:

$R^2 = .796$

$\bar{R}^2 = .783$

Since the function contains a lagged variable the Durbin-Watson h-statistic becomes the primary test for serial correlation.

$$h = (1 - 1/2d)\sqrt{\frac{T}{1 - T\ \hat{V}(\hat{b})}}$$

$$h = (1-1/2(.89))\sqrt{\frac{52}{1 - 52(.0082)}} = 5.27$$

Comparison with the critical values from the standard normal distribution table enables acceptance of the null hypothesis of no serial correlation.

Price-quantity intercepts for a graphical exposition of the demand curve can be determined by setting quantity equal to zero and solving for price or vice versa as shown below.

$$0 = 44.3 - 2469P_t + .11\ (304.9) + .622\ (59.9)$$

$$2469P_t = \frac{44.3 + 33.54 + 37.26}{2469}$$

$P_t = .047$ price intercept

$Q_t = 44.3 - 2469\ (0) + .11\ (304.9) + .622\ (59.9)$

$Q_t = 115.1$ quantity intercept

Figure 2 represents the negative relationship that exists between price and quantity of KWH demanded for Tallahassee. The Y intercept shows the price for which zero power would be demanded and the X intercept shows the quantity that would be demanded if price were zero.

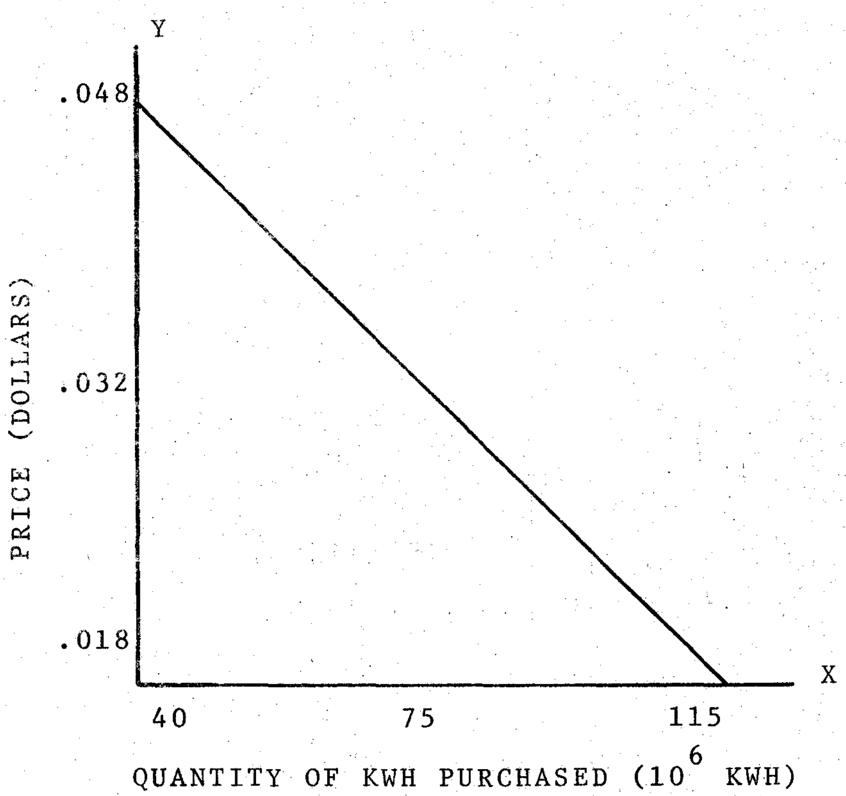


Fig. 2. Price and quantity of KWH demanded for Tallahassee

Now that the demand function has been determined, consumer surplus may be calculated so as to derive positive or negative benefits accruing to the community.

The market demand curve can be regarded as the marginal valuation curve for the service area. For example, the height QR, in Fig. 3, corresponding to output OQ, gives the maximum value some person in the community is willing to pay for the

Qth unit of the good which, for that person, may be the first, second, or nth KWH of power bought. But to each of the total number of KWH's purchased, which total is measured as a distance along the quantity axis, there corresponds some individual's maximum valuation. The whole area under the demand curve, therefore, corresponds to Tallahassee's maximum valuation for the quantity in question. If OQ is bought, the maximum worth of OQ units to the City is given by the trapezoid area ODRQ. Now the quantity OQ is bought at price OP. Total expenditure by power customers is, therefore, represented by the area OPRQ (price OP times quantity OQ). Subtracting the maximum worth to consumers (ODRQ) from what they have to pay (OPRQ) results in the total consumer's surplus equal to triangle DRP and derived by

$$CS = \frac{D.Q - P.Q}{2}$$

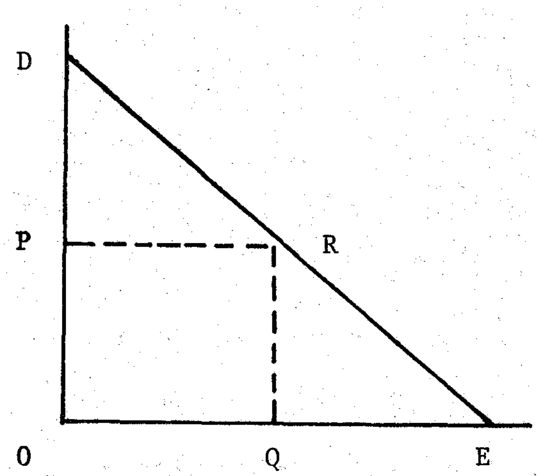


Fig. 3. Measure of total consumer's surplus

Cost estimates of ABH Unit 2 are based on projected figures provided by the City of Tallahassee. It should be understood, however, that these estimates were regarded as conservative by the City and constant escalation of price by contractors and other factors may increase these costs.

The cost of the physical plant itself can be broken down into five primary categories which are: total construction costs, boiler, cooling towers, structural steel, and fuel oil tank. Under each of these titles fall the subcategories: Construction, sales tax, engineering, and legal and administrative costs. An estimate given for the total cost of the physical plant, including all the above headings, which would place Unit 2 on line is $55,373,300.00.

The next factor considered in computing costs was operating expenses. These outlays are broken down into four areas: production, other production, transport and distribution, and administrative and general. TABLE 3 provides estimates of the costs in these categories.

TABLE 3
OPERATING COSTS 1978

Production	$16,957,000
Other Production	484,000
Transport and Distribution	18,000
Administrative and General	120,000
Total	$17,579,000

In addition to these factors, the costs attributed to pollution control were also considered. TABLE 4 presents the projected costs necessary to meet pollution requirements.

TABLE 4
COST OF POLLUTION ABATEMENT

Control on Boiler	$400,000
Industrial waste	400,000
Fuel spills	35,000
Total	$835,000

Once all costs have been accounted for, these expenditures must be accurately distributed over the life of the plant so that an approximation of annual expenses can be provided. For the purposes of this report it is assumed that total capital costs ($55,373,300) are to be paid over a 31 year period ending in 2006, and that these costs will be paid in equal amounts during this time. This method almost certainly underestimates these costs since most capital financing is done through various bond issues which are based on equity-capital ratios and require paid interest. It is further assumed that operating expenditures and pollution control cost will remain constant. Again, this is a conservative assumption.

TABLE 5 represents the flow of costs of the plant and its operation over the period beginning with its construction and continuing over the estimated 30-year life of the facility.

TABLE 5
COSTS OF PLANT AND OPERATION (1975-2008)

YEAR	COSTS	YEAR	COSTS
1975	$ 1,786,235	1992	$20,200,235
1976	1,786.235	1993	20,200,235
1977	1,786,235	1994	20,200,235
1978	20,200,235	1995	20,200,235
1979	20,200,235	1996	20,200,235
1980	20,200,235	1997	20,200,235
1981	20,200,235	1998	20,200,235
1982	20,200,235	1999	20,200,235
1983	20,200,235	2000	20,200,235
1984	20,200,235	2001	20,200,235
1985	20,200,235	2002	20,200,235
1986	20,200,235	2003	20,200,235
1987	20,200,235	2004	20,200,235
1988	20,200,235	2005	20,200,235
1989	20,200,235	2006	18,414,000
1990	20,200,235	2007	18,414,000
1991	20,200,235	2008	15,645,335

IV. THE QUESTION OF FUEL

According to the Site Certification, ABH units 2 and 3 will be oil and gas fired. This, in the opinion of the PPSG, is a very restrictive choice. According to Dr. W. F. Tanner, professor of geology at FSU, "domestic oil supplies have been falling dramatically for about four years...and will continue to fall." Tanner states that "The U.S. has available, in known reserves, about 40 billion barrels of oil. At the present rate of consumption this is 6.2 years' supply." Now, we are "importing about 40% of our current usage. If this percentage continues to hold in the future, then our known reserves will last 10.3 years."

A study, recently completed by Tanner, indicates that "our grand total of oil production will be about 170 billion barrels of which we have already used 105 billion. This leaves us, apparently, about 65 billion barrels (of which 40 billion are in known reserves). Even if we assume that this amount can be utilized at a level rate (i.e. the current rate), we will only have 16.7 years of consumption left."

It is very unlikely, however, that we can use our domestic oil at a level rate. Tanner notes that, in fact, production has been declining for the last three years. He predicts, on the basis of this information, that "A serious deficiency (i.e. a major crisis) can be predicted within the next eight years."

This study has the advantage of using current data. However, a previous study made by Tanner, nearly 20 years ago, produced figures which have been borne out by experience in the last two decades, and which are now incorporated in the more recent study. Furthermore, the earlier study was preceded by an even more complete investigation, made by M. King Hubbert, which predicted rather closely the peaking of domestic output in 1970 or 1971 (actually reached in 1970). Hence the recent study is based on a history of successful forecasts nearly two decades earlier.

The only known alternate method of predicting future developments, the Zapp procedure used for many years by the U.S. Geological Survey, depends on the basic assumption that the supply of oil is infinite (that is, that the amount of oil recovered by a given amount of drilling, does <u>not</u> decrease as drilling proceeds). In actual fact, the amount recovered <u>does</u> decrease, as was clearly obvious 20 years ago, and as continues to be true.

Tanner goes on to state that if "...demand increases, or foreign oil supplies are reduced, this crisis will be moved closer to the present. A reasonable estimate is within four years, rather than eight years. Only with unusual luck can we expect as much as eight years to make major adjustments."

Recent discoveries and reported discoveries, in other parts of the world, are less than encouraging. A report of a Mexican discovery of 20 billion barrels of reserves publicized widely in the U.S. in the fall of 1974, was exaggerated. In reality, a discovery of about one billion barrels was made in June, 1972, in the Mexican states of Tabasco and Chiapas. This would supply the U.S. for about 60 days, assuming that it would be exported. Similar caution should be used in interpreting all such reports, for the finds may not be as large as reported, or the new oil may not be exported to other nations.

In addition, and of equal importance with regard to the ABH plant, Tanner is convinced that the outlook for natural gas supply is even bleaker. He predicts that "interruptable" users like the City of Tallahassee may soon be shut off permanently. (A natural gas cutback has already been imposed on Tallahassee as of this writing, November, 1974.)

Tanner's position is supported by a Shell Oil Report, "The National Energy Outlook" (1973) which states that they believe natural gas "...production peaked in 1972, will show a decline in 1973 and will continue downward. The speed of decline will depend on the scale and degree of success of new exploration activity."

Dr. Philip Sorensen, associate professor of economics, Florida State University, who has studied the economics of international energy markets for the past six years, believes there is no technical or geological barrier to increased oil supplies worldwide throughout the century. Indeed, he believes that the combination of North Sea oil production, production from the North Slope of Alaska, and increased production in

Africa, Indonesia, and Mexico will weaken the OPEC cartel and result in some reduction in world oil prices. He is convinced that the real price of oil will not rise in international markets over the next decade. Therefore, the prices utilities are presently paying for oil-based fuels are at the maximum levels (in real terms) that are likely to be observed throughout the century. It is reasonable therefore, for the ABH plant to be designed to burn fuel oil.

Dr. Sorensen agrees with most energy experts that natural gas availability will be severely curtailed in the future. Indeed it is likely that utilities will be required to reduce their consumption of natural gas by from 50-75% within the next 5 years and that natural gas will not thereafter be generally available to utilities. Furthermore, the price of natural gas (now fixed in interstate markets at 43¢ per thousand cubic feet) will most likely double or triple in the near future, bringing the cost per BTU of natural gas into more reasonable equality with the energy cost of other fuels. This will effectively eliminate the advantages which natural gas has previously has as a fuel input for utilities, an advantage which has been based very largely on federal price fixing.

In respect to coal, Dr. Sorensen points out that recent spot prices for coal in the Northeast have reached the level of \$35 per ton, as compared to \$7-10 per ton as recently as a year ago. The increased price of coal is the result of the close substitutability of coal for other fuels in many uses. The quadrupling of oil prices over the past year has resulted in a spillover demand into coal markets resulting in a sympathetic rise in the price of coal. It is expected that the combination of militant union action to raise wages and benefits in the coal mining industry, rising costs of production for coal resulting from increased safety and environmental regulations, serious bottlenecks in the production of mining and transportation facilities and rolling stock, and high and rising export demand for coal will keep the price of coal high over the next decade. There is no reason to suppose that coal either presently or in the future will offer a low cost alternative to petroleum-based fuels.

The painful fact is that there will be no low cost source of energy available to utilities in the coming decades, according to Dr. Sorensen. The only real opportunity that utility managers will have of reducing their overall costs will come in the form of additional gridding, the development of more efficient generation and transmission facilities, or the decision by the federal government to subsidize utility operations either directly by underwriting some capital costs or indirectly by offering low interest loans to utilities.

The PPSG feels that experts disagree concerning the availability and price of petroleum required to meet the projected increase in our energy demands for the next 30 years and out dependence on sources from abroad. According to the Shell report, "...newly found domestic oil can just offset declines in older fields... U.S. crude oil production has peaked at just over 9 million barrels a day and will now decline even though Arctic crude and production from the Lower 48 will slow this trend."

Using the data presented in the Shell report which forecasts the petroleum demand in 1985 at over 28 million barrels per day, and with an optimistic assumption that domestic supply will approach 10 million barrels per day (a figure which includes new discoveries, synthetic oil, oil shale, oil from coal, and arctic oil), the U.S. will have a deficit of 18 million barrels/day. Comparison of this figure with the Shell data which forecasts the range of cost from U.S. oil imports in 1985 to be from 31 billion to 69 billion U.S. dollars, yields a cost between $4.72 and $10.50 per barrel of imported crude ten years from today. Arab oil now costs about $12.00 per barrel so it may be that prices are rising even more quickly than Shell predicts.

In Tallahassee, as well as in other sections of the country, we have already discovered that the price of fuel oil has put electric power out of reach for some citizens. An increasing number of people are finding the front porch a more economical alternative to air conditioning and, in general, fewer and fewer are "living better electrically". The PPSG recommends that coal be considered as an alternative or a supplement to fuel oil at ABH. At the very least, the cost associated with convertibility of ABH to other fuels should be documented.

V. THE SITE

The ABH generating station is located about seven miles west of the center of Tallahassee, incorrectly indicated on the map shown in Exhibit II-1 of the Site Certification. The correct location is latitude 30°27'08"N, longitude 84°21'00"W. (Lake Talquin is also improperly located on this map, and Ochlockonee is spelled two different ways.)

A. Site Geology

The site is situated on the Hawthorn (or Post St. Marks) formation which is approximately 60 feet thick in this area (Hendry, 1966). This formation is composed of medium to fine quartz sand, montmorillinite, and attapulgite, with phosphoritic limestone at the base. The montmorillinite clay present in this formation has the potential to cause some problems for construction, especially if it is present as a lens. It is assumed that a core will be taken directly under the sites of the generator beds for both Unit #2 and #3, so that any possible clay lens may be examined for bearing strength and engineered for accordingly.

Below the Hawthorn formation lie the limestones of the St. Marks and Suwannee formations, aquifers which produce a reasonable supply of water. The aquicludes are of dolomite or highly dolomitized limestone (Hendry 1966). The Suwannee limestone is known as a cavernous zone and investigation of this formation on the site should be considered when planning construction.

The Crystal River formation, below the St. Marks and Suwanee formations, is the oldest formation that has been penetrated by wells in Leon County. The uppermost 60 ft. of this formation has produced excellent supplies of water and is used in the cased wells of the City of Tallahassee. There are no recorded wells in current use in this area that are deeper than 525 ft.

B. Socio-Economic Aspects of the Present Site

The ABH plant is situated in a sparsely settled section of western Leon County. As the EIS states, Tallahassee's growth has not been in this direction. No implication that this will continue to be true can (or should) be made. (See comments by Dr. Robert Weller in Appendix I). However, the PPSG sees no reason to expect any major changes in this area.

It should be noted, though, that the City's application for site certification is brief as regards socio-economic impact. Dr. Robert G. Turner, associate professor of finance in the School of Business at FSU, comments that "...there are few economic analyses presented in the certification application. What few data that exist are not analyzed concerning their impact upon the economic characteristics of the geographic area surrounding the proposed site." Turner goes on to state that "No indication of changing traffic flows nor of vehicular traffic patterns was presented." He feels that "...depending on types of traffic flows and types of vehicles, property located on highways servicing the plant site might be adversely affected." This factor may present a continuing problem caused by the method of fuel delivery to the plant. Oil is transported by barge to the Sam O. Purdom Generating Station at the mouth of the St. Marks River. From here, it is delivered to ABH via tank truck from the 155,000 barrel storage facilities at the Purdom Station. In 1986, with all three units on line, the projected fuel oil consumption is 4.589 million barrels per year. Assuming a truck load of 167 barrels, this will mean that 27,534 truck loads of fuel must move from St. Marks to Tallahassee each year. This represents an average of 75 truckloads per day. But, as Dr. Turner states, "No indication of road or highway construction or improvement to service increased traffic to and from the site was presented. These costs should be considered vis-a-vis other alternative sites, or, at least, they should be presented relative to this particular site."

Presumably it would not be economical to transport so much fuel to the plant by truck. If some new plan for transport must be considered for Unit 3 (e.g. a pipeline) then its possible environmental impact should be evaluated as part of the Site Certification.

In addition to the economic disadvantages of fuel transport by barge to truck, the PPSG notes that considerable oil pollution results from spillage during loading and unloading (e.g. barge to tank to truck). The proposed method of fuel shipment involves several such transfers and does not consider alternative procedures for an environmentally optimal minimum. For this reason the PPSG recommends strict surveillance of the transfer operations between the Gulf coast and Tallahassee.

Dr. Turner also notes that "The emission of smoke, steam, odor, etc., could affect property values where such pollutants could be seen, heard, or smelled. These data should be presented and their impact analyzed..." in a socio-economic sense. In addition, the "...visibility of the boiler stacks may adversely affect property values in surrounding areas and should be discussed."

Turner concludes that these details are not in his opinion, "...of sufficient magnitude to render the Site Certification inoperative." From what he knows "...of the economic characteristics of Leon County, it appears that the proposed site is justified from an economic standpoint."

In addition to physical aspects of the area, the attention of the PPSG has been drawn to historical and archaeological sites which may be impacted by the construction of ABH units 2 and 3. According to Daniel T. Penton of the Division of Archives, History, and Records Management, Florida Department of State: "The probability of encountering heretofore unrecorded cultural resources is moderately high, however, due to the physiographic characteristics of the project area. We recommend that the project sponsor arrange for a professional on-site evaluation of the project area to insure that construction of the generating facility will not adversely impact presently unrecorded cultural resources."

VI. HEAT DISSIPATION TECHNIQUES

A large part of the environmental impact associated with power plants is attributable to waste heat problems. In a steam-electric plant, the efficiency of operation is governed by the thermodynamics of the heat cycle. The ideal efficiency is determined by the differential in temperature between the heat source and the temperature of the surrounding water or air which acts as a heat sink. The ideal efficiency is described by:

$$E_i = \left(1 - \frac{T_{sink}}{T_{source}}\right) 100$$

where the temperatures are measured on an absolute scale. In a modern fossil fuel station, maximum temperatures are of the order of $1200^{o}F$ ($1660^{o}R$), and the average annual temperature of the heat sink may be $60^{o}F$ ($520^{o}R$); thus, the ideal efficiency is approximately 68% (COPPS, 1972). Since new fossil fuel stations achieve only about 60% of the ideal efficiency, their overall efficiency is around 40%. This means that 60% of the heat liberated by the fuel is released into the surrounding air or water.

The heat sink at the ABH station is a condenser through which water flows. For this 600 MW plant, the condenser probably transfers about 2.5×10^{9} Btu/hr. This heat must leave the system by some means. The alternatives are once-through cooling, cooling ponds, spray ponds, and wet or dry cooling towers.

Once-through cooling is, in this situation, unacceptable because of the large volumes of water required relative to the water supply near the site. In addition, there is greater potential for adverse ecological impact with this system than with the other types. In general, once-through cooling is only a viable mechanism for heat dissipation in lakes or reservoirs, major rivers, and coastal waters.

The closed loop systems, ponds and cooling towers, are usually safer environmentally. Both cooling ponds and spray ponds, however, require large amounts of land not available near the site. What may be worse, in the long run, is that this land is rendered unavailable for any future use.

Closed loop systems which utilize wet or dry cooling towers are probably, for inland plants, the most environmentally advantageous of the cooling schemes. The dry cooling towers, which have the advantage of discharging only sensible heat, require large amounts of power and would probably not be economical in this climate.

There are two basic types of wet cooling towers: 1) mechanical draft and 2) natural draft.

In the mechanical draft tower, air is forced upward past the falling water droplets with a large fan, cooling by sensible and evaporative heat transfer. A natural draft tower is similar but is designed in such a way that the air rises naturally through the tower and no fan is needed. It has the advantage of virtually maintenance-free operation, high efficiency in humid climates, less mechanical equipment, less noise, and no electrical demand for fan operation. Contrary to the information contained in the Site Certification, natural draft towers require less ground space than mechanical draft towers (COPPS, 1972; McKelvey and Brooke, 1959). On the other hand, natural draft towers require much greater capital investment than the mechanical draft towers.

The PPSG agrees with the applicant that cooling towers are the most environmentally and economically acceptable heat dissipation alternative. Nevertheless, the reasons for the choice between natural and mechanical draft towers should be supported with an analysis of the long-term economics which would include a discussion of maintenance costs and tower electrical demand vis-a-vis increasing fuel costs.

VII. DIRECT IMPACTS FROM INCREASED GENERATING CAPACITY

As previously stated, four major impacts from the proposed expansion have been identified. In the following section, each of these (blow-down discharge, water vapor from the cooling towers, air pollution from stack gases, and hydrological effects) will be analyzed. In addition, some other, probably less important effects will be discussed.

A. Cooling Tower Effects

Careful use of the atmosphere to diffuse wastes is well established and is accepted by professional meteorologists (Smith, 1963). However, one question that is becoming increasingly important is that of man's effect on world wide climate.

The rejection of waste heat into the atmosphere has changed in magnitude from almost zero a century ago to the point where it may be approaching the values necessary to cause significant climatic change. We know, for example, that the amount of heat rejected from some of our major cities is about three percent of the solar heat reaching the earth's surface in that region (Brooks, 1967). This may not be a negligible amount. At present, over the entire earth's surface, the yearly production of man-made energy is about 1/2,500 of the radiation balance if compounded annually at 10% for 100 years (Fletcher, 1969). "...Current projections show that power generating capacity is increasing by 7% each year, representing a doubling of man-generated energy about every 10 years. If this increase continues...experts predict that a 1^{o}C increase in the earth's mean temperature...(would occur) in 91 years" (Strahler and Strahler, 1973). A change of this order would be sufficient to move the boundaries of the deserts, plains, and forests a significant distance. "Other experts predict that an increase of 3^{o}C could begin to cause melting of the ice sheets. The liquid water produced would raise sea level by some 100 feet... This water conversion would be complete in 108 years, if present trends continue. Of course, our reserves of fossil fuels will be exhausted by that time." (ibid.) But nuclear fuels will still provide the potential for this effect.

At the present time, due to the natural variability of climate and scarcity of historical data, there have been no demonstrated or proven man-induced changes in world-wide climate. However, reason indicates that the potential for these changes exists or will exist in the near future. But, at this time, small plants like ABH probably makes no significant contribution towards long term climate change. As Dr. Charles L. Jordan, professor of meteorology at FSU comments, in this region, forest fires are probably a much more important factor. The State of Florida should probably evaluate the cumulative effect of all of its existing and proposed plants as part of its long range planning process.

Another problem which should be considered is the effect of cooling towers on regional climatology. Based on the effect of Lake Meade and similar large scale man-made systems, the professional opinion is that cooling towers will not affect the local climatology (COPPS, 1972).

One reason for this is that "...the moisture for precipitation in the United States...(is) derived mainly from the oceans and transported by maritime air masses" (Holzman, 1941). This is especially true in Gulf-bounded North Florida. It is known that cities do increase precipitation but this effect is most pronounced in the colder half year of humid continental climates (Chagnon, 1961). Also, the main causes for increased precipitation in urban areas are added nuclei of condensation, thermal updrafts from local heating and updrafts from increased friction turbulence, in addition to more water vapor (COPPS, 1972).

No measurable effect on local or regional precipitation is anticipated from expansion of the ABH generating station.

Localized ground fog often occurs around cooling towers when the cooling air water vapor saturation exceeds the capacity of the ambient air for water vapor (Buss, 1968). Some question exists as to whether or not the discharge of water vapor from the cooling towers will increase the fogging potential at the Tallahassee Municipal Airport, 4.7 miles from the site.

According to Dr. John W. Winchester, professor of oceanography at FSU, the applicant's "discussion of fog incidence during plant operation is deficient in the following respects: 1) No model calculations are presented for the increase in fog incidence at the Tallahassee Municipal Airport. This calculation should be done in a sophisticated manner taking into account wind direction and other data. It may be that a relatively small perturbation on ambient humidity by the plant could drastically increase the incidence of fog. Therefore, a careful model should be developed for fog prediction. 2) Small droplets of chloride-rich water from cooling tower drift may have an effect on fog droplet nucleation and cause either an increase or a decrease in the tendency for fog formation. The advice of a cloud physics specialist should be obtained in writing a discussion of this point."

The EIS goes into more detail than is necessary in addressing the physics of fog formation but, according to Dr. Charles Jordan, meteorology professor at FSU, it manages to omit necessary data. There is little discussion, for example, of the diurnal variation in fogging potential at the airport. The hours when the fog is the worse (probably in the early morning) should be compared with the wind distribution for these hours. Perhaps of greater significance is the fact that the data presented are only for a single year. At least, the choice of this year should be justified by comparison to other years to show that is it not atypical.

Dr. Jordan comments that, in his opinion, the data may show that the greatest fogging occurs when there is no wind, but careful analysis should be made by the applicant of potential for airport ground fog and fog along airport approach pathways.

The PPSG has, however, studied this problem and found that, "the prediction of the size and path of the fog (generating potential--ed.) from cooling towers is possible by analogy with smoke plumes. The angle of the spread of the plume usually varies from 18 to 24 degrees and the length of the visible plume is

$$X_p = 5.7 \left(\frac{Vg}{102. \quad .Vw} \right)^{1/2} \cdot \left(\frac{tge - tgi}{tp - tgi} - 1 \right)^{1/2}$$

where

tg = air or plume temperature (^{o}C)

tp = temperature at end of visible plume (^{o}C)

Vw = wind speed (ft./sec.)

Vg = total rate from tower (m^3/hr)(N.B. - All gas volumes refer to $20^{o}C$ and 1 atm pressure)

Xp = visible plume length (ft.)

i = inlet

e = exit." (COPPS, 1972)

If we assume very low wind velocities (Vw) then the length of the visible plume (Xp) approaches zero.

According to Spurr (1974), "...with light winds and possibly the presence of a near surface inversion, the cooling tower plume is able to rise unaffected by the aerodynamic influences of the cooling tower structures... and the plumes rise to considerable heights and have no adverse influence on the humidity and visibility conditions at ground level in the vicinity of a tower site...

"...In strong winds...excessive dilution is a factor but, equally important, it appears that in the turbulent wake a neutral atmosphere is created which causes the surface air to become sub-saturated and gives...a clear horizontal base to the visible plume at a few hundred feed above the ground."

In addition, Broehl (1968) reported that "...the plume from large natural draft towers does not produce even under the most adverse weather conditions, ground-level fog..." Also, a study by Spurr (1974) in which simultaneous measurements of humidity were taken upwind and downwind of a power station in various weather conditions showed no measurable change in relative humidity due to the presence of the station.

Further evidence is presented by Martin (1974) who examined local weather records near a 2000 MW power station in Great Britain and concluded "...that the emissions from the station have not affected the values of total rainfall, hours of bright sunshine, or incidence of morning fog recorded by climatological stations at a distance of 4km (2.5 mi) (the nearest station) and above from the station."

In summary, it is the opinion of the PPSG that the cooling towers may have no measurable effect on local or regional climate. There is no direct indication that increased fogging potential will be a problem at the Tallahassee Municipal Airport, although the effect of the power plant plume on visibility for approaching aircraft remains unresolved.

Noise from fans and rushing air associated with the new cooling towers may be a factor at ABH but this factor was not addressed by the applicant. The ambient noise information presented was incomplete. Mr. Jeff B. Meeker of the statistics department at FSU notes that each of the sampling locations, according to Exhibit III-1 and Exhibit IV-1, is protected from the station by some varying distance of vegetative cover which would possibly reduce noise levels. The boundary without the vegetative protection, that along SR 260, was not sampled. Meeker cautions that each sampling site should be checked for peculiarities of the site which might alter the conclusions obtained from it.

B. Water Quality Effects of Blowdown Discharge

With cooling towers, chemicals contained in the makeup water are concentrated as evaporation proceeds. In addition, algicides, fungicides, and corrosion inhibitors are added to the circulating water. At the ABH plant, these chemcials are discharged into the Ochlockonee River via a small tributary stream. This effluent, combined with the blowdown of scale inhibiting chemicals from the boilers, poses a major ecological threat to the Ochlockonee River-Lake Talquin system.

Cooling tower blowdown presently comprises 80% of the effluent entering the discharge ditch. Acording to Table III-3 of the EIS, it will make up 90% and 94%, respectively, of the discharged waste water with the addition of Units 2 and 3. Thus, cooling tower blowdown is easily the most significant component of the power plant effluent. Simple calculations based upon the stream flow model shown in Exhibit V-4 and an assumed maximum blowdown rate of 2,000 gallons per minute for all three units, indicate that plant discharge will represent 87.1% of the outfall stream's water discharged into the Ochlockonee River when all three units are operating. Presently, the plant accounts for approximately 40% of the water discharged from the outfall stream. Consequently, the impact of increased discharge into the Ochlockonee River will be due mainly to cooling tower blowdown (CTB). For this reason, CTB will be the focal point for this section of the review.

(Note: The analytical methods used by Environmental Science and Engineering, Inc. were reviewed by Dr. T. Vickers, professor of chemistry at FSU. They were found to be acceptable. It is suggested, however, that detailed procedures for sample handling and analysis be provided in the future.)

1. Concentrated salts

The composition of cooling water is determined by a number of factors including: ground (or source) water quality; the cycles of concentration of the condenser/cooling system; and anti-scaling and biocide additives (Anon., 1974, Lee and Stratton, 1972). The concentration of certain chemical species in the cooling cycle can occasionally be predicted (Davies, 1966), but more frequently concentrations of specific ions must be determined by direct measurement. Comparison of data given for well water (i.e. makeup water) at the Hopkins Plant and blowdown discharge yields information on the concentration of chemicals in the cooling cycle (see pages 3-11 and 3-19 of the EIS). The following is a table of these data showing the percent change in concentration during cooling along with Florida Department of Pollution Control standards for given parameters.

TABLE 6
COOLING WATER QUALITY PARAMETERS

Parameter	Wellwater	Blowdown	$\Delta\psi$	%Δ	State Standard*
Calcium-$CaCO_3$(ppm)	74	250	176	238	none
Magnesium-$CaCO_3$ (ppm)	52	110	58	112	none

TABLE 6 (cont.)

Total Hardness-$CaCO_3$ (ppm)	126	360	234	186	none
Alkalinity-Methyl Orange (ppm)	86	170	84	98	none
Sulphate (ppm)	7	240	233	3328	none
Chloride (ppm)	12	48	36	300	250mg/1
pH	7.9	8.3	0.4	---	6.5-8.5 or Δ>1.0
Specific Conductance (μmhos)	240	550	310	129	100% incr. or 500 μmhos

ψΔ is the equivalent of (blowdown-wellwater)
* see Chapter 17-3 DPC rules

Note: It should be remembered that since H_2SO_4 is an additive to cooling water, the % for $SO_4^=$ during cooling shown in TABLE 6 is not indicative of evaporative concentration alone.

It is apparent from the available data that CTB falls outside State standards for specific conductance. Although the applicant freely admits this (p. 5-8), no remedial action is proposed for this already existing violation of State water quality standards. Deletion of oxygen, BOD, coliform, dissolved solids, and trace metal measurements from the tables on pages 3-11 and 3-19 precludes any evaluation of other possible violations, although previous experience indicates that in passing through wet cooling towers, the water is oxygenated, the BOD is reduced, and the chlorine demand is lowered (Dalton, 1965). Nevertheless, this information should be provided in the application. Additionally, nitrate, ammonia, and phosphate measurements for makeup water could be given for comparison to CTB data.

Statistically, the data presented on pages 3-11 and 3-19 as well as that found in other tables are inadequate for several reasons. First, it is not known whether the tabulated values represent averaged measurements or one-sample determinations. Second, it would be useful to know maximum and minimum values for all parameters including an estimate of the precision of the measurements, yet this information is not given. Finally, data on the variability of CTB water quality during plant operation are missing. Without such information the significance of apparent concentration factors (as in TABLE 6) cannot be determined.

Table V-2 of the application provides a listing of data on makeup and blowdown water from the cooling tower along with station data. Here again BOD, dissolved solids, and mercury measurement were not reported. Beyond this, when values for $SO_4^{=}$, Cl^{-}, and specific conductance from Table V-2 are compared with those found on page 3-19, large discrepancies are apparent which lend further support to the previously stated need for information on the variance of measurements of this type. On the other hand, data for makeup water in Table V-2 do correspond well with those on page 3-11.

2. Additives

In addition to the concentration of those salts found in makeup water during cooling, certain chemicals are added to cooling water to prevent scale deposition and the buildup of algae (Silverstein and Curtis, 1971). In the case of the Hopkins plant three chemicals are used for this purpose. TABLE 7 lists these chemicals along with treatment levels.

TABLE 7
CHEMICAL TREATMENT LEVELS

Additive	Treatment Level	Purpose
$(N(CH_2PO_3H_2)_3)$	Added @ 3-5 ppm Maintained @ 5ppm	a sequestrant to prevent the deposition of Fe and Ca
H_2SO_4	Added to maintain a pH of 8.0-8.5	reduction of scale formation by conversion of $CaHCO_3$ to $CaSO_4$
Cl_2	Continuously @ 0.85-0.5ppm Occasionally 0.75-1.0 ppm	control of algal growth

The organic base phosphate sequestrant contributes significantly to phosphate and nitrogen levels in the stream. Presently, this chemical accounts for 4.6 pounds of phosphorus and 6.5 pounds of nitrogen which is dumped daily into the discharge ditch. Although these amounts do not necessarily constitute a basis for alarm at the moment, a sixfold increase in such a discharge could lead to serious nutrification problems. Whether or not this chemical significantly affects the Ochlockonee River or Lake Talquin at the present time is not known. However, data obtained from the Florida Game and Freshwater Fish Commission and the United States Geological Survey show that nutrient data given in the application is high for both the Ochlockonee River and Lake Talquin. Deletion of the data from FGFWFC and USCS, which have been collected for a three year period, is a serious drawback in the comparison of nutrient levels in the outfall stream to the Ochlockonee River and Lake Talquin.

The sulfuric acid added to the cooling water undoubtedly contributes to the high sulfate concentration in the blowdown. While the application states, "Sulfate levels which are toxic to benthic invertebrates and fish range 1,000 mg/l and higher", no evidence to support this statement is provided. Furthermore, the references to toxicity studies in Tables V-3, V-4, and V-5 were not found in the application. Consequently, the validity of these tables could not be determined.

Our analysis shows that there is evidence that sulfates are, in fact, toxic to aquatic organisms below the state level of 1,000 mg/l (see Dowden and Bennett, 1965, Gohar and El-Gindy, 1961, Leclerc, 1960, Becker and Thatcher, 1973). This fact, complicated by the wide range of sulfate levels reported (from 52 mg/l to 240 mg/l), leaves unresolved the question of whether or not the sulfate found in the effluent exerts a toxic effect on aquatic life. We suggest that further documentation of sulfate levels and toxicities should be presented by the applicant.

In addition to the direct toxic effects of $SO_4^{=}$, there is major concern over the role of sulfate in the formation of anoxic bottom layers. Dr. Robert Harriss, associate professor of oceanography at FSU, comments that sulfate reducing bacteria could easily utilize the available sulfate, releasing toxic H_2S. This condition develops along with the depletion of oxygen which occurs when Lake Talquin becomes stratified in the summer and could lead to the destruction of benthic and neritic organisms. High sulfate levels do not directly cause such a condition to develop, but it would, in this case, provide a supply of substrate for bacteria of the sulfate-reducing type.

Sulfuric acid is also used to maintain the pH level of cooling water within the range of 8.0 to 8.5. This is permissible according to the limits set by the DPC; however, inspection of Florida Game and Freshwater Fish Commission data over a three year period indicates that the "ambient" values presented in the application (7.19 to 7.54 for the Ochlockonee River and Lake Talquin) are much higher than the commission's average of 6.6 $\pm$ 0.5. The United States Geological Survey also obtained lower values at the Havana Station on February 4, 1974 (pH=6.2) and April 3, 1974 (pH=6.3). This discussion is raised to point out that the values used as "ambient" pH levels in the application do not correspond with values obtained over a long period of time by other investigators. Therefore, before the data are to be used in comparing "ambient" to stream conditions the reasons for this discrepancy should be discovered.

The addition of chlorine to cooling water for control of algal growth is a common practice. Unfortunately, the properties that make chlorine an effective algicide in the tower persist in the blowdown. The application states that, "Although no chlorine residual is maintained in the tower, blowdown concentrations during shock treatment should approximate tower treatment levels. Therefore, some impact should occur in the stream. However, based on available data no impact is evident beyond Station 3." (p 5-10). Thus, under present conditions, nearly 1.5 miles of the stream has been stressed by chlorine addition. It is likely that with the proposed sixfold increase in effluent volume from all three units, the extent of this impact will be felt well beyond Station 3, possibly even in the Ochlockonee.

Biological data on the degree of stress are provided in Exhibit II-21 of the EIS. The application says that "The power plant stream, particularly Stations 3 and 7, showed the highest densities of stress tolerant organisms. The dominance of tolerant benthic organisms and low species diversity in the power plant stream indicates high stress (Exhibit II-21)", and "Station 1 is an obvious high stress area. Biotic recovery from the station state occurs with distance downstream. Recovery is essentially complete at Station 3 which is approximately 1.5 miles downstream." A conservative intuitive estimate of the impact after expansion might lead one to believe that the impact would be felt all the way to the Ochlockonee. Irregardless, the ecology of the stream, even at present, has been adversely affected.

Several questions may also be raised with regard to the investigation of chlorine and trace metal distributions described in Addendum #2. First, the time of sampling appears to have been inappropriate. Information obtained from the National Weather Service at the Tallahassee Municipal Airport indicates that unusually heavy rainfall occurred on the morning of sampling (March 21, 1974). From 9:10 A.M. to 9:43 A.M. essentially all of that day's total of 0.64 inches occurred. This amount is over 20% of all the rain that was recorded for the entire month of March (3.0 inches) and well over three times the average rainfall for that date according to records for the period from 1941 to 1970. The dilution of the power plant effluent must have been considerable, but, more importantly, the results do not represent the maximum stress conditions (i.e. high treatment level, no runoff) possible. In fact, it is doubtful if they even represent average results. Consequently, the data gathered for Addendum 2 must be considered nondefinitive.

As in the case of other parameters, the chlorine data were not acompanied by the number of samples, precision, maximum/minimum, or mean information. It is noteworthy that on this sampling date, the sulfate results were nearly three times as high as the datum shown in Table V-2. This was also true for chloride and, once again, the variability of the results indicates a need for additional information on the concentration limits expected for pollutants. This should include data on chlorine variability in blowdown as well as figures on the percent loss of chlorine in the cooling cycle for different operation conditions.

Calculations show that the treatment level on March 21st was 4.83ppm as an average. If a value of 0.69mg/l is chosen as the average concentration for free residual chlorine in the effluent, a chlorine loss of approximately 88% is indicated. This is in contradiction with the statement that, "...blowdown concentrations during shock treatment should approximate tower treatment levels." (p. 5-10). The point of this discussion is that, as yet, the actual levels of chlorine likely to enter the outfall stream are unknown. Therefore, predictions of potential concentrations and the effects resulting from these levels are impossible to determine. (It is also curious that the 4.8ppm treatment level is nearly five times the maximum concentration designated for shock treatment on page 3-14.)

The deleterious effects of chlorine on aquatic organisms are well documented (Becker and Thatcher, 1973, Hamilton *et al*., 1970, Brook and Baker, 1972, and Brungs, 1973). Many studies have shown that knowledge of the level of chlorine in power plant effluent is essential to avoiding possible destruction of biota in receiving waters. Although the power plant siting application made no mention of the excellent work of Nelson (1973) regarding the prediction and control of chlorine in blowdown water, the PPSG suggests that this model approach be implemented in analyzing the use of the chlorine biocide planned for the future.

3. Boiler blowdown

The problem of boiler blowdown with future expansion is considered minimal since no increase in effluent will result due to the use of condensate polishing units. Dr. Thomas Burton, research associate in the oceanography department at FSU, suggests that this same system be used for Unit 1 also, thereby eliminating 5600 gallons of blowdown.

4. Ion exchange regeneration wastes (IERW)

The proposed adjustment of pH for IERW provides for the satisfactory disposal of these materials. Nevertheless, data on dissolved solids and sulfate should be provided.

5. Future water quality problems

Possibly the greatest shortcoming of this application is the absence of any water quality model to be used in predicting the levels of pollutant species after plant expansion. Indeed, information on the existing conditions has been found lacking. The application states that, "The extent of downstream impact will be increased as a result of plant expansion. Two factors, the presence of the beaver pond which serves as a temporary retention basin and the absence of predictive study input for source to sink calculations, preclude a statement of the linear extent of impact after the proposed expansion is operational". Granted the possible difficulties of modeling this stream, the application is severly limited in its usefulness without a water quality model. How can predictions be made and subsequent system controls be implemented without one? There are presently two computer models which are available for use in estimating downstream water quality under varying effluent loads. Depending on the ease with which they can be obtained and implemented it is suggested that the applicant consider use of them prior to certification. (Anon., 1971a; Anon, 1971b).

With regard to thermal studies, insufficient evidence has been provided to assure that the proposed expansion will not lead to environmental degradation. The statement that, "It is unlikely that a thermal exclusion zone will occur for a sufficient distance below the blowdown outfall of the A. B. Hopkins Station that the river or lake will be affected", appears to be unsubstantiated in view of the absence of any thermal plume model. Furthermore, the applicant apparently does not regard the effects of thermal discharge upon stream water quality to be of importance. Here it is worthwhile to note that plant effluent could constitute over 80% of the outfall stream's discharge when all three units are in operation. Aside from strictly physical thermal impact and enhanced productivity, the possibility of synergistic effects between thermal and chemical components was not addressed. A review of thermal/chemical effects has been provided by Lee and Veith (1971) which indicates that temperature and chemical parameters cannot be considered separately.

In reviewing the data in Table III-2 it was noted that the records upon which blowdown discharge for Units 2 and 3 are predicted, were not presented nor was a justification for extrapolation of these records provided. This information is essential in ascertaining exactly how much effluent can be expected in the future and with what degree of certainty predictions of this type can be made.

The application frequently refers to "ambient" conditions, meaning conditions found for the Ochlockonee River or Lake Talquin. To imply that the conditions (parameters) of these water bodies are "ambient" for the outfall stream is not only misleading, but erroneous. Consider the case of stream temperature distribution. Ordinarily, the temperature of a stream increases downstream. In this case, the ambient temperature is the temperature of the stream at a given point along its path. Yet, the application implies that the temperature of the Ochlockonee River is the "ambient" temperature for the stream as a whole. Although the use of another stream (one not under the influence of thermal discharge) as a control is not without problems, its thermal and other parameter gradients might be more indicative of "ambient" stream conditions. Since it is not feasible to shut down the plant for measurement of ambient stream parameters (which, of course, are time dependent as well), this alternative control seems reasonable. The fact that values for pH, nutrients, etc... in the Ochlockonee River are at variance with measurements from other sources make the use of the term "ambient" by the applicant even more dubious.

Dr. Burton notes that water quality sampling was conducted when Lake Talquin was drawn down for weed control. "As a result of this and low river flow, gradients of chloride, dissolved solids, and sulfate were reversed from the normal gradients. The applicant's sulfate values, for example, are higher (6.0 to 8.0) than the normal values (3.0 to 4.0) observed when the lake level is up. (See additional technical comments by Dr. Burton in Appendix II).

For these reasons, the PPSG suggests that the problem of ambience be re-evaluated by the applicant.

Dr. Burton also comments that the "Loss of materials (sulfate, metals, chlorides, hydrazine, etc.) to the sediments may not be a permanent loss. During periods of high discharge these sediments may be resuspended and transported into Lake Talquin (where, under the low current velocity regime they will accumulate, ed. note) resulting in potential damage. Dilution is not necessarily the solution to pollution as seems to be indicated in this report."

In general the data presentation was poor, as previously noted, and for purposes of certification, it was inadequate. Deficiencies in sampling times, sample replicate numbers, variance statistics, and plant operation variability data were found throughout the application. It is not shown, for example, whether time-dependent parameters such as DO and temperature were sampled simultaneously or not.

In conclusion, a major problem in this application is the lack of data on existing conditions. Such a deficiency precludes the prediction of future environmental conditions which is essential to a complete analysis of impact.

C. Air Pollution Potential

The EIS states that "the new units will normally burn 0.75 percent sulfur fuel oil, with the capability of burning higher sulfur (1.8 percent maximum) oil in combination with natural gas." (p. 3-22). It should be stressed that in order to comply with the standards established in Chapter 17-2.04 of the Florida Administrative Code, oil with a sulfur content higher than 0.75 percent must be burned in combination with natural gas as stated in the Site Certification. The ABH plant now burns 1.85 percent sulfur fuel oil. The data presented by the applicant in Table III-4 indicate that in order to burn fuel oil with this great a sulfur content, it must be mixed with natural gas at a ratio of 59 percent gas to 41 percent oil. Unit number two and possibly unit number three will have the capability of burning the oil-natural gas mixture but it is the opinion of the PPSG that supplies of both low sulfur fuel oil and natural gas are undependable.

In the last year, fuel oil prices have tripled and low sulfur fuel oil has been in extrememly short supply. As stated earlier in this report, we feel that this situation will not improve but will, in fact, deteriorate rapidly during the next 20 years. For these reasons, it is not reasonable to plan on burning low ash, 0.75 percent sulfur oil for the life of this power plant.

However, the applicant states in section 3.2 that the capability of burning the oil-gas mixture will only be incorporated in Unit 3 "if the quantities of natural gas available at the site increase substantially by the time of Unit 3 construction." This is unlikely.

As stated previously in this report, Dr. William F. Tanner is convinced that the supply of natural gas presents an even worse situation than the fuel oil supply. Tanner agrees with the PPSG that the supply of natural gas cannot be depended upon.

Since it appears that the low sulfur oil and the oil-gas combinations listed in the Site Certification will probably not be available in the near future, a discussion of the effects of air pollutants resulting from combustion of higher sulfur oils should be included in the impact statement.

Two of the most hazardous substances emitted from an oil fired power plant are oxides of sulfur and oxides of nitrogen.

1. Oxides of sulfur

A 600 MW power plant burning 1.6 percent sulfur fuel oil will emit approximately 70 x 10^6 pounds of sulfur oxides annually. This material is primarily SO_2 with a small percentage of SO_3. In the atmosphere the SO_2 is converted to sulfuric acid (H_2SO_4) or sulfate salts, "both of which can be more irritating to the lung than the parent gas... An important characteristic of SO_2 is its high solubility in tissue fluids at body temperature. As a consequence virtually all of the gas in inspired air is taken up by the airways above the trachea..." but... "the activity is out of proportion to the simple increase in the volume of ventilation." (COPPS, 1972).

In polluted urban atmospheres SO_2, particularly in combination with atmospheric particulates, has been demonstrated to be associated with increased rates of respiratory infection (bronchitis and pneumonia) and increased mortality rates in patients with cardiorespiratory disease. "There is evidence, requiring confirmation, for a 'no-threshold' response among high-risk individuals: In a study recently conducted in Chicago, elderly patients with chronic bronchitis exhibited symptoms of increased illness at each elevated level of pollution (as measured by SO_2)" (COPPS, 1972).

In addition to its harmful effects on man, SO_2 is also toxic to vegetation. Although some elemental sulfur is necessary for growth in plants, the absorption of gaseous SO_2 by the leaves during respiration results in oxidation to sulfite and sulfate. In sufficient concentrations these chemicals cause defoliation and eventual mortality. According to Gordon and Gorham (1963) and Woodell (1970), a region's ecology may be changed when sensitive plant species die out and resistant species take over. This alters the natural habitat, producing effects which cascade through the system, quite possibly resulting in the elimination of certain species of fauna as well as flora.

Damage has been observed in conifers (e.g. Eastern white pine and Jack pine) years after initial exposure. These slow growing plants, when continuously exposed to low concentrations of sulfur dioxide, often show more damage than plants exposed to intermittent equivalent total doses (COPPS, 1972).

The applicants have sought to enlarge their consideration of air pollution impacts of SO_2 emissions according to alternative means of control by preparation of Addendum No. 3 to the Application for Power Plant Certification. Of the alternatives - natural gas blending with fuel oil, purchase of low sulfur fuel oil, installation of fuel gas scrubbers or a fuel oil hydrodesulfurization system, or building of tall stacks for enhanced dispersion of sulfur dioxide - the case for the last alternative is compelling. From the standpoints of the availability of natural gas or of low sulfur oil at reasonable prices and of the availability of technology for sulfur removal in the stacks or from the fuel, the other alternatives appear to be relatively less practical, and the economic arguments presented in the addendum support this view.

Adoption of the TVA Sulfur Dioxide Emission Limitation system, which combines the use of tall stacks and extensive meteorological monitoring, will build on experience gained by the TVA and minimize special studies of the Tallahassee area which may be needed for other alternatives. However, the addendum did not give details of the height of the stacks intended and the design of the meteorological monitoring planned. We recognize that the impact of SO_2 emissions from tall stacks in the Tallahassee area on human habitation may be less than in more densely populated regions of Florida, because of the absence of other nearby stacks emitting SO_2 to augment the total atmospheric pollution loading, but the abundant agricultural and other plant life in the area may be very susceptible to even low concentrations of SO_2. Therefore, the PPSG regards the proper design of the tall stack and meteorological monitoring system for ABH to be as important as in any area of Florida.

Thus, the addendum leaves unanswered the important question of what predictive model will be used for the dispersion of air pollution and over what area the meteorological measurements will be made. In addition, it raises the new question of whether tall stacks will pose a hazard to aircraft approaching the Tallahassee Municipal Airport.

2. Oxides of nitrogen

Extrapolation of 1000 MW plant data indicates an annual release of approximately 29×10^6 pounds of nitrogen oxides from a 600 MW plant burning 1.6 percent sulfur, 0.05 percent ash fuel oil. These oxides, primarily NO with smaller quantities of NO_2, result from reaction of atmospheric nitrogen and nitrogen contained in the fuel with oxygen in the air during the combustion proces($N_2 + O_2 \rightarrow 2NO$). After the NO leaves the stack, a major portion of it is further oxidized to form NO_2.

The release of both NO and NO_2 (referred to collectively as NO_x) can be minimized by appropriate boiler design. However, the major consideration in most of today's boilers has not been to reduce NO but, rather, to produce steam efficiently from combustion of the fuel. For this reason, two NO_x generation levels are not often one of the design criteria in power plants (COPPS, 1972).

In the atmosphere, NO_x undergoes photochemical reaction with many hydrocarbons forming a variety of unstable oxidants which include ozone and peroxyacetyl nitrate, PAN.

These oxides are a major constituent of the photochemical air pollution known as smog. In large cities where this problem is acute, smog discolors the atmosphere, damages vegetation, and causes eye irritation. Ozone and nitrogen oxides can damage the peripheral portions of the lung. Ozone, according to the Committee on Power Plant Siting (1972), "is particularly toxic to the capillary endothelial wall, causing an increase in capillary permeability that leads to pulmonary edema". Evidence is also available that indicates that nitrogen dioxide and ozone may plan a role in increasing man's susceptibility to respiratory infections.

3. Atmospheric particulates

If the ABH power plant burns low ash oil (i.e. less than 0.05 percent ash content), production of atmospheric particulates will be less than 1.0×10^6 pounds annually. This is a relatively small figure compared to natural sources of particulates, and little impact is expected from this aspect of the expansion. We note, however, that the plant presently burns number six fuel oil with an ash content of .15 percent. If the oil continues to be burned, the particulate generation from the new power plant will be significantly higher.

The point of this discussion is that although air pollution from oxides of sulfur and nitrogen and from atmospheric particulates will not be a problem when low sulfur, low ash fuel oil is burned, the PPSG feels that adequate quantities of this oil will be impossible to supply. Additionally, the supply of natural gas needed to burn less pure oil is, as implied by the applicant, extremely questionable. With these constraints in mind, the PPSG doubts that the ABH plant will be able to comply with state standards through the next 30 years. In this case, state standards may be relaxed but a better plan may be to consider the use of low sulfur, but high ash coal, whose supply seems slightly more certain, in combination with oil whose sulfur content has been lowered at the refinery. This plan will have the effect of stretching the short supplies of fuel oil, while maintaining a sufficiently low overall sulfur and ash content to comply with present and future air quality standards.

At any rate, it is the opinion of the PPSG that alternative fuels should be considered and the reasons for their acceptance or rejection should be presented as part of the Site Certification application. Once the fuel is selected, an air quality model should be developed which includes data for atmospheric particulates and oxidants of sulfur and nitrogen.

For these reasons, the application for Site Certification should include an air quality model which predicts pollutant levels from each of the new units based on a number of different sulfur content oils. According to Dr. John W. Winchester, professor of oceanography at FSU, this model must predict levels for sulfur and nitrogen oxides as well as an assessment of "...the impact of particulate matter emissions on air quality, including treatment of (a) fine particles and (b) sulfate content of the particulate matter."

D. Impact on the Ground Water System

1. Hydrology

The geographical position of Leon County is reflected in the humid sub-tropical climate, and the water derived from the high annual rainfall is the principal factor in the erosion of surface sediments and the removal of the carbonate substrata by solution. The average precipitation is about 56 inches per year with the heaviest rainfall in the summer months. These data were not included in the Hydrological section of the impact statement.

2. Surface water

Leon County is characterized by many solutional depressions that usually contain water as small ponds and lakes. Commonly, there are small streams of relatively short length that empty into these ponds and lakes. These small streams have dendritic patterns and their upper reaches may be dry for short periods following the rainy season. Within the site area, however resistant underlying materials influence the pattern of the stream resulting in trellis rather than dendritic drainage patterns. The site lies within close proximity of two major bodies of water in the county, the Ochlockonee River and Lake Talquin. The distance from these waters are 6,500 feet and 13,000 feet respectively.

The Ochlockonee River is the largest river in the county. Beginning in Georgia, it flows southward to its junction with the Gulf of Mexico in southwestern Wakulla County. The river is mature, with numerous meanders and meander scars. Its gradient from the Georgia state line to the southwestern tip of Leon County is 1.5 feet per mile.

Lake Talquin, a man-made lake created by the Florida Power Corporation dam on the Ochlockonee River, is one of the most popular recreational resources in the region. The lake is about 15 miles long and one-half to a mile wide and its water level, controlled by the dam, is about 69 feet in elevation.

3. Groundwater

The groundwater reservoir in Leon County consists of a sequence of limestones and dolomites plus the saturated portions of overlying sands, silts and clays. The limestone and dolomite section has been named the Floridan Aquifer. Overlying sands, silts and clays, named the Florida Aquiclude confine water in the Florida Aquifer under artesian pressure. Some beds within the Aquiclude, known as water table aquifers, are capable of yielding small supplies of groundwater. The Floridan Aquiclude consists of a series of hydraulically connected limestones of Miocene through middle Eocene age and underlies all of Florida and parts of southern Alabama and Georgia. The geologic formations from which water is obtained in Leon county are as follows: The Crystal River Formation, the Suwannee Limestone and the St. Marks and Hawthorn Formations.

In Leon County, over 95% of the groundwater used is derived from the Florida aquifer (Hendry, 1966). The City of Tallahassee uses an average of 18 million gallons per day (mgd) obtained from 13 wells 18 to 24 inches in diameter and from 290 to 470 feet deep. It is estimated that rated capacity of these City wells is 34 mgd. (Bureau of Geology, DNR, Florida).

An additional demand on the aquifer is the 27+ mgd used for air-conditioning in the State buildings. About 80% of this is reintroduced to the aquifer by return wells (Bureau of Geology, DNR, Florida) but only after its temperature has been increased from 21°C (70°F) to above 32°C (90°F).

In addition to these demands, industrial use in the Tallahassee area is approximately 0.4 mgd, private and small-holding use is about 3.5 mgd, and the Arvah B. Hopkins Power Plant uses about 1.5 mgd. Thus it can be seen the total use of water in Leon County is close to 27.5 mgd. At the present time, the ABH Plant uses about six percent of this total but, when Units 2 and 3 are on line, this figure will rise to approximately 20 percent.

4. Water demands for ABH

Existing water demands, used primarily for cooling purposes, are 1,422 gpm at maximum operating conditions, and a large portion of this water is lost by evaporation from cooling towers. These demands are supplied by groundwater from two existing on site wells numbered 1 and 2. On the Site Certification map, these two wells appear to have been misnumbered. According to the plant site engineer, the traditional numbering of pumps in power plants is from North to South, and East to West. In this report, the numbering of the wells has been revised so as to coincide with the numbers presently used in the plant.

These two wells provide approximately 1.5 million gallons per day (mgd) for cooling tower makeup and for secondary operations in the plant. Both number 1 and 2 are ten inches in diameter and 380 ft. and 365 ft. in depth, respectively. The temperature of the water supplied is about 65^{o}F.

In addition to these wells, there is a 4-inch exploratory well (426 ft.) that has been capped, and is not used for any supply.

Local rainfall supplies 35% of the water for the ABH wells; rainfall in the Georgian hills, via the aquifer, supplies the remaining 65% (Fla. Geo. Surv., Bull. #47). This water is under artesian pressure which forms a level called the piezometric level which represents the horizontal distribution of a pressure head in an aquifer. It is usually the measured height above mean sea level at which the water will stand in a cased well during times of average rainfall. It fluctuates slightly during times of high and low rainfall, but on charts, it is usually shown as an average taken over many years. Unfortunately, the piezometric level for the plant site wells has not been recorded regularly since the time they were drilled, but estimates by employees at the site indicate that the level is about 115 ft. from the surface (20 ft. above MSL) for both #1 and #2 wells and about 106 ft. (29 ft. above MSL) for the exploratory well which lies 100 ft. to the North of Well #1 and about 370 ft. from Well #2.

5. Effects of future water demands on water supply

A review of the hydrology of Leon County shows that with anticipated increases in population and industrialization, there will be an increase in demand for a relatively fixed water supply. At the plant site, the demand will be increased by 3.9 mgd for the second unit, and by 2.9 mgd for the third unit. The pumping rate of the present wells is 1,500 gallons per minute (gpm), and the same rate of flow is envisioned for the proposed wells.

To determine if these needs could be met, a theoretical drawdown model was constructed by the applicant. This model, as presented in Addendum 4 was reviewed by Dr. George M. Hornberger, an expert in ground water hydrology with the department of environmental sciences at the University of Virginia.

Dr. Hornberger comments that the methodology used by the applicant in constructing the drawdown model followed established procedures and no doubt provides the best estimate of drawdown possible with the data available.

However, the PPSG feels that the figures presented by the applicant for use in this model may be inaccurate. The yields of the Florida Aquifer within the area of the power plant are not necessarily characteristic of conditions exiting elsewhere in the county. At the site low yields are known to result from the low transmissivity of the aquifer in that area. For this reason, it is unlikely that specific capacities (gallons per minute per foot of drawdown) in this area will approach those in other parts of the County. There is also a very slow movement of water in that part of the aquifer, possibly indicating a local area of recharge as opposed to other areas in which water moves freely, and over great distances. The authors of the E.I.S. cite two aquifer recovery tests in the vicinity, in which transmissivity coefficients of 6,500 gpd and 8,700 gpd are derived. An estimate of transmissivity of the aquifer in the Apalachicola Coastal Lowlands is roughly 10,000 gpd per foot of aquifer width. In the drawdown model, a coefficient of 250,000 gpd per foot is utilized. Either one or both of these figures must be incorrect.

Also, there is a problem with storage coefficients. In the Floridan aquifer the storage coefficient has not been determined by well tests anywhere in the county. This coefficient is typically 1×10^{-4} for aquifers under artesian conditions and 1×10^{-2} for water table aquifers; the storage coefficient used in computing the drawdown graphs was a compromise of 5×10^{-3}. These figures do not have the accuracy required to determine any quantitative estimate of water availability. The reference used in compiling the drawdown graph also states that, "There appears to be a rather sharp change in transmissibility of the Floridan Aquifer across the transition zone between the Apalachicola Coastal Lowlands and the physiographic units to the north and east. For this reason, any development in this area which requires large volumes of water should be preceeded by tests to determine if necessary water is available" (Hendry & Sproul, 1966, p. 129).

The PPSG feels that future demands of this magnitude necessitate some long term water management plan for this area. But, in order to have water management, the supply of water to the aquifer, especially that of the Crystal River formation, must be traced. In order to delineate the major sources of Leon County's water supply, the PPSG suggests consideration of the radioactivity techniques which are currently being used in North Florida by Dr. J. K. Osmond, associate professor of geology at FSU. Once this task is accomplished, it will be possible to institute a comprehensive water management plan for this part of Florida.

E. Effects of increased water demands

Drawdown of existing wells is an excellent indicator for predicting the possible effects of increased demand on the aquifer. From this information, and figures on permeability, the cones of depression can be approximated. Average drawdown during full operation on the two wells at the present moment is about 11 ft. for #1 and 13 ft. for #2 well. Associated with this drawdown is the cone of depression in which the water table is lowered for some radius around the well. It can be minimized at the surface if the well is cased. In this way, water from shallow and intermediate levels does not enter the well, and only the deep aquifer is drawn upon.

In Fig. 4, the theoretical drawdown for various time limits is shown, using a storage capacity of 4×10^{-4} and a coefficient of transmissibility of 4×10^{5} gpd/ft. (Florida Geological Survey). The theoretical drawdown from a cased well drilled into the Crystal River formation, after one day of continuous pumping at 1,500 gpm, should be about 3.5 ft. At a distance of 1,000 ft. from the wellhead, the effect of this same drawdown should be about 1 ft. Thus, it can be seen that, theoretically, in order to avoid overlap of the cones of depression, the minimum distance between the wells should be at least 1,000 ft. At the present time, the distance between the two existing wells is approximately 350 ft.

The effect on the surrounding wells is a function of

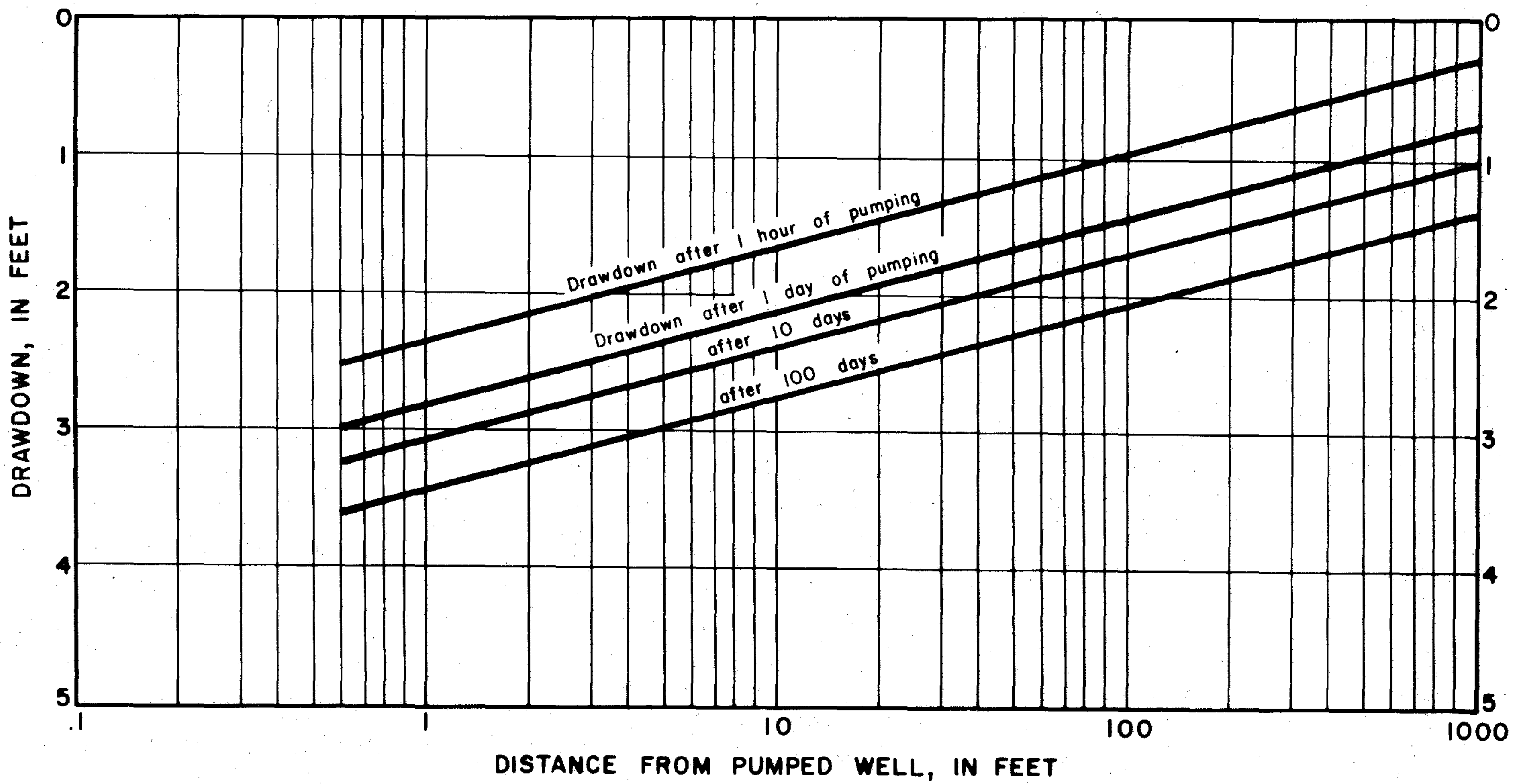


Fig. 4: Theoretical Drawdown

the dimensions of the cone of depression extending from the site. According to the theoretical drawdown, there should be no effect from the site wells on other wells in the county during an average season since the effect of the cones of depression will be restricted to the site area.

In the case of a severe drought, when water is withdrawn faster than it is supplied, the effect of drawdown could be more widespread. In 1954-1956, for example, the Ochlockonee River flow rate dropped from an average 600 mgd to 10 mgd (USGS), wells became dry, lakes became small ponds, and, in some cases dried up altogether. In this kind of situation, the effects of drawing off water from the aquifer may be felt in the area south of the plant. The expected frequency of this extent of drought should be determined by the applicant.

If the water table is lowered, lakes and marshes which normally stand at the water table will cease to exist and the ecosystems which they support will be destroyed.

A depressed water table can also have adverse effects on stream flow. In this region the year-around flow of many of the smaller streams is sustained by groundwater seepage. If the water table is drawn below stream level, the stream will contain water only after heavy rains. Again, the ecosystem of the permanent stream is destroyed (Strahler and Strahler, 1973).

Another adverse effect which can be expected from excessive drawdown is an increase in the rate of karstification.

According to Rhoades and Sinacori (1941), a depression of the water table accelerates the solution of limestone in the aquifer as an adjustment to a perturbation of its equilibrium. Kaye (1957) reports that an increase in the flow velocity will increase the rate of solution in a limestone aquifer.

Both of these effects occur during pumping and could result in an increase in the rate of sinkhole formation. Professor Harold McConnel, a specialist in karst processes in the geography department at FSU, comments that this factor should be considered in evaluating the effects of large withdrawals from an aquifer.

Return wells may be used advantageously on the site, to reduce the area of depression, as they have near the State buildings. These cased wells used in the return of water should be at a greater depth than the wells which draw the water in order to prevent contamination at any shallower level. The major disadvantage concerning the return wells is that the temperature of the returned water may accelerate solution of subsurface limestone. However, the temperature of the return water could be lowered by the use of a cooling-holding pond. By using return wells the effects of the ground-water dewatering of the area south of the plant should be minimized, and the lowering of the piezometric level should be slowed. The PPSG suggests that this methodology be considered in evaluating the alternatives for Unit 3's water supply.

In summary, the PPSG feels that the following points should be considered in the evaluation of the hydrological impacts associated with Units 2 and 3:

1. Groundwater - Actual drawdown caused by the proposed water demands has been quantitatively estimated in Addendum 4. However, the data used is open to some question, but should be sufficient to allow certification of Unit 2. Unit 3 will require more accurate estimates of transmissivity and storage coefficients to determine if there would be excessive drawdown to alter the regions ecosystem, adversely affect other wells in the area and, possibly accelerate karstification resulting in an increased rate of sinkhole formation.

   If the wells are cased and deep, we expect that these effects should be minimal for Unit 2 water demands. Nevertheless, an accurate and quantitative model which predicts drawdown and dimensions of the cones of depression is necessary for a definitive analysis which would include an evaluation of both water availability and possible environmental problems. This information is not adequately presented in the application.

2. Runoff - The topography of the site indicates that sediment runoff will not be a problem if grass is replanted after construction is completed.

3. Erosion potential - Some consideration should be

taken with respect to the possibility of an increased rate of downcutting in the disposal stream under the great increases in discharge proposed. The EIS comments that a beaver dam slows the waste water on its way to the Ochlockonee but this dam may not last. It should be noted that the disposal stream is well above base level and has a steep gradient of 50 feet per mile.

F. Ecological Impact

In the biological analysis of the ABH Power Plant Siting Application, the main concern has been to evaluate the aquatic aspects of the ecological survey conducted by Environmental Science and Engineering, Inc. (ESE). It is the opinion of the PPSG that any aquatic ecological survey, to provide meaningful information, should include data on:

1. Quantity and Quality of the components in the ecosystem.
   a. Benthos
   b. Plankton
   c. Nekton
   d. Microbes
   e. Water
   f. Substrate
2. General trends in the ecosystem
   a. Distribution and budget of nutrients, oxygen, specific conductance, etc.

b. Distribution patterns of organisms

3. Trophic relationships and energy flow

4. Reproductive nature and capacity of dominant organisms in the ecosystem

5. Seasonal biological community parameters.

    a. Density

    b. Biomass

    c. Diversity

    d. Dominance and Species Equitability

6. Faunal similarities according to:

    a. Area

    b. Depth

    c. Substrate

The benthic community is generally considered to be the most important faunal element in assessing environmental stress due to its relative lack of mobility and varied sensitivities to physiological stresses (Dills and Rogers, 1972). In addition, the relatively long life histories of benthic organisms make them valuable indicators of past and present water quality (Mackenthum, 1966; Cairns and Dickson, 1971). For these reasons we have centered our analysis of the ESE ecological survey on the benthic investigations of Lake Talquin, the Ochlockonee River and the ABH outfall stream. Further analyses which we feel are necessary for a sound aquatic ecological survey are also provided in this review and are based on data presented in the application.

1. Critique of biological survey methodology

Although no reference was provided in the application for certification justifying the use of the Ponar dredge for benthic sampling, we have determined that this device is an accepted and adequate benthic sampler. The sampling scheme, however, was poor. Based on our analysis of benthic faunal affinities (TABLE 9), it is apparent that more sampling stations and increased sampling effort at each station should have been included. The moderate faunal affinities found between two lake stations (0.391 for Stations 12 and 13) and two outfall creek stations (0.656 for Stations 2 and 3) indicate either transitions in benthic communities or lack of representative sampling. If there is a transition in communities, new stations are needed to fully describe the benthic ecosystem. On the other hand, increasing the number of samples at each station from one or two as were collected, to three or four, may provide information necessary to fully describe the endemic benthic communities.

Discussion of periphyton sampling methods was lacking. It is stated on page 6-5 of the application that "Periphyton samples were collected in duplicate from natural substrates at three stations in the outfall canal (1, 2, and 3), four stations in Ochlockonee River (7, 9, 10, and 11) and two stations in Lake Talquin (12 and 13)". This is not an adequate account of sampling procedure. The preservation and analysis techniques do appear to be sound. It is, however, not clear that diatom counts were properly conducted. These counts should be made on an uncleaned fraction, as cleaning results in a loss of more delicate species.

The phytoplankton sampling technique was also not discussed. On page 6-7 of the application it is stated that "Winter phytoplankton grab samples were collected in duplicate at Station 2 in the outfall canal, Stations 7, 9, and 10 in the river and Stations 12 and 13 in Lake Talquin". This description of methodology is inadequate. Such information as the type of device which was used for taking grab samples of phytoplankton is necessary for evaluating the data presented.

In general, the sampling and analytical procedures that were described in the application are acceptable. It is a definite weakness of the application, however, that much of the methodology is not described and references are not provided.

2. Critique of biological data analysis

In our opinion, data collected by ESE from their biological tasks have not been analyzed and interpreted adequately. Two glaring deficiencies are that:

a) no biomass measurements are presented

b) inter-station analysis of faunal similarities has not been conducted

Further, we feel that ESE's reliance on the Shannon-Weaver diversity index H', (1963) as the major community parameter is warranted - Pielou (1966), Fager (1972), Sanders (1968), and Hurlbert (1971) have all pointed out problems which can occur when using the Shannon-Weaver index, particularly when dealing with disparate sized samples (as is the case of ESE stations). As Boesch (1972) showed, it is imperative that duplicate or triplicate samples be taken at each station to insure that the maximum estimated diversity of the habitat is computed. Use of the rarefaction technique (Sanders, 1968) with either Simberloff's (1972) modification or Hurlbert's (1971) modification is recommended in the case of disparate sized samples.

As an example, we have, in TABLE 8 and Figs. 5 and 6 elaborated on the benthic data provided by ESE. Equitability (J') was calculated as equal to H'/log S, wher H' is the Shannon-Weaver diversity index and S, the number of species. (Pielou, 1966). A recent method of computing equitability was proposed by Sheldon (1969) and modified by Heip (1974). With the use of this equitability index Heip and Engels (1974) have shown that small samples (such as the ESE samples) could be well characterized. The computing formula is:

$$\text{equitability index} = \frac{e^{H'}-1}{s-1}$$

The rarefaction technique was employed to compute the expected number of species at a sub-sample size of 45 individuals, this being the smallest benthic sample of the ESE stations. The computing formula was:

$$E(S_m) = S - (N/M)^{-1} \sum_{j=1}^{s} \frac{(N-n_j)}{M}$$

(Van Belle, 1974)

TABLE 8: FURTHER ANALYSIS OF BENTHIC SPECIES DIVERSITY DATA PROVIDED BY ENVIRONMENTAL SCIENCES AND ENGINEERING INCORPORATED

E.S.E. Station No.	Area	Number of* Species	Number of * Individuals	Equitability Index J'	Shannon-Weaver Diversity Index H'	Expected No. of Species at 45 Individual level
2	Creek	4	45	0.961	1.332	4.000
3	Creek	10	1596	0.688	1.585	7.436
10	River Upstream	2	342	0.503	0.348	1.997
11	River Upstream	4	247	0.573	0.794	3.944
7	Mouth of Creek	3	846	0.520	0.571	2.629
9	River Downstream	10	666	0.617	1.421	7.339
12	Lake	12	1566	0.561	1.395	6.448
13	Lake	11	744	0.582	1.395	7.608

* values per square meter

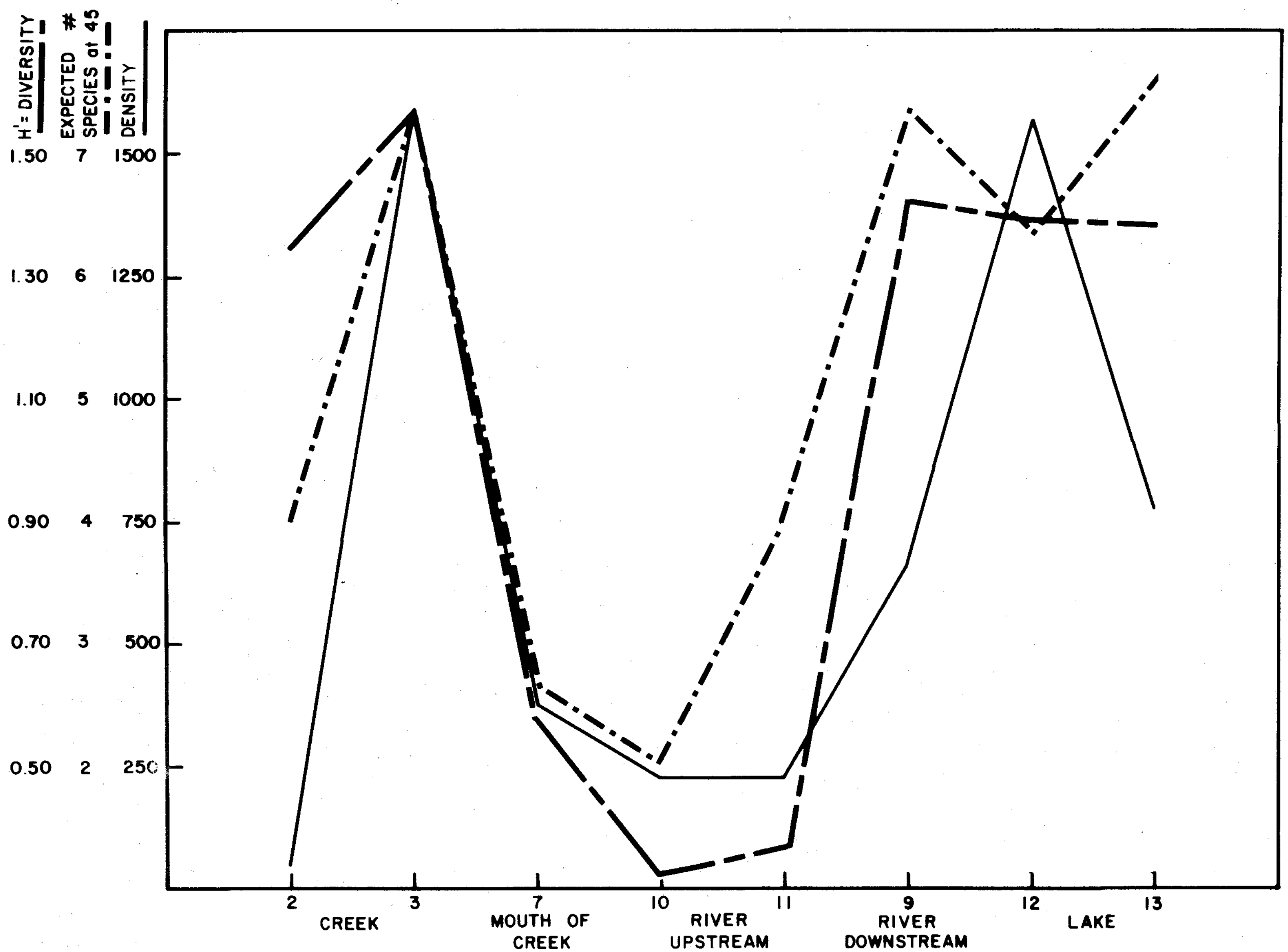


Fig. 5: Plot of species diversity (H'), rarefaction values (at 45 individual level) for E.S.E. benthic stations.

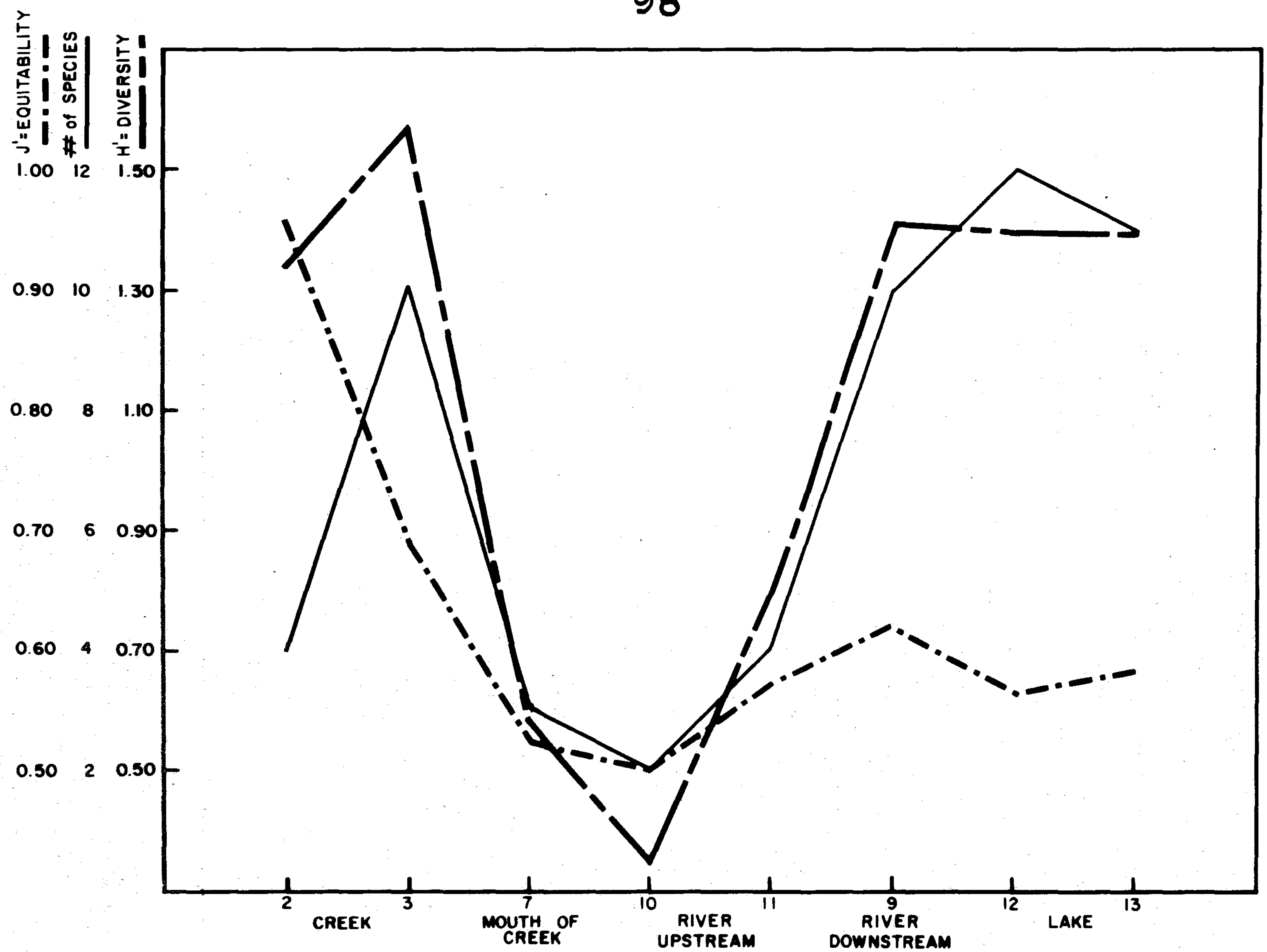


Fig. 6.: Plot of species diversity (H'), equitability (J') and species richness for E.S.E. benthic stations

where M is the size of the subsample; S, the number of species; N, the sample size and n_j, the number of individuals in the jth species. Rarefaction curves generated from various subsamples (Sanders, 1968) would provide a better diversity measure for the ESE data.

It is apparent from TABLE 8 that H' is more greatly influenced by species richness than equitability (except for Stations 12 and 13). Only more thorough sampling could confirm or contradict this trend. It should be noted that Sager and Hasler (1969) showed that H' values were influenced more by equitability in their phytoplankton samples. The anomalous trend of Stations 12 and 13 could only be explained after more sampling has been conducted.

TABLE 9 shows that density and diversity exhibit similar trends (except for stations 12 and 13). This may indicate problems because, theoretically, diversity is expected to be independent of density, unless sampling biases exist. Also, the expected number of species at the 45 individuals level follows the general trend of H' except in Stations 12 and 13. Because of the anomalous results in diversity, equitability and density, we believe that the benthic sampling program conducted by ESE was not conclusive.

TABLE 9 presents the ESE benthic data in the form of Morisita's index of faunal affinity (Morisita, 1959; Ono, 1961; Mauchline, 1972). The computational formula of this index is:

TABLE 9

MORISTA'S INDEX OF FAUNAL AFFINITY VALUES FOR E.S.E. STATIONS

	sta.2	sta.3	sta.10	sta.11	sta.7	sta.9	sta.12	sta.13
sta.13	0.000	0.479**	0.884*	0.910*	0.891*	0.934*	0.391**	1.000
sta.12	0.000	0.133	0.091	0.094	0.177	0.229	1.000	
sta.3	0.000	0.575**	0.023	0.906*	0.947*	1.000		
sta.7	0.000	0.499**	0.964*	0.960*	1.000			
sta.11	0.035	0.065	0.980*	1.000				
sta.10	0.000	0.447**	1.000					
sta.3	0.656**	1.000						
sta.2	1.000							

* High faunal similarity

** Moderate faunal similarity

$$C_\lambda = 2\sum_{i=1}^{\infty} n_{1i}\, n_{2i}/(\lambda_1 + \lambda_2)\, N_1 N_2$$

where:

$$\lambda_1 = \sum_{i=1}^{\infty} n_{1i}\, (n_{1i} - 1)/N_1 - 1)$$

and

$$\lambda_2 = \sum_{i=1}^{\infty} n_{2i}\, (n_{2i} - 1)/(N_2 - 1)$$

where N_1 and N_2 are total number of individuals in samples 1 and 2 respectively; n_{1i} and n_{2i} are the numbers of individuals in the ith species of samples 1 and 2 respectively; λ_1 and λ_2 are Simpson's (1949) measure of dominance diversity. The value of C_λ is 1 when the two samples are identical and 0 when no common species are present in the samples.

Inspection of TABLE 9 reveals the following anomalies in faunal affinities:

a) Stations 12 and 13, both from Lake Talquin, show only moderate faunal resemblance.

b) The Lake Station 13 closely resembles Stations 10 and 11 (river upstream), Station 7 (mouth of outfall canal), and Station 9 (river downstream, suggesting a homogeneous benthic fauna throughout the lake and river. Station 12 (lake), however, does not resemble any other benthic station.

c) While Station 9 (river downstream) is apparently unrelated to Station 10 (river upstream), it is closely related to Station 11 (river upstream).

These three anomalies in benthic faunal similarity values further strengthen our belief that the sampling conducted by ESE for the aquatic ecological survey was inadequate. We further suggest that the analyses of species diversity and community similarities previously discussed be conducted on phytoplankton, zooplankton, and terrestrial assemblages.

Although species diversity values have been provided in the application for certification, no rationale for the use of Shannon-Weaver (H') diversity has been provided. Also, more importantly, interpretation of the reported diversity values was certainly not exhaustive.

It should be noted that several investigators have utilized species diversity indices to show biotic alterations in streams due to effluents (Swartz, 1972). Aquatic communities exposed to environmental stress generally have fewer species and less diversity than naturally occurring communities (Mathis, 1968; Odum, 1971; Odum, 1967). For example, Harrel (1966) reported reduced species diversity of benthic macro-invertebrates below an effluent outfall, with a progressive increase in diversity downstream.

The possibility of seasonal changes in species diversity has also not been addressed in the application. Such seasonal changes may result from variations in stream flow or input of detrital material and may also reflect life history patterns of aquatic insects (Clifford, 1969; Mackay and Kaliff, 1968). These factors are all of great importance in the Ochlockonee

River - Lake Talquin systems. In fact, at the time of ESE benthic sampling, insects were the dominant benthic macro-invertebrates.

Other weaknesses are also apparent in the interpretation of data presented in the application. It is stated on page 2-60 that "Station 1, located immediately below the blowdown outfall, was devoid of benthic life". This statement is based on one sample covering only 81 square inches. Although we may agree to the possibility that benthic organisms are absent at Station 1 due to the prevailing stress conditions, it is not correct to make such a definitive statement such as the one cited above on the merit of a single 9 inch by 9 inch sample.

There also appears to be an error in some data on density of benthic organisms reported in Table II-18 of the application. Simple calculations result in a conversion factor of 19.14 Ponar dredge units (9 inch by 9 inch area sampled) per square meter. Thus, collection of one organism would yield a density value of 19 organisms per square meter. Such correctly calculated density figures are reported for Stations 3 and 11. For samples collected in duplicate (Stations 2, 10 7, and 9) collection of one organism in the two combined samples should result in a density of 9.57 organisms/m^2. In Table II-18, this value has been rounded off to 9, and density values of 9 organisms/m^2 are also reported for Stations 12 and 13.

These two stations were not sampled in duplicate and could not possibly yield density values of 9 organisms/m^2.

3. Environmental impact - potential problems

It is our opinion, based on data provided in the application, that increased sulfate input to the Ochlockonee River - Lake Talquin system, with the proposed addition of Units 2 and 3, may represent the major stress-producing impact on the aquatic communities. Conflicting values for sulfate concentration present in Unit 1 cooling tower blowdown discharge are reported in the application. On page 3-19 a concentration of 240 ppm sulfate is given for cooling tower discharge, while exhibit V-4 and page 5-8 report a concentration of 52 ppm sulfate.

Due to dilution, direct toxic affects of sulfate on aquatic organisms are not likely beyond the immediate area of discharge. We do not agree, however, with the unreferenced statement on page 5-9 that "Sulfate levels which are toxic to benthic invertebrates and fish range 1,000 mg/l and higher". Evidence has been provided by Leclerc (1960), Gohan and El-Gindy (1961), Dowden and Bennett (1965) and Becker and Thatcher (1973) that sulfate concentrations lower than 1,000 mg/l may be toxic to aquatic organisms.

A problem of greater concern than direct toxic effects of sulfate is the possible bacterial reduction of sulfate, resulting in the formation of highly toxic hydrogen sulfide (H_2S). Dr. Paul A. LaRock, assistant professor of oceanography at

FSU, pointed out that the reported concentration of 240 mg/1 sulfate in cooling tower blowdown is greater than the sulfate concentration of 208 mg/1 of agar media used in cultivating sulfate reducing bacteria. The conditions (biological, chemical and physical) prevailing in Lake Talquin make it highly susceptible to bacterial sulfate reduction. As described on page 2-52 of the application, "The lake has periodic phytoplankton blooms, high nutrient levels and anoxic conditions during periods of thermal stratification". Such anoxic conditions, along with nutrient and carbon source availability, are required for bacterial sulfate reduction. With expansion to 3 power generating units, a sixfold increase in cooling tower blowdown will result. This condition could lead to accumulation of sulfate in lake sediments to concentrations required by sulfate reducing bacteria. Resulting H_2S formation would soon lead to the destruction of recreationally valuable benthic and nektonic communities as well as the associated planktonic communities.

The applicants have sought to enlarge their assessment of environmental impact of sulfate and phosphorus levels in the cooling tower blowdown discharge by preparation of Addendum 4 to the Application for Power Plant Site Certification.

It is the opinion of the PPSG that the continued use of sulfuric acid in Unit 1 and the proposed additional use in Unit 2 resulting in approximately 6.6% of the average daily flux of sulfate in the Ochlockonee River is a source of concern.

Present concentration in Unit 1 blowdown is given in Addendum 4 (250 mg/1 SO_4) but expected concentrations **after** addition of the new units are not. The additional flux of approximately 557 Kg SO_4/day is high and would result in elevated sulfate concentrations in stream water entering the Ochlockonee River. We feel that any increase in sulfate concentration could result in deleterious effects considering the prevailing physical, chemical and biological factors in Lake Talquin. The possibility of bacterial sulfate reduction with the resulting production of toxic hydrogen sulfide cannot be overlooked. If there is continued use of sulfuric acid, monitoring of sulfate concentrations in Lake Talquin water and sediment should be conducted. We also recommend microbial surveys of Lake Talquin water and sediments before any additional use of sulfuric acid in Unit 2, and monthly thereafter to establish trend assessment.

The alternative use of hydrochloric acid for scale control instead of sulfuric acid could also result in problems. With the expected increase in chloride flux of 412 Kg/day, the DPC standard for waste discharge of 250 mg/1 Cl would undoubtedly be exceeded in cooling tower blowdown discharge.

However, the conservative nature of chloride is definitely an advantage over sulfate discharge. Because studies in this area are few, predictions of possible long term effects due to chloride are very difficult, however, the possible effects resulting from increased chloride concentration warrant toxicity tests on biota inhabiting the outfall stream, Ochlockonee River and Lake Talquin.

Relating the total phosphorus input to the total flux for Lake Talquin as done in Addendum 4, is misleading in terms of the local impact. It is likely to be utilized by the biota rapidly and could increase the eutrophication problems of Lake Talquin.

4. Summary

The PPSG recommends that alternate methods for pH adjustment of cooling tower water be considered before the application is certified. All of the alternatives - H_2SO_4, HCl, and low acid treatment - should be considered by the applicant in terms of their environmental effect as well as their cost. For example, the 45% increase in water treatment cost associated with the HCl option may represent only a small increase in the plant's total operating budget and its cost should be considered in this light.

It is the opinion of the PPSG that the H_2SO_4 treatment option is the least attractive of the three alternatives suggested. The low acid treatment option is not feasible because of its additional water demands and elevated pH. For these reasons, the PPSG suggests that HCl treatment may prove to be the most advantageous method of treating the cooling tower water. Nevertheless, microbiological investigations of Lake Talquin water and sediments are suggested. Whatever means of treatment is decided upon, it is imperative that monitoring of Lake Talquin water and sediments for chloride (or sulfate) concentration be conducted at sufficient intervals to establish trend assessment.

Our analysis has indicated that data contained in this application on the biological aspects of the outfall canal, Ochlockonee River and Lake Talquin are inadequate. Hence, the possible ecological effects of the proposed expansion of the ABH Power Plant are difficult to evaluate. However, it is the feeling of the PPSG that if sulfate, phosphate, and chlorine discharge into the Ochlockonee River - Lake Talquin system are minimized, the ecological damage associated with Unit 2 will be minimal. On the other hand, evaluation of the effects of Unit 3 will require more data and we suggest assimilation of more baseline biological information and continued seasonal monitoring.

Specifically, we recommend the following:

a) More complete descriptions of methodology

b) Accurate and complete citation of factual material presented

c) Biomass measurements

d) Microbiological investigations

e) Zooplankton investigations

f) More rigorous interpretations of data presented

g) The study of alternate methods of pH adjustment of cooling tower water to eliminate addition of H_2SO_4.

VIII. INDIRECT IMPACTS

Today, in Florida, there is an increasing concern for the overall environmental effect of the race to supply electric power. It seems, to many, that it might be more sensible to limit demand and let supply catch up. This is a course of action directly opposed to the present plan in which supply constantly chases the soaring demand curve - a situation which many environmentalists consider absurd.

In an effort to find a solution to this problem, the factors which create demand should first be identified. In the electric power industry, growth comes from four basic sources: "(1) an increase in the population, (2) the development of new applications for the use of electricity, (3) an improvement in the standard of living, and (4) the shifts from other sources of energy to electricity." (COPPS, 1972).

Of course, Florida's rate of population increase plays a major role in accelerating demand. At the present time, it appears that this factor may be impossible to control.

The second source of growth, the development of new applications for electricity, is irreversible. Once the application is conceived, it will persist as long as it is a viable solution for some need.

Our options for manipulating demand are, to a great extent, controlled by the latter two factors - the standard of living and the shifts from other forms of energy to electricity and vice versa. These points are interconnected. When some factor either real (e.g. and increase in fuel costs) or contrived (e.g. a surcharge) causes electricity to be less economical than some other source of energy, a shift to this source may occur. If no substitute is acceptable - as in a television set, for example - a drop in the standard of living will occur. Of course, other factors may interfere. It might take a long time for the population to shift from the electric stove back to coal but this is strictly because they are willing to pay for convenience, and it is difficult to determine at which price this shift will occur.

It can be seen, then, that the demand curve can be influenced to a great extent by economic factors. Recently, natural economic constraints on demand have occurred as fuel costs have risen. The essential question is whether or not natural constraints will occur rapidly enough to decrease consumption sufficiently for maintenance of a clean, and healthy environment.

Of course, many environmentalists assume that expansion of electric power production leads to some sort of incremental ecological degradation. This may not be the case. Many large-scale uses of electricity probably provide the "cleanest" alternative in a number of situations. Mass transit systems, for example, when powered by electricity, provide clean energy to those who would otherwise ride sprawling, crowded highways in polluting autos. In Tallahassee a rapid transit system is not on the horizon, but large amounts of electricity will probably be needed for sewage treatment and recycling, both of which should result in a cleaner environment.

The most logical plan seems to be one which shifts electrical demand from environmentally "dirty" uses to the "clean" ones. One way which this would be implemented would be to view the costs of pollution as a residual. Pollution in the power production process can be considered as something left which has no economic value on the existing market. In the past, this unwanted matter and energy - the residuals - were always dumped on the environment. This problem has been analyzed by Resources for the Future (a non profit corporation) as follows:

> "Water and air are traditionally examples of free goods in economics. But in reality in developed economics they are common property resources of great and increasing value, which present society with important and difficult allocation problems that exchange in private markets cannot solve. These problems loom larger as increased population and and industrial production put more pressure on the environment's ability to dilute, chemically degrade, and simple, accumulate residuals from production consumption processes. Only the crudest estimates of present external costs associated with residuals discharge exist, but it would not be surprising if these costs were already in the tens of billions of dollars annually. Moreover, as we shall emphasize again, technological means for processing or purifying one or another type of residuals do not destroy the residuals but only alter their form. Thus, given the level, patterns, and technology of production and consumption, recycle of materials into productive uses or discharge into an alternative medium are the only general operations for protecting a particular environmental medium such as water. Residual problems must be seen in a broad regional or economy-wide context rather than as separate and isolated problems of disposal of gaseous, liquid, solid, and energy waste products...

> Yet we persist in referring to the "final consumption" of goods as though material objects such as fuels, materials, and finished goods somehow disappear into a void - a practice which was comparatively harmless only so long as air and water were almost literally "free goods". Of course, residuals from both the production and consumption processes remain, and they usually render disservices (like killing fish, increasing the difficulty of water treatment, reducing public health, soiling and deteriorating buildings, etc.) rather than services. These disservices flow to consumers and producers whether they want them or not, and except in unusual cases they cannot control them by engaging individual exchanges."

These researchers propose the "materials balance approach" in which the costs of all raw materials are traced from the time of their withdrawal from the environment to their return to that enviornment. In this way, pollutants which incur costs due to their environmental impact may not be released. Instead, it may be more profitable, or at least less costly, to recycle these wastes.

S. Fred Singer, professor of environmental sciences at the University of Virginia, proposes that environmental costs of generating clean electricity be passed on to the consumer and, in this way, electrical demand will be diminished. If the cost of electricity is high, inefficient applicances, manufacturing processes, and uses for electricity will be rejected by consumers.

In summary, it is the opinion of the PPSG that abundant, inexpensive electricity does create demand. The only alternative available is to supply clean power which is environmentally safe and perhaps costly enough to limit demand to some extent. Higher costs for energy should lead to its more efficient use. As the commodity becomes more expensive, inefficient appliances become less marketable, care will be taken to minimize line losses, and luxury uses will be reduced.

Phillip H. Abelson, Editor of the journal "Science" comments that,

> "A major factor in the burgeoning use of energy is its low price-one that does not take into account all the costs to society. In the generation of electric power from coal and oil, millions of tons of sulfur dioxide are released, which cause billions of dollars worth of damage to health and property. We are consuming rapidly, at ridiculously low prices, natural gas reserves that accumulated during millions of years. Prices for energy should reflect their full cost to society. The Nixon Administration's proposed tax on sulfur in fuel should be enacted. The rate structure for electric power should be modified to discourage excessive use. A substantial increase in the price of natural gas, including a new federal tax, would diminish waste of this resource...
>
> Slowing down the rate of increase in use of energy will not be easy. Public habits of energy consumption will not be quickly altered, and a sudden change in the rate of growth of energy consumption would cause major additional unemployment."

In summary, it is the opinion of the PPSG that due to the high costs of producing clean electricity at the ABH power plant rates will not be low enough to attract energy intensive industries. This greatly lessens the possibility of secondary environmental impact from this effect. However, if the cost of producing energy by other means (e.g. coal-fired or nuclear plants) also rises and keeps pace with the anticipated costs of electrical generation in an oil-fired plant this price differential may not exist. In this event, secondary environmental impacts arising from the abundance of power produced by Unit 3 may indeed occur.

REFERENCES CITED

Becker, C. D. and Thatcher, T. O., 1973, Toxicity of Power plant chemicals to aquatic life: U.S.A. E.C., G1-613, R1-R9.

Boesch, D. F., 1972, Species diversity of marine macrobenthos in the Virginia area: Chesapeake Science, v.13, no.3, p. 206-211.

Brook, A. J. and Baker, A. L., 1972, Chlorination at power plants: impact on phytoplankton productivity: Science, v.176, p. 1414-5.

Brooks, N. H., 1967, Man, water and waste: California Institute of Technology, Pasadena California, p. 110.

Brungs, W. A., 1973, Effects of residual chlorine on aquatic life: Journal Water Pollution Control Federation, v.45, p. 2180-93.

Buss, J. R., 1968, How to control fog from cooling towers: Power, p. 72, 112.

Cairns, J. and Dickson, K. L., 1971, A simple method for the biological assessment of the effects of waste discharge on the aquatic bottom-dwelling organisms: Water Pollution Control Federation Journal, v.43, no.5, p. 755-772.

Chagnon, S. A., Jr., 1961, A climatological evaluation of precipitation patterns over an urban area: Public Health Service, Cincinnati, Ohio, p. 45.

Clifford, H. F., 1969, Limnological feature of a northern brown-water stream, with special reference to the life histories of the aquatic insects: American Midland Naturalist, v.82, no.2, p. 578-597.

Committee on Power Plant Siting, 1972, Engineering for resolution of the energy-environment dilemma: National Academy of Engineering, Washington, D.C., p. 340.

Dills, G. G. and Rogers, D. T., 1972, Aquatic-biotic community structure as an indicator of pollution: Geologic Survey of Alabama, Circular 80, 21p.

Dowden, B. F. and Bennett, H. J., 1965, Toxicity of selected chemicals to certain animals: Journal Water Pollution Control Federation, v.37, p. 1308-1316.

Fager, E. W., 1972, Diversity: A sampling study: The American Naturalist, v.106, p. 293-310.

Fletcher, J. O., 1969, Managing climatic resources: Rand Corporation, Santa Monica, California, p. 3.

Gohar, H. A. F. and El-Gindy, H., 1961, Tolerance of snails of Gilharziasis and Fascialiasis to some chemicals: Proceedings of Egyptian Academy of Science, v.16, p. 37-48.

Gordon, A. G., and Gorham, E., 1963, Ecological aspects of air pollution from an iron-sintering plant at Wawa, Ontario, Canada: J. Bot., v.41, p. 1063-1078.

Hamilton, D. H., Flemer, D. A., Keefe, C. W., and Mihursky, J. A., 1970, Power plants: Effects of chlorination on estuarine primary production: Science, v.169, p. 197-8.

Harrel, R. C., 1966, Stream order and community structure of the benthic macroinvertebrates and fishes in an intermittent stream: Ph.D. Thesis, Oklahoma State University.

Heip, C., 1974, A new index measuring evenness: Journal of the Marine Biological Association, v.54, p. 559-63.

Heip, C., & Engels, P., 1974, Comparing species diversity and evenness indices: Journal of the Marine Biological Association, v.54, p. 449-63.

Hendry, C. W., Sproul, C. R., 1966, Geology and groundwater resources of Leon County, Florida: Florida Geologic Survey, Bulletin No. 47.

Holzman, B., 1941, The hydrologic cycle; In Climate and Man: U.S. Government Printing Office, Washington, D.C.

Hurlbert, S. H., 1971, The nonconcept of species diversity: a critique and alternate parameters: Ecology, v.52, p. 577-585.

Kaye, C. A., 1956, The effect of solvent motion of limestone solution: Jour. Geol., v.65, p. 35-46.

Leclerc, E., 1960, The self-purification of streams and the relationship between chemical and biological tests: In Proceedings 2nd Symposium on Treatment of Wastewaters, Pergamon Press, London, p. 281-316.

Lee, G. F. and Stratton, C. L., 1972, Effect of cooling tower blowdown water on receiving water quality - a literature review: Presented at the Lake Michigan Enforcement Conference, Sept., 1972.

Leopold, L., 1971, A procedure for evaluating environmental impact: Geologic Survey Circular, no.645, p. 13.

Mackay, R. J. and Kaliff, J., 1968, Seasonal variations in standing crop and species diversity of insect communities in a small Quebec stream: Ecology, v.50, no.1, p. 101-109.

Mackenthum, K. M., 1966, Biological evaluation of polluted streams: Water Pollution Control Federation Journal, v.38, no.2, p. 241-247.

Manchline, J., 1972, Assessing similarity between samples of plankton: Journal Marine Biological Association of India, v.14, no.1, p. 26-41.

Martin, A. and Barber, F. R., 1974, Measurements of precipitation downwind of cooling towers: Atmospheric Environment, v.8, no.4, p. 373- 381.

Martin, A., 1974, The influence of a power station on climate - A study of local weather records: Atmospheric Environment, v.8, no.4, p. 419- 424.

Mathis, B. J., 1968, Species diversity of benthic macroinvertebrates in three mountain streams: Illinois Academy Science Transactions, v.61, no.2, p. 171-176.

McKelvey, K. K. and Brooke, E. M., 1959, The industrial cooling tower: Elsevier, Amsterdam, Netherlands.

Morista, M., 1959, Measuring of interspecific association and similarity between communities: Man. Fac. Sci., Kyushu University, Ser. E. (Biol.), v.3, no.1, p. 65-80.

Nelson, G. R., July, 1973, Predicting and controlling residual chlorine in cooling tower blowdown: U.S.E.P.S., EPS - R2-73-273, 49p.

Odum, E. P., 1971, Fundamentals of Ecology: W. B. Saunders Co., Philadelphia, 574p.

Odum, H. T., 1967, Biological circuits and the marine systems of Texas: Pollution and Marine Ecology, Interscience, New York, 349p.

Ono, Y., 1961, An ecological study of the brachyuran community in Tomaika Bay, Amakuse, Kyushu: Recs. Oceanographic Works in Japan v.5, p. 199-210.

Pielou, E. C., 1966, Shannon's formula as a measure of specific diversity: its use and misuse: American Naturalist, v. 914, p. 463-465.

Rhoades, R., and Sinacori, M. N., 1941, Pattern of groundwater flow and solution: Jour. Geol., v.49, p. 785-794.

Sager, P. E. and Hasler, A. D., 1969, Species diversity in lacustrine phytoplankton: American Naturalists, v.103, p. 51-59.

Sanders, H. L., 1968, Marine benthic diversity: A comparative study: The American Naturalist, v.102, p. 243-282.

Shannon, C. E. and Weaver, W., 1963, The mathematical theory of communication: University of Illinois Press, Urbana, 177p.

Sheldon, A. L., 1969, Equitability indices: dependence on the species count: Ecology, v.50, p. 466-7.

Silverstein, R. M. and Curtis, S. D., 1971, Controlling Contaminants in cooling water: Chemical Engineering, p. 84-89.

Simpson, E. H., 1949, Measurement of diversity: Nature, V.163, p. 688.

Spurr, G., 1974, Meteorology and cooling tower operation: Atmospheric Environment An International Journal, v.8, no.4, p. 321- 329.

Strahler, A., 1973, Environmental Geoscience interaction between natural systems and man: Hamilton Publishing Company, Santa Barbara, California, 511p.

Simberloff, D., 1972, Properties of the rarefaction diversity measurements: American Naturalist, v.106, p. 414-418.

Swartz, R. C., 1972, Biological criteria of environmental change in the Chesapeake Bay: Chesapeake Science, v.13, Supplement, p. 517-541.

The National Energy Outlook, 1973, Shell Oil Company Report.

Weber, E., 1970, Contribution to the residence time of SO_2 in a polluted atmosphere: J. Geophys. Res., v.75, no.15, p. 2909.

APPENDIX I.

Selected Bibliography

Air Pollution

Anonymous, 1973, Air pollution: Power Magazine special report, 47p.

Anonymous, 1973, Cleaning up SO_2: Chemical Engineering, April 16, p.AAA-EEE.

Cox, R.A., 1973, Predictions of fog formation due to a warm water lagoon proposed for power station cooling: Atmospheric Environment, v.7, p.363-368.

EPA, 1973, Control of air pollution from fossil fuel-fired steam generators greater than 250×10^6 BTU/hour heat inject: EPA, Dunham, N.C.

EPA, 1973, Effects of sulfuroxides in the atmosphere on vegetation; revised chapter 5 for air quality criteria for sulfuroxides: Ecol. Res. Ser., EPA-R3-73-030.

Federal Power Commission, 1968, Air pollution and the Regulated electric power and national gas industries, Sept.

FWPCA, Report on cooling towers and weather: Report for FWPCA, Corvallis, Oregon.

Horlacher, W.R., et al, 1972, Four SO^2 removal systems: Chemical Engineering Progress, v.68, no.8, p.43-50.

Nadler, Allen, A., et al, 1970, Air pollution a scientists institute for public information workbook: Scientists' Institute for Public Information, 28p.

U.S. Dept. of H.E.W., 1969, Air quality criteria for sulfur oxides: U.S. Govt. Printing Office.

U.S. Dept. of H.E.W., 1969, Control techniques for sulfur oxides and particulates: U.S. Govt. Printing Office.

U.S. Dept. of H.E.W., 1970, Danger in the air: Sulfur oxides and particulates: U.S. Govt. Printing Office.

Biology

Anonymous, 1973, Annotated bibliography on biological effects of metals in aquatic environments: Ecol. Res. Ser., EPA-R3-73-007.

Becker, C.D. and Thatcher, 1973, Toxicity of power plant chemicals to aquatic life: U.S.A.E.C., June, p.G1-G13, R1-R9.

Cairns, J. and Dickson, 1971, A simple method for the biological assessment of the effects of waste discharge on the aquatic bottom-dwelling organisms: Water Pollution Contr. Fed.J., v.43, no.5, p.755-772.

Dills, G.G. and Rogers, 1972, Aquatic-biotic community structure as an indicator of pollution: Geologic Survey of Alabama, Circular 80, 21p.

Dowden, B.F. and Bennett, 1965, Toxicity of selected chemicals to certain animals: Journal of Water Pollution Control Federation, v.37, p.1308-1316.

Garton, R.R., 1972, Biological effects of cooling tower blowdown, for presentation at 71st national meeting American Institute of Chemical Engineers, Feb.20-23.

Gohar, H.A.F. and El-Gindy, 1961, Tolerance of snails of Gilharziasis and Fascioliasis to some chemicals: Proc. Egypt Acad. Sci., v.16, p.37-48.

Hirayama, K., and Hirano, R., 1970, Influences of high temperature and residual Chlorine on marine phytoplankton: Marine Biology, v.7, no.3, p.205-213.

Leclerc, E., 1960, The self-purification of streams and the relationship between chemical and biological tests: Proc. 2nd Symp. on Treatment of Waste Waters, Pergamon Press, London, p.281-316.

Mackenthum, K.M., 1966, Biological evaluation of polluted streams: Water Pollution Control Fed. J., v.38, no.2, p.241-247.

Certification Review Methodology

Anonymous, 1972, Standards for evaluating NEPA environmental statements: Public Utilities Fortnightly, v.90, no.5, p.29-32.

Anonymous, 1973, Environmental impact statement procedures programs: University of Southern California Report, USC-SG-ASZ-73, v.39, April.

Anonymous, 1973, Looking at the impact statements: Pollution Engineering, v.5, no.5, p.23.

Anonymous, 1973, Workshop in environmental impact analysis summary: Special Report, no.40, 07-73-00701.

Anonymous, 1973, Reviewing environmental impact statements; power plant cooling systems, engineering aspects: U.S. Environmental Protection Agency Report, EPA-660/2-73-016.

Enk, G.A., 1973, Beyond NEPA: criteria for environmental review: Institute on Man and Science Report 140, May.

High, M.D., 1974, A review of the background preparation and use of environmental impact statements: Engineering-Science, Va. APCA Journal, v.24, no.2, p.111,114.

Wanielista, McLellon and FTU, 1973, Proceedings of workshop on environmental impact statements held at Florida Technological University, Orlando, Florida.

Cooling Technology

Anonymous, A survey of alternate methods for cooling condenser discharge water, operating characteristics and design criteria: Dynatech R/D.

Anonymous, 1969, A survey of thermal power plant cooling facilities: Pollution Control Council, Pacific Northwest Area, April.

Anonymous, 1969, Cooling tower fundamentals and application principles: The Marley Company.

Anonymous, 1969, Reduction of blowdown from power plant cooling tower systems: A.I.Ch.E. Workshop, Industrial Process Design for Water Pollution Control, Houston, Texas, v.2, April 24-25.

Anonymous, 1970, A method for predicting the performance of natural draft cooling towers: EPA, Water Quality Office, Pacific Northwest Water Laboratory, Project No.16130 GKF, Dec.

Anonymous, 1970, A survey of alternative methods for cooling condenser discharge water, total community considerations in the utilization of refected heat: Dynatech R/D Company, for the Water Quality Office, EPA project No. 16130 DHS, June.

Anonymous, 1970, Cooling towers special report: Industrial Water Engineering, May.

Anonymous, 1971, Advanced nonthermally polluting turbines in utility applications: United Aircraft Research Laboratories of the United Aircraft Corp., for the EPA Water Quality Office, Project No. 16130 DNE, Mar.

Anonymous, 1971, A survey of alternative methods for cooling condenser discharge water, system, selection, design, and optimization: Dynatech R/D Company, for the Water Quality Office, EPA, Project No. 16130, DHS Jan.

Anonymous, 1972, Cooling towers - part II, Are hyperbolics a waste of money?: Electric Light and Power, Dec., p.30-37.

Anonymous, 1972, Cooling towers - part III, Drying up the cooling cycle: Electric Light and Power, Nov., p.45-48.

Anonymous, 1972, Cooling towers: Power Engineering, Dec., p.30-37.

Anonymous, 1973, Canals cool hot water for reuse: Environmental Science and Technology, Jan., p.20-21.

Anonymous, 1973, Cooling towers power special report: Power, March.

Anonymous, 1973, Technical and economical evaluations of cooling systems blowdown control techniques: EPA Technol. Series, EPA - 660/2-73-026, Nov., p.63-67.

Brady, D.K., et al, 1969, Cooling water studies for Edison Electric Institute: Report N.5, Research project RP-49, Johns Hopkins University, Nov.

Budenholzer, R.J., et al, 1971, Selecting heat rejection systems for future steam-electric power plants: Westinghouse Engineer, Nov.

Decker, F.W., Report on cooling towers and weather: Report for FWPCA, Corvallis, Oregon.

DeMonbrun, J.R., 1968, Factors to consider in selecting a cooling tower: Chemical Engineering, Sept.9.

Derrick, A.E., 1963, Cooling pond proves to be economic choice at Four Corners: Power Engineering, Nov.

Elliott, T.C., 1970, Options for cooling large plants in the 70's: Power, Dec.

Goldman, E. and Kelleher, 1973, Water reuse in fossil fueled power stations: presented at conference on Complete Water Reuse sponsored by A.I.Ch.E. and EPA, Wash., D.C., April 23-27.

Kelley, R.B., 1971, Large-scale spray cooling: Industrial Water Engineering, Aug./Sept., p.18-20.

Kolflat, T.D., 1973, Cooling towers state of the art: Department of Int. Atomic Industrial Forum Seminar, Feb. 13-14.

Leung, P. and Moore, 1971, Thermal cycle arrangements for power plants employing dry cooling towers: ASME Trans. Journ. of Eng. for Power, v.93, no.2.

Li, K.W., Combined cooling systems for power plants: prepared for Northern States Power Co., Minneapolis, Minnesota.

Morgenweck, F.E., 1968, Performance testing of large natural draft cooling towers: The American Society of Mechanical Engineers, paper no.68 - WA/PTC-4, Dec.

Puckorius, P.R., 1970, Tower as part of cooling system: Industrial Water Engineering, v.7, no.5, p.4304.

Economics

Anonymous, 1970, An engineering-economic study of cooling pond performance: Water Pollution Control Research Series, EPA, 16130 DFX, March.

Anonymous, 1970, Electric utility depreciation practices: Federal Power Commission, Jan.

Anonymous, 1971, California's projected electrical energy demand and supply: Assembly Science and Technology Advisory Council, A report to the assembly general research committee California Legislature, Nov.

Anonymous, 1972, Electrical power supply and demand forecasts for the United States through 2050: Hittman Associates, Inc., Feb.

Askew T., 1973, Selecting economics boiler-water retreatment equipment: Chemical Engineering, v.80, no.9, p.114-120.

Berthoulex, P.M., 1972, Evaluating economy of scale: Journal WPCF, v.44, no.11, p.2111-2119.

Jimeson, R.M. and Chilton, 1972, A model for determining the minimum cost allocation for fossil fuels: 2nd National Cost Engineering Congress and 1st International Cost Engineering Symposium, Mexico City, Oct.29-Nov.1.

Lof, G. and Ward, 1970, Economics of thermal pollution control: Journal WPCF, Dec., p.2102-2116.

Schurr, S., and Netschert, 1960, Energy and the American economy 1950-1975: Scientific American, Issue on energy, v.224, no.3., 774p.

Lotten, D., 1971, The economic geography of energy: Energy and Power, p.109-117.

U.S. Congress, Joint Economic Committee, 1970, The economy, energy, and the environment: prepared by the Environmental Policy Division of the Legislative Reference Service, Washington D.C., Sept., 131p.

Energy

Abelson, P.H., 1971, Continuing increase in use of energy: Science, v.172, no.976.

Anonymous, 1973, Energy crisis: Consulting Engineer, Mar., p.97-192.

Anonymous, 1974, Energy in Florida report and recommendations on energy and energy policy in Florida: Fla. Energy Committee, Mar.

Ayres, E., 1956, The age of fossil fuels: Man's Role in Changing the Face of the Earth, Univ. of Chicago Press, 1193p.

Freeman, 1971, Energy and power: Scientific American Book, 144p.

Gambs, G.C. and Rauth, 1971, The energy crisis: Chemical Engineering, May 31, p.56-68.

Hottel, H.C., and Howard, 1971, New energy technology some facts and assessments: M.I.T., 364p.

Jones, L.W., 1971, Liquid Hydrogen as a fuel for the future: Science, v.174, p.367-370.

Krieger, J.H., 1972, Energy: the squeeze begins: Chemical and Engineering News, Nov., p.20-37.

Murdoch, W.W., 1971, Environment resources, pollution, and society: Sinaver Associates Inc., Stamford, Conn., 440p.

Risser, H.E., 1971, Fossil fuel supplies and future energy needs: Transactions of the American Geophysical Union, p.763-767.

Still, H., 1971, Energy; a crisis in the offing: As We Live and Breathe; the Challenge of Our Environment, National Geographic Society, Washington, D.C., p.78-101.

Energy Planning

Anonymous, 1968, Considerations affecting steam power plant site selection: Office of Science and Technology, U.S. Govt. Printing Office, Dec., 132p.

Anonymous, 1970, Electric power statistics: Federal Power Commission, Jan.

Anonymous, 1971, Electric utilities industry research and development goals through the year 2000: Report of the Research and Development Task Force of the Electric Research Council, pub.#1-71, June, 176p.

Anonymous, 1972, Annual plant design report: Power, Nov., p.5.1-5.24.

Anonymous, 1972, Engineering for resolution of the energy-environment dilemma: Committee on Power Plant Siting, National Academy of Engineering, Washington, D.C., 340p.

Anonymous, 1972, Licensing and site selection of power plants: NTIS report, 73-10262.

Anonymous, 1973, Considerations in viewing the role of state government in energy planning and power plant siting: Assembly Science and Technology Advisory Council, A Report to the Assembly General Research Committee, California Legislature, Feb.

Anonymous, 1973, Plant siting at Florida Power and Light Company: Public Utilities Fortnightly, v.91, no.2, p.21-25.

Anonymous, Criteria for electric transmission systems: Department of the Interior and Dept. of Agriculture, Environmental Criteria for Electric Transmission Systems.

Anonymous, Resources and man; a study and recommendations: Committee on resources and man, Division of Earth Science.

Geyer, J.C., et al, 1968, Field site and survey methods report no.3: Cooling water studies for Edison Electric Institute, The Johns Hopkins University, (RP-49).

Golze, A.R., 1973, Impact of urban planning on electric utilities, Mar.

Murdoch, W.W., Environment, resources, pollution, and society: Sinaver Associates Inc., Stamford, Conn.

U.S. Congress, Senate, Committee on Interior and Insular Affairs, 1971, A national fuels and energy policy study, Hearings and committee prints pursuent to S. Res. 92-95, 92nd Congress, 1st Session, Washington, D.C.

U.S. Congress, Senate, Subcommittee on Intergovernment relations, 1970, Hearings on intergovernmental coordination of power development and environmental protection act, 91st Congress, 2nd session.

U.S. Office of Science and Technology, Considerations affecting steam power plant site selection: U.S. Government Printing Office.

Environment

Anonymous, 1968, The electric utility industry and the environment: Electric Utility Industry Task Force on Environment, a report to the citizens advisory committee on recreation and natural beauty, 105p.

Anonymous, 1970, Environmental effects of producing electric power: Hearings before the joint committee on Atomic Energy 91st Congress, Second Session, v.1 and 11, parts 1 and 2.

Anonymous, 1970, Electric power facilities and the environment: Edison Electric Institute Plant Siting Task Force, Committee on Environment report, Feb., 31p.

Anonymous, 1970, Electric power and the environment: U.S. Govt. Printing Office, Aug., 71p.

Anonymous, 1970, Major electric power facilities and the environment: Plant Siting Task Force of the Edison Electric Institute, Committee on Environment, Feb., 31p.

Anonymous, 1971, People, power, pollution, environmental public interest aspects of electric power plant siting: Environmental Quality Lab, California Institute of Technology, Sept.

Anonymous, 1971, Resources for the future, research needs; consumption, production, technology, environmental effects, policy issues: Report to the National Science Foundation in cooperation with MIT Environmental Laboratory, Oct.

Anonymous, 1972, Environmental aspects of site selection: Journal Power Division (ASCE), v.98, no.P01, June, p.21-27.

Anonymous, 1972, Final environmental statement for the Palisades nuclear generating plant: Consumers Power Company Docket, June, no.50-200.

Anonymous, 1974, Development document for proposed effluent limitations guidelines and new source performance standards for the new steam electric power generating: EPA 440/1-73/029.

Berkowitz, D.A. and Squires, 1972, Power generation and environmental change: MIT, 464p.

Clark and Brownell, 1973, Electric power plants in the coastal zone: American Littoral Society Special Publ., no.7.

Day, J.A., Frost, and Rose, Dimensions of the environmental crisis: Wiley Co.

Eliassen and Rolf, 1971, Power generation and the environment: Science and Public Affairs, v.27, no.7, Sept., p.37-42.

U.S. Congress, 1969, Hearings on environmental effects of producing electric power: 91st Cong., 2nd Sess.

U.S. Congress, Senate, Commitee on Government Operations, 1970, The intergovernmental coordination of power development and environmental protection act. Hearings before the subcommittee on intergovernmental operations: 91st Congress 2nd session: U.S. Government Printing office, 882p.

U.S. Congress, House, Committee on Interstate and Foreign Commerce, 1971, Power plant siting and environmental protection: Hearings before the subcommittee on communications and power, 92nd Congress, 1st Session, U.S. Govt. Printing office.

U.S. Congress, House, Subcommittee and power, 1971, Hearings on power plant siting and environmental protection: 92nd Cong., 1st Sess.

Pollution (general)

Browning, J.E., 1973, Ash- the useable waste: Chemical Engineering, April.

Scott, D.L., 1973, Pollution in the electric power industry: Lexington Books, Lexington, Mass., 104p.

U.S.Congress, Senate, Subcommittee on Air and Water Pollution, 1972, Hearings on Thermal Pollution: 90th, Cong., 2nd Sess.

U.S.Congress, Senate, Subcommittee on Intergovernmental Relations, 1970, Hearings on Intergovernmental Coordination of Power Development and Environmental Protection Act: 91st. Cong., 2nd Sess.

Thermal Pollution

Anonymous, 1968, Industrial waste guide on thermal pollution: U.S. Dept. of the Interior Federal Water Pollution Control Administration, Pacific Northwest water laboratory, Sept., 112p.

Beall, S.E., Jr., and Miller, 1971, The use of heat as well as electricity from electricity generating stations: Paper presented at annual meeting of American Association for the Advancement of Science, Philadelphia, Pa., Dec.29.

Beall, S.E., Jr., 1969, Uses of waste heat: research sponsored by the U.S.A.E.C. under contract with the Union Carbide Corporation, Nov.3.

Boersma, L., Beneficial use of waste heat in agriculture: Dept. of Soils, Oregon State Univ.

Brady, D.K., et al, 1969, Cooling water studies for Edison Electric Institute: Research project RP-49, Report no.5, the Johns Hopkins University, Nov.

Christiansen, P.E. and Colman, 1969, Reduction of blowdown from power plant cooling tower systems: A.I.Ch.E. Workshop, Industrial Process Design for Water Pollution Control, Houston, Texas, v.2, April 24-25.

Clark, J., 1969, Thermal pollution and aquatic life: Scientific American, v.220, March, p.18.

Coutant, C.C., 1970, Thermal pollution biological effects: Journal of Water Pollution Control Federation, v.43, p.1292-1334.

Dallarie, E.E., 1970, Thermal pollution threat draws nearer: Civil Engineering, A.S.C.E., Oct., p.67-71.

Edinger, J.E. and Geyer, 1965, Heat exchange in the environment: Cooling Water Studies for Edison Electric Institute, Johns Hopkins Univ., RP-49.

Edinger, J.E., et al, 1968, The variation of water temperatures due to steam electric cooling operation: Journal WPCF, Sept., p.1632-1639.

Eisenbud, Merril, and Gleason, 1969, Electric power and thermal discharges: Gordon and Breach, New York, 423p.

Garton, R. and Christianson, 1970, Beneficial uses of waste heat - an evaluation: Beneficial Uses of Thermal Discharges, sponsored by New York State Department of Environmental Conservation, Sept.

Grimes, C.B., 1971, Thermal addition studies of the Crystal River steam electric station: Professional Papers Series II, D.N.R., Marine Research Lab, Fla.

Jaske, R.T., et al, 1970, Heat rejection requirements of the United States: Chemical Engineering Progress, v.66, no.11, p.17-22.

Jaske, R.T., 1970, Thermal pollution and its treatment: The Implications of Unrestricted Energy Usage with Suggestions for Moderations of the Impact, Oct.

Jimeson, R.M., and Adkins, 1971, Factors in waste heat disposal associated with power generation: Paper presented at 68th national meeting American Institute of Chemical Engineers, Houston, Texas, paper 6A, Feb.28-Mar.4.

Levin, A., Birch, Hillman, Gilbert, 1972, Thermal Discharges; ecological effects: Environmental Science and Technology, v.1, no.3, March, p.224-230.

Lusby, W.S.and Somers, 1972, Power plant effluent thermal pollution or energy at a bargain price?: Mechanical Engineering, June, p.12-15.

Moore, F.K. and Jaluria, 1972, Thermal effects of power plants on lakes: Transactions of the ASME Journal of Heat Transfer, May, p.163-168.

Parken, G.L. and Krenkel, 1969, Thermal pollution; state of the art: Report #3, Dept. of Environmental Resource Engineering, Vanderbilt University, Nash., Tenn.

Water Pollution

Anonymous,1971, A summary of environmental studies on water problems: Edison Electric Inst., March.

Anonymous, 1971, Simplified mathmatical modeling of water quality: U.S.E.P.A., March.

Anonymous, 1971, Simulating water quality in streams and canals: Texas Water Development Board, May.

Anonymous, 1973, Cleanup system makes pure processing - water: Chemical Engineering, v.80, no.4, p.66.

Anonymous, 1973, Predicting and controlling residual chlorine in cooling tower blowdown: EPA Technol. Series, EPA-R2-73-273, 48p.

Anonymous, 1974, Development document for proposed effluent limitations guidelines and new source performance standards for the steam electric power generating point source category: U.S.E.P.A., EPA 440/1-73/029.

Argo, D.G. and Culp, 1972, Heavy metals removal in waste water treatment processes; part 1, water and sewage works, part 2 - pilot plant operation: Water and Sewage Works, Aug.-Sept.

Aschoff, A.F., 1973, Water reuse in industry: Mechanical Engineering, April, p.21-25.

Cheremisinoff, P.N., et al, 1972, Cadmium, Chromium, lead. mercury; a plenary account for water pollution, part I - occurence, toxicity and detection, part II - removal techniques: Water and Sewage Works, July-August.

Cohen, J.M. and Kugelman, 1972, Wastewater treatment physical and chemical methods: Journal WPCF, June, p.915-923.

Davies, I., 1966, Chemical changes in cooling water towers: Air and Water Pollution International Journal, 10;853-63.

Dean, J.G., et al, 1972, Removing heavy metals from waste water: Environmental Science and Technology, v.6, no.6, p.518-522.

Draley, J.E., (1972), The treatment of cooling waters with chlorine: Argonne National Laboratories, Feb.

Fosberg, T.M., 1972, Reclaiming cooling tower blowdown: Industrial Water Engineering, June/July.

Jaske, R.T., 1973, Water reuse in power production an overview: Paper for publication in the Proceedings of the National Conference on Complete Water Reuse, April.

Lee, G.F., and Stratton, 1972, Effect of cooling tower blowdown water quality - a literature review: Presented at the Lake Michigan Enforcement Conference, Sept.

APPENDIX II.

Comments from the Faculty

Faculty Review Committee, Florida State University:

Dr. Thomas Burton*	Department of Oceanography
Dr. George W. DeVore	Department of Geology
Dr. Loretta C. Ellias*	Department of Biological Science
Dr. Edward A. Fernald*	Florida Resources and Environment Analysis Center
Dr. Robert C. Harriss	Department of Oceanography
Dr. Charles L. Jordan*	Department of Meteorology
Dr. Robert A. Kromhout*	Department of Physics
Dr. Edward A. Laws*	Department of Oceanography
Dr. Robert J. Livingston	Department of Biological Sciences
Dr. Harold L. McConnell	Department of Geography
Dr. Jeff B. Meeker*	Department of Statistics
Dr. Robert J. Menzies*	Department of Oceanography
Dr. J. Kenneth Osmond*	Department of Geology
Dr. Donald Patton	Department of Geography
Dr. Mildred W. Ravenell*	Department of Law
Dr. Stephen Schamel*	Department of Geology
Dr. Phillip E. Sorensen*	Department of Economics
Dr. William F. Tanner*	Department of Geology
Dr. Robert G. Turner*	School of Business
Dr. Robert H. Weller*	Department of Sociology
Dr. David C. White*	Department of Biological Science
Dr. John W. Winchester*	Department of Oceanography
Dr. Sherwood W. Wise, Jr.*	Department of Geology
Dr. Thomas J. Vickers	Department of Chemistry

* Written comments included in this appendix

Comments by Dr. Thomas Burton

I. They "write off" about 1.5 miles of stream at present usuage rates and will "write off" more when the expansion is completed. The loss of a stream due to environmental degradation is no small thing and, if associated with each power plant and industrial site, would soon lead to no viable remaining streams.

II. They failed to consider three years of routine water quality data on Lake Talquin and the Ochlockonee River. Inclusion of this data in consideration of environmental damage should be a prerequisite to site approval.

III. They sampled at a time when Lake Talquin was drawn down for weed control. As a result of this and low river flow, gradients of chloride, dissolved solids, and sulfate were reversed from the normal gradients.

IV. Specific differences between their data andthe FSU Game and Fish Data:

a) Their pH values are high for the Ochlockonee and Lake Talquin (7.19 to 7.54) conditions due to the draw-down and low flow conditions vs. 6.6 ± .5 for three years data.

b) Their sulfate values are comparable over the same sampling period but are high due to low river flow and lake draw-down (6.0 to 8.0 versus 3.0 to 4.0 normally in the river). This invalidates one of the assumptions of the sulfate-discharge model (Exhibit V-4).

c) The reported values of NH_3 and NO_3 are extremely high if they are actually N

They are still drastically high for NH_3 if these values are really NH_3-N as the discussion in the paper would indicate. The NH_3 values are questionable; the NO_3 values are on the high side but comparable only if they are actually NO_3-N not only NO_3/l as indicated in the table.

d) The phosphorous values are also high if they are actually reporting mg P/l. If the ortho P values are actually PO_4 (mg PO_4/l), they are comparable but if they are actually P they are much too high.

e) Conductivity is comparable over the sampling period but is high compared to normal conditions due to the draw-down and low flow conditions.

V. The use of the Ochlockonee River as an ambient station for temperature bias is the data as stream gradients exist from cool headwater streams to larger rivers; therefore ambient at the point of discharge in the stream should be significantly lower than the River.

VI. The introduction of 4 or 5 pounds of P per day needs to be assessed in terms of its potential for causing nuisance algal and macrophyte growths. Such growth is likely to occur in the discharge stream with ultimate transport downstream into Lake Talquin.

VII. Loss of materials (sulfate, metals, chlorides, hydrozine, etc.) to the sediments may not be a permaneny loss. During periods of high discharge, these sediments may be resuspended and transported into Lake Talquin resulting in potential damage. Dilution is not necessarily the solution to pollution as seems to be indicated in this report.

VIII. If ion exchange "polishing" units can be installed on units 2 and 3, why couldn't they also be installed on unit 1? This apparently would result in 5600 gallons of boiler water not being discharged and would alleviate the problems with discharge of such toxins as hydrozine assiciated with this discharge.

IX. Could aesthetically pleasing holding ponds be designed for this water and use to support fish and wild life? This concept is dismissed because of need for land but would seem to be a viable alternative to dumping in the stream.

X. The burning of high sulfur coal as proposed for part of the plant operation can perhaps lead to acid rain problem and possible loss of forest productivity. This problem needs to be discussed. See paper by Likens and Bermann in recent issue of Science, Vol 184 page 1176 (14 June).

Department of Biological Science The Florida State University
Tallahassee, Florida 32306

November 4, 1974

Dr. John W. Winchester
Principal Investigator Review Committee
Power Plant Site Certification
Florida State University
Tallahassee, Fl., 32306

Dear Dr. Winchester:

My examination of the application for Power Plant Site Certification leads me to the conclusion that token acknowledgement only has been given to the microbiological aspects of potential problems that may be associated with this project. In my opinion, more studies, in breadth and in depth, are advisable.

Sincerely yours,

Loretta C. Ellias

Loretta C. Ellias
Associate Professor
of Microbiology

LCE/cw

Florida Resources and
Environmental Analysis
Center

The Florida State University
Tallahassee, Florida 32306

August 9, 1974

MEMORANDUM

TO: Robert C. Glassen
Research Associste

FROM: Edward A. Fernald Fernald
Director

RE: Land use section of the Arvah Baker Hopkins Power Plant Impact Statement

I find the very short and very general land use and population sections to be correct in the data they provide. Mark Hurd aerial photographs & the 1970 census were utilized to make this judgment. My personal knowledge of the area supports the idea that no significant changes in land use or population location have been made in the interim between the aerial photography data and that of the census.

My only concern is that the vegetation associated with the forestry or natural land use in this area may ~~not~~ be endangered. I assume that vegetation is checked in another part of this study. If this assumption is correct I approve of the portion of the impact statement as written.

M E M O R A N D U M

DATE: September 26, 1974

TO : Robert Glassen, Director, Power Plant Siting Evaluation Project, Fla. Resources and Environmental Analysis Center

FROM: Edward A. Fernald EAF

RE : Land Use and Power Plant Siting

Florida's citizens are becoming increasingly urban. This urbanization trend is largely made possible by the high level of technology attained by our society and the affluence it provides. In turn, these characteristics and trends place a heavy demand on our economic and governmental structures to provide more power in the future for the maintenance of these accomplishments. As population densities increase more rapidly in the finite space called Florida, it is imperative that society devote more time and effort to the planning of both the sites of future power plants and the associated land use changes.

There must be a dual concern over the impact of energy production on land use and the environment on one hand, and on the availability and reliability of energy supplies on the other. Rational concern, which should generate anticipatory planning and regional coordination of power plant sites, will produce a better defined process for siting energy facilities. Properly achieved, power plant siting will be a part of a coordinated state and regional land use and environmental plan.

Proper land use and environmental planning would, of necessity, require that power demands for the future be integrated into them. This kind of planning requires that pertinent information be available to all participants in the planning process, including the general public. The power plant siting portions of such plans would have to take into consideration: the land use needs of an expanding population; the physical characteristics in terms of not only a sound physical base for a plant site, but also the environmental impacts made by the construction, on the natural systems; and, the associated economic activities, including transportation facilities, that may be encouraged by the power plant site approval. An historical study of land use in the area contiguous to the proposed plant site would be helpful in determining potimum land use in the area after the site is developed.

In the interest of efficiency, both in land use and in energy consumption, it might be desirable to study the feasibility of developing industrial parks in concert with power plant locations in order to encourage the use of the waste heat from the power plant operation. This could be utilized in the form of hot water or steam. Another possible land use for areas contiguous to power plant sites would be open space for esthetic or recreation activities where the environmental considerations show an overload of the natural systems.

In summary, it is desirable for the State of Florida to engage in anticipatory land use studies which would help direct the proper choices of power plant sites by both public and private power companies. Such studies should include the population land needs, the physical characteristics of the land, an historical survey of land use, and the major economic activities which would be encouraged by such power plant site development.

EAF/gm

Department of Meteorology

The Florida State University
Tallahassee, Florida 32306

September 25, 1974

Mr. Robert C. Glasson
Department of Oceanography
Campus Mail

Dear Mr. Glasson:

I have spent a little time looking over the meteorological aspects of the impact statement for the Hopkins Generating Station which you left with Dr. Long during the summer. I found nothing really wrong with the meteorology but there are several deficiencies, from my point of view.

1. Much of the meteorological data presented are for a single year (1972). With such a short record, an effort should be made to show that this particular year was not anomalous in comparison with long term records.

2. The stability classification used in Table II-7 is not sufficiently well known that it should be presented without some definitions. Furthermore, some explanation should be offered as to how data for Tallahassee were obtained. Since soundings are not made at Tallahassee, these stability data were somehow determined from "nearby" locations. (The nearest stations are presently Valpariso, Florida; Montgomery, Alabama and Waycross, Georgia).

3. The section on "Fogging Potentail Impact Evaluation" does not take diurnal variations into account to any appreciable extent. The "fogging potential" is very much greater around daybreak, especially in summer, and even the use of three-hourly averages is open to some question. The use of mean monthly values in exhibit V-13 is very questionable.

If you would like for me to follow up on any of these points or if you have specific questions, please let me know.

Sincerely,

C L Jordan

C. L. Jordan
Professor

cdu

Department of Physics

The Florida State University
Tallahassee, Florida 32306

October 8, 1974

M E M O R A N D U M

To : Robert C. Glassen

From: Robert A. Kromhout

Re : Arvah B. Hopkins Power Plant Site Certification

I've read through the section of the Impact Statement, but have been completely unable to contact you. I'm leaving for California in a couple of days, so I thought it best to return this now.

It appears to me that the obvious weakness here is the blowdown. To really get a handle on the probable effects, one needs more information than I have, but let me briefly summarize the problem as I see it:

1. The report states that blowdown temperature would exceed standards 20% of the time if (two contrary opinions):

   a) Cooling tower operation were "ideal"

   b) There was no cooling between tower and river

Obviously, neither of these will hold.

2. Data is needed as to the situation in situ

   a) What is present blowdown temperature compared to wet-bulb?

b) What is drop in temperature in ditch and beaver stream under current light load? The <u>heat</u> loss is likely to be nearly the same with the heavier load, because it is mainly surface cooling, unless stream bed is very shallow. Will blowdown be separate from separate towers? If so, impact will not be as bad as if, at convenience of operators, several or all towers are blown at the same time.

c) What impact has current blowdown (which presumably exceeds standards) <u>had</u>? How much worse is the increased blowdown impact expected to be?

3. Will the beaver pond hold up under the increased blowdown? Will it continue to delay flow over a period of years, even at present load? (Who repairs the dam? Surely the beavers do not stay?).

I'm really not competant to tackle the question of stack efficiency or ground water impact, although some of the estimated distribution of pollutants look peculiar to me. I presume a meteorologist is looking at those. Can the area afford addtional ground water, or will water dilute the blowdown; if we take the Statement at face value, this appears to be the most practical approach a priori.

Comments by Dr. Edward Laws, faculty member, Dept. of Oceanography Florida State University

The material you gave me contains only very qualitative discussions about the quantities of various chemicals that will be dumped into the Ochlockonee River when the generating station has been expanded. While the concentration of chemicals entering the Ochlockonee River under present conditions is of some interest, it is necessary to have a quantitative estimate of the flux of chemical species entering the river when the plant is expanded in order to evaluate its impact on the environment.

1. The statement on page 2-15 that "No water quality information is available on a regular basis" for Lake Talquin is clearly false, since the FSU lakes project has been in progress for three years. I have computed average daily fluxes of relevant chemical species into the lake from the lakes project data collected at the intersection of the Ochlockonee River and I-90 (station 8 in the impact statement). These fluxes are given in the tabulation below.

Chemical species	Flux (kg/day)
chloride	4.6×10^4
sulfate	8.4×10^3
silica (as Si)	9.4×10^3
nitrate (as N)	6.6×10^2
nitrite (as N)	12
ammonia (as N)	3.9×10^2
orthophosphate (as P)	1.9×10^2
dissolved P (as P)	2.9×10^2
total P (as P)	7.6×10^2

These fluxes are based on data collected over a 700 day period, and should therefore be fairly representative. I would suggest that the anticipated impact of the power plant expansion, as far as chemical inputs are concerned, should be based on a comparison between projected fluxes of chemical species from the plant and data such as the above. I believe that some interaction between individuals writing the impact statement and lakes project personnel would be highly appropriate. If it appears that the plant expansion will cause a significant modification in these fluxes, then some additional analysis (e.g. loss of chlorine to the atmosphere and/or discharge ditch sediments) may be appropriate.

2. Ralph Turner tells me that pH values measured by the FSU lakes project for the Ochlockonee River are consistently lower (pH about 6.5) than the value reported in Table V-6 as the ambient pH (7.37). This discrepancy should be investigated, since the effluent and discharge ditch pH values are consistently higher than 7.37. What sort of pH control will be incorporated in the plant expansion.

3. If the NO_x emission level must be lower than 0.3 lb/10^6 BTU, then the calculated NO_x emission levels of 0.299 and 0.289 for combustion of natural gas and fuel oil respectively appear to leave very little margin for error. Is 0.3 lb/10^6 BTU a legal limit? If not, what is the legal limit (if one exists).

Trivia

4. Ochlockonee is spelled three different ways in the statement. I suggest that the correct spelling be adhered to.

5. I assume that the plant is not located in the vicinity of the north (or is it the south) pole, though the latitude given in exhibit II-1 would lead one to this conclusion. The correct location is latitude 30° 27' 08" N, longitude 84° 21' 00" W.

Department of Statistics and
Statistical Consulting Center

The Florida State University
Tallahassee, Florida 32306

August 9, 1974

MEMORANDUM

To: Mr. Robert C. Glassen, Department of Oceanography

From: Jeff B. Meeker, Department of Statistics

Subject: City of Tallahassee application for power plant site certification.

The majority of the data involved in the application consist of reporting observations and related descriptive statistics and there is, therefore, little evaluation, statistically, that can be done. The only way to check these data would be to make additional, independent measurements or recheck the sources quoted. Two discrepencies were noted. The percentage breakdown of phytoplankton into diatoms, green algae, blue-green algae, and Euglenoids totals 199.6%. Also, Table V-8 on page 5-27 does not contain probabilities as properted but some form of average frequencies.

The selection of the sites at which to take measurements, both of water conditions and of noise levels, was evidently made for ease of access. There could be properties of these sites which could affect the results. Stream measurements, for instance, were all made at bridge crossings (See Exhibit II-12). Bridge crossings are generally in open areas and the direct sunlight could increase water temperatures. The same criticism can be made of the locations used for measuring noise levels. By comparing Exhibit IV-I with Exhibit III-I, it is noted that the noise sampling is done at locations easily reached. Each of the locations is also seen to be protected from the plant by some varying distance of plant cover which would possibly reduce noise levels. The boundary without the vegetation protection, that along SR260, was not sampled. Each sampling site, therefore, should be checked for peculiarities of the site which might alter the conclusions obtained from it.

On page 3-2, the report refers to the projected annual fuel consumption rates for Units I, 2, and 3 given in Table III-I on page 3-3. On page 3-4 the report states "As may be seen in Table III-I, the quantities of gas predicted to be available to the Hopkins Plant remains essentially unchanged through 1986." The table does not report predicted availability of gas, but predicted usage of gas. In fact, the report does not appear to address itself to predicted availability of gas.

The Shannon-Weaver Information Index of Species Diversity deserves some comment. Mathematically, it is

$$H = \sum_j p_j \ln p_j$$

where p_i is the probability that a randomly selected individual will be a member of species j. Its use as a measure of diversity is controversial, although in this context it should give a relative indication of species diversity. E. C. Pielou (An Introduction To Mathematical Ecology, 1969, pp. 225-233) explains it as follows: "If an individual is picked at random from a many-species population, we are uncertain which species it will belong to and the greater the population's diversity (in an intuitive sense), the greater our uncertainty.

In Table IV-I the existing ambient noise levels at the plant site are reported in the form of the .10, .50, and .90 quantities. The report states that 95% confidence intervals could be obtained. This is not true based on the information presented, but would require the entire data collected. These intervals could also be specified for L_{50} and L_{90} as well as L_{10}. Confidence intervals might also be informative on other data collected and reported as, for example, the stream flows reported on page 2-20.

JBM:at

Department of Statistics and
Statistical Consulting Center

The Florida State University
Tallahassee, Florida 32306

August 21, 1974

MEMORANDUM

To: Mr. Robert C. Glassen, Department of Oceanography

From: Jeff B. Meeker, Statistical Consulting Center

Subject: City of Tallahassee Ten Year Site Plan.

I was not able to reproduce the forcasts given by the City of Tallahassee. A comparison of Tallahassee's forcasts to those of Florida Power Corporation's, however, indicates there is a possibility they used similar methods. If so, the description of the computer programs given by Florida Power indicates Purdue University, who wrote the programs, used a fairly sophisticated procedure for handling such external factors as weather extremes. The process would not be reproducable without the computer programs.

A few observations were made. The actual forcasts were made using an exponentially weighted least squares regression, adjusted for external factors. This procedure assumes the power consumption follows a first order Markov process, that is, the power use for one year depends only on the previous year's consumption and the external factors and not on any earlier year's consumption. Secondly, the residual errors of this data often ~~has~~ is highly correlated causing an increased chance of error. Thirdly, it appears that more data was used for the predictions than was reported. If this is true, the forcasts are on safer grounds than I had earlier thought. It should be noted, though, that confidence intervals for forcasts increase tremendously as the forcast is further into the future.

I would recommend that, in future Ten Year Site Plans, some statement as to the assumptions underlying forcasts and the methods used to obtain them be included.

JBM:at

Department of Oceanography

The Florida State University
Tallahassee, Florida 32306

October 3, 1974

M E M O R A N D U M

To : Robert C. Glassen

From: Robert J. Menzies R.J.M.

Re : Arvah B. Hopkins Power Plant Siting Application

The ecological survey reported in the Arvah B. Hopkins Power Plant Siting Application included an unsound program of benthic investigation, from which no conclusions may be drawn. A benthic sample of 81 square inches is an inadequate sample, the total number of stations was inadequate, and no station was identified as a control.

Department of Geology

The Florida State University
Tallahassee, Florida 32306

SEPT 23

MEMO

TO Dr. Glassen

FROM J. K. Osmond

As I mentioned in our conversation, a professional hydrologist would be needed to evaluate with confidence the report on the impact study relating to the Hopkins Power Plant expansion.

My reaction, for what it's worth, is that the data and analysis of the river discharge pattern is adequate, but that the ground water study is not. It looks like the aquifer properties can only be guessed at without further pumping tests.

J.K.O.

October 8, 1974

MEMORANDUM

TO: Bob Glassen, Department of Oceanography

FROM: Mildred W. Ravenell MWR

RE: Application for Power Plant Site Certification

Pursuant to your request I have reviewed this application in light of the Florida Electrical Power Plant Siting Law, Florida Statutes 1973, Chapter 403. Generally, the application seems to attempt to comply with the spirit of the law. There has been an attempt to ". . . ensure through available and reasonable methods that the location and operation of electrical power plants will produce minimal adverse effects on human health, the environment, the ecology of the land and its wildlife, and the ecology of state water and their aquatic life." Florida Statutes, Chapter 403.502.

However, I do have reservations regarding the analysis of the long-range environmental effects of the plant's operation. Assuming that I have correctly interpreted the data in Section 5, I believe that the proposition established is that there will be minimal impact on a day-to-day basis. However, it has not been clearly established that steps will be taken to avoid any cumulative negative impact on the environment which may occur because of the plant's operation. For example, it appears that, on a long-range basis:

1) thermal pollution in the Ochlocknee River will occur because of the continuous discharge of the blowdown,

2) chemical imbalances which could eventually disrupt the aquatic ecosystem may occur if no effect is made to remove, particularly, the heavier elements prior to discharge.

It is true that the act does not specifically require a detailed evaluation of the long-range impact of power plants in the language quoted above. However, in view of developing data which indicate that many of the side-effects of technological development are not immediately discernible but become apparent over a period of time, it does not seem unreasonable to expect that some attempt to address such possibilities will be required.

I would suggest that you (1) clearly establish the steps which will be taken to "make [the blowdown] compatible with the receiving system"(5-29) in order to minimize the possibilities of long-range damage and (b) include a discussion of alternatives to direct discharge which were considered along with reasons supporting the choice of disposal finally made.

Department of Geology

The Florida State University
Tallahassee, Florida 32306

September 3, 1974

MEMORANDUM

TO: Robert C. Glassen, Oceanography

FROM: Steven Schamel, Geology

The principal environmental hazard presented by the A.B. Hopkins plant clearly is air and water pollution. Purely geologic problems are trivial in comparison, but must be treated completely and objectively in a DRI statement.

I share your concern with the drawdown projections and on-site availibility of ground water. The projected demand of 8.3 MGD is nearly half of the peak demands on the municipal water system, which has four times the number of wells scattered over a much larger area than the Hopkins plant site. There is no danger that the Florida aquifer will be pumped dry, however, such a large withdrawal rate may seriously lower the pieziometrie surface in the area around the plant and dry up small private wells or make ground water more difficult to obtain for future residents. Are there no State regulations limiting the demands that can be made on the ground water system by a single user? It may be necessary to establish a few additional off-site wells, if indeed the drawdown by the on-site wells is considered excessive.

The projected surface outflow from the plant of 3.0 MGD or 4.6 cfs is about five times the measured natural flow rate in the small stream receiving the discharge. There is no discussion of the impact of this large increase of discharge on erosion and flooding potential of the stream. Additional clearing at the plant site would also increase storm-water runoff into the stream.

The greater than 4 foot-thick seam of pipe clay 20 feet beneath the plant site may present a hazard to foundations, especially to the oil storage tanks. Also the poorly drained, strongly acid soils of the site may cause problems with corrosion of buried piped and foundations, if not properly designed for.

The statement does not completely address the problem of erosion and sediment and chemical runoff during the construction phase. The last statement on p. 3-27 leaves much to desire. There seems to be no provision for a catchment pond to trap pollutants in the surface runoff during and after construction.

Was any thought given to the possibility that local ground fogs generated by the cooling towers might interfer with air traffic at the Tallahassee airport?

SS:lmc

Department of Economics
College of Social Sciences

The Florida State University
Tallahassee, Florida 32306

MEMORANDUM

TO: Bob Glassen

FROM: Phil Sorensen

SUBJECT: Energy Supply forecast for the United States and Florida

DATE: October 3, 1974

This forecast is based upon the Ford Energy Policy Program results, forecasts made by Shell Oil Company, and the National Petroleum Council forecasts. It should be emphasized that all supply forecasts are based upon certain assumptions about Energy prices. The forecasts I am making assume energy prices will rise at the same rate over the next 30 years as the general price level. In other words, the real prices of oil, natural gas, and coal will not change in this period. I should also stress that supply requirements will very much depend upon the strength and timing of programs of enforced demand reduction. I can not make a separate forecast for Florida; I am simply assumming that Florida will share proportionately in the national energy supply in the future.

Energy Forecasts:

Domestic production of oil peaked at just over 9.6 million barrels per day in 1970 and has declined since that time, reaching a level of 8.9 million barrels per day in recent weeks.

/pam

Enclosures

6 Aug. 1974

The difficulty with long-range planning which depends on continued or expanded use of oil.

The U.S. has available, in known reserves, about 40×10^9 bbls of oil. At the present rate of consumption (6.5×10^9 bbls per year), this is 6.15 years' supply. We are actually importing about 40% of current usage; if this percentage continues to hold, our known reserves will last for 10.26 years.

A study I have just completed indicates that our grand total of oil production will be about 170×10^9 bbls, of which we have already used 105×10^9 bbls. This leaves us, apparently. about 65×10^9 bbls (of which 40×10^9 bbls are in known reserves). If we assume that this amount can be utilized at a level rate (the current rate), then we have 16.67 years of consumption left.

However, it is the nature of exploitation of a decreasing resource that prices rise and the commodity gets scarcer and scarcer. Therefore it is very unlikely that we can use our domestic oil at a level rate. In fact, production has been declining for three years. A serious deficiency (a major crisis) can be predicted within the first half of the time predicted above; that is, within the next eight years.

None of the above has allowed for any increase in demand. To the extent that demand increases, or that foreign oil supplies are reduced, this crisis will be moved closer to the present.

A reasonable estimate is within four years, rather than within eight years. Only with unusual luck can we expect as much as eight years to make major adjustments.

Any new power plant should be planned with these restrictions clearly in mind.

W.F. Tanner
Geology

July 30 1974

Site study: Hopkins Power Plant, Tallahassee.

Comments:

I. Table III-1 predicts an increase of oil consumption of more than 2000% by 1986. The Hopkins plant will not be the only one coming on line in the U.S. Of course total oil consumption will not increase by 2000%, but domestic oil supplies have been falling dramatically for about four years, now, and will continue to fall; therefore it is quite likely that a 2000% increase in oil utilization in 12 years will not be economically reasonable. The only substitute fuel in sight is coal. Will coal be a satisfactory substitute for this plant?

II. The parts of the report that I have seen do not evaluate the effects of draw-down on the water table, due to utilization by the power plant. If ground water wells are located in the vicinity, either up the ground gradient, or down it, they will be affected by plant operations. Has this been evaluated?

III. The discharge area creek has gradient, in the discharge area, of about 85 feet/mile (almost 1°). Blowdown discharge will increase the flow in this creek considerable. Will this significant change in flow lead to erosion within the creek channel? If no preventive measures are taken, this may be very difficult to demonstrate.

W F Tanner

W. F. Tanner
Geology Dept., F.S.U.

The energy problem:

State contribution to a national policy

There are certain actions which the state can take in connection with the energy problem. In general, these actions can effect some savings in energy use, provide that the available supplies are distributed more evenly, and encourage the development of substitute uses (such as busses instead of private cars).

There are other aspects of the problem which the state cannot afford to face. Instead, the state should seek to influence national decisions so that new policies will affect all of the states more-or-less equitably, rather than just one. The reasons for attempting to bring state influence to bear during the formulation of new national policy are many; a few can be listed here.

1. It is a national problem.
2. More than energy is involved (for example, petrochemicals, including synthetics and plastics, and fertilizer).
3. Important methods of saving, such as redesigning automobile engines, cannot be implemented effectively and efficiently by Florida alone.
4. Florida is basically a consumer, rather than a producer, in these matters.

A brief summary of the dimensions of the problem will be useful, especially in view of the tremendous amounts of misinformation widely disseminated throughout the country. No rational planning, on state or federal level, can be based on the wild guesswork which lies behind many recent public pronouncements.

The energy and petrochemical problem in the United States first appeared approximately 20 years ago, when M. King Hubbert, an eminent geologist with an international reputation, undertook a study of the oil industry. The results of this study were first published in 1956. The study itself was largely ignored, because people in government and the oil industry did not like the clear implications. Hubbert included in his work a detailed prediction of developments in the domestic oil industry. Over the last 18 years, his predictions have proven to be completely correct. No other investigator, then or later, has produced a study so complete, rational, and correct.

Using a totally different approach, I made an independent study. Although my methods were less precise than Hubbert's, I got essentially the same results (within the margin of error).

Investigations which have obtained markedly different results, even though made by otherwise competent people, have been based on one or more unacceptable assumptions. For example, one method for approaching the problem, from a geological point of view, has been to take the ratio of oil-to-rock-volume, in old, well-known producing areas, and to extrapolate this ratio to all similar rocks everywhere. This procedure ignores the fact that the oil which has been found, already, was precisely the "easy" oil, located early in the history of the industry because of the unusually large local concentrations. Such ratios cannot be extrapolated to other areas.

Hubbert's work, and mine, made no assumptions about oil-rock ratios. Hubbert's study used several different methods, one of which involves the change, with time, in the amount of oil obtained per foot of well drilled. This has the advantage that it includes the effects of technological improvements. He also used some pure statistical manipulation of the quantities of oil produced throughout the history of the industry. His resulting total was 180 billion barrels of crude oil, plus or minus 10 percent. My result, somewhat less precise, was 200 billion barrels, plus or minus 10 percent. (One barrel equals 42 gallons, or approximately 159 liters.)

At the end of 1973, the United States had already produced 105 billion barrels. That is 58.3% of Hubbert's total, or 52.5% of my more optimistic result. In either event, one fact is clear. The nation has passed the 50% mark in its long-term crude oil production. We have moved from a "golden age" of oil abundance to an austere period of oil scarcity. Hubbert's original prediction was that output would continue to rise until about 1971, and then would begin to decline, for the simple reason that our older fields were being exhausted, and there would not be enough new fields to cover the tremendous internal demand.

This prediction has proven to be correct. This is not a matter of oil companies shifting their emphasis to other parts of the world, thereby neglecting domestic exploration. Precisely the opposite has been true: domestic exploration has yielded less and less oil, forcing the companies to look elsewhere. This was, in fact, the basis for the most rigorous method that Hubbert used (the amount of oil recovered, per foot of well drilled, had begun to decline at an essentially steady rate, well before he made his original study).

Subtracting the amount of crude oil already produced and used, from the long-term total, leaves a balance of 75 billion barrels (95 billion, if we adopt the larger estimate). Between 30% and 40% of this remaining crude has been found already, inside the United States. Between 20% and 25% will be obtained, probably, by increasing the efficiency with which oil is withdrawn from the ground; however, this is not a highly elastic process, and cannot be extended appreciably.

The remainder is still to be found. It will, however, be found at a declining rate, because this is the oil which is hard to locate.

Present domestic production is close to four billion barrels per year, and is declining at a rate of two or three percent per year (furthermore, this rate can be expected to increase, as old fields play out, and new oil gets more and more difficult to find). However, if this production were to be held steady, by some technique which is not now known, the remaining crude oil would supply a constant demand--at the present level--for about 19 years (24 years, if we use the more optimistic figure).

The realities are less attractive, however. The combination of declining production, and rising demand, means an annual adjustment which can be projected at about 10 per cent per year. This would exhaust Hubbert's estimate of remaining oil in eleven years, or my estimate in less than 13 years. This is a more realistic assessment of what we can expect, if we do not make major adjustments on the national level, and that quickly.

It is an article of faith in many circles that a few major finds, like the Prudhoe Bay field, on the north slope of Alaska, or the even larger Ekofisk field, in northwestern Europe, will mean important delays in running out of domestic crude. The Ekofisk field is really not a potential supply for the United States; its oil is needed much more in Europe. However, the Ekofisk field would supply U.S. demand for less than seven weeks, and the Prudhoe Bay field for only six weeks. We will have to have approximately 60 more discoveries like these, merely to realize Hubbert's forecast, or 85 to reach my projected total. Our actual discovery rate, however, over the last quarter century, has been only a few giant fields per decade.

One of the problems lies in the fact that many people do not appreciate the gigantic size of U.S. demand. During the third week of January, 1974, this demand reached 17.6 million barrels per day (about 6.5 billion barrels per year). We have been importing, in recent months, more than one third of this demand. Two of our most important sources, Canada and Venezuela, will not be exporting to us in large quantities very much longer.

Canada is starting construction of a pipeline system, which will divert western Canadian oil (now coming to the U.S.) to Canadian markets in the east, which until recently depended largely on Arab states. This pipeline is scheduled for completion in 1977. And Venezuela, which is producing from very old fields well along in decline, will complicate this fact--beginning with the new administration taking office in March, 1974--by two new policies: (a) more rapid nationalization of the oil industry, and (b) preferential shipment to other Latin American countries, rather than to the U.S. or Europe. Perhaps these major losses can be made up from Arab sources. It is more likely that they cannot. But even if they can, there is the very serious question of how long we can continue importation, on such a large scale, at current prices.

The best evaluation of the Canadian and Venezuelan situations is that we can expect, within three or four years, to lose most of these sources. To the degree that these losses occur, we must reduce the estimates of 11 years (or 13 years) to even lower figures. Perhaps what we really have is something more nearly like eight years (or nine).

It should be kept in mind, also, that the nation's oil wells will not run dry one morning some eight or 10 years from now. Instead, the effects are being felt <u>now</u>, and these effects will grow more serious (rather than more favorable) as time passes.

A problem of these dimensions cannot be solved by one state alone, even if that state is relatively rich in petroleum resources. The solutions must be undertaken, in good part, on a national basis. Two general categories of solution are available.

One involves a program of saving, the other a program of substitution. Savings can be adopted on either a state or a national level, and many of the suggestions in other papers in this report are aimed at effecting savings on the state level. Other savings, however, must be initiated in Washington, New York or Detroit. A national shift to mass transit (in good part, trains) is called for, and a national program to penalize automobiles that use more fuel than they should. An example of the latter would be a stiff tax on weight and horsepower beyond a reasonable cut-off: so much per pound of excess weight, and so much per excess unit of horsepower. A state like Florida, economically dependent as it is on automobile travel, cannot institute measures such as these without the cooperation of many other states. Other methods of saving are also available.

Substitution revolves around two main ideas: substitute uses of available fuels, and exploitation of presently unused materials. An example of the former would be a return to coal-powered railroad locomotives. There are few or no such locomotives in use in the U.S. now. Furthermore, the old familiar iron horse won't do the job, without extensive redesigning to cut down on the notorious pollution from coal. Equipping our railroad system with coal locomotives which do not foul the air will probably take more than 10 years. This is a national task which needs to be started now. (Fortunately, we have ample reserves of coal for several centuries.)

An example of the latter would be development of the oil shales of Wyoming and adjacent states. Facilities to do this, already under contract, will require eight years to complete, and then will produce less than one percent of our present demand. The lead time, here, is very great, and construction will be extremely expensive. (The tar sands of Canada do not constitute either a state or a national solution to the problem.)

It should be emphasized again that gasoline, diesel fuel and heating oil are not the only things involved. From petroleum hydrocarbons we obtain much of our plastic goods, synthetic fibers, automobile tires, automobile batteries, fertilizer, and other things. Synthetic fibers can be replaced, relatively easily, one way or another; fertilizer is another matter.

The picture is not an attractive one. If major and correct decisions are not made, on the state and national levels, in the very near future, it will become a bleak one. On the other hand, we have large supplies of substitute materials, and we have enough knowledge, now, to begin the long and expensive process of introducing them in the place of our rapidly declining reserves of oil. Unfortunately, the margin of time available for making decisions is very close to zero.

The state should be active in helping to develop an appropriate national policy.

William F. Tanner
Professor of Geology
Florida State Univ.
Tallahassee, Fl. 32306

References

Hubbert, M. King, 1956. Nuclear energy and the fossil fuels. Drilling and Production Practice, American Petroleum Inst., New York, p. 7-25.

Hubbert, M. King, 1967. Degree of advancement of petroleum exploration in United States. Bulletin, American Association of Petroleum Geologists, vol. 51, p. 2207-2227.

11 February 1974

Comments on Economic Analysis contained in the Certification Application for the Arvah B. Hopkins Generating Station

Robert G. Turner, Ph.D.
Associate Professor of Finance
College of Business
Florida State University

Introduction

Actually, there are few economic analyses presented in the Certification Application (C.A.). What few data that exist are not analyzed concerning their impact upon the economic characteristics of the geographic area surrounding the proposed site.

Specific Comments

1. No indication of changing traffic flows nor of vehicular traffic patterns was presented. Depending on types of traffic flows and types of vehicles, property located on highways servicing the plant site might be adversely affected.

2. No indication of road or highway construction or improvement to service increased traffic to and from the site was presented. These costs should be considered vis-a-vis other alternative sites, or, at least, they should be presented relative to this specific site.

3. It would be valuable to know the distance in land miles from which the boiler stacks will be visable. This visability

may adversely affect property values in surrounding areas and should be discussed.

The emission of smoke, steam, odor, etc., could affect property values where such pollutants could be seen, heard, or smelled. These data should be presented and their impact analyzed.

The "Important Species" sections appear to be adequate in that little economic impact on these items will result from this site being chosen.

Conclusion

None of the specific comments, in my opinion, are of sufficient magnitude to render the C.A. inoperative. From what I know of the economic characteristics of Leon County, it appears that the proposed site is to be justified from an economic standpoint. However, I do believe the C.A. would be improved if it included an analysis of the points mentioned above.

THE FLORIDA STATE UNIVERSITY TALLAHASSEE 32306

Department of Sociology

August 16, 1974

Mr. Robert Glassen
Department of Oceanography
FSU

I've reviewed the portion of the EIS for the Arvah Hopkins Generating Station pertaining to the demographic characteristics of the region. The methodology employed is adequate for the limited purpose of documenting that the area is sparsely settled. However, predictive powers should not be imputed to it.

Sincerely yours,

Robert H Weller

Robert H. Weller
Assistant Professor of Sociology

RHW:ajh

THE FLORIDA STATE UNIVERSITY TALLAHASSEE 32306

Department of Biological Science

Critique of the Arvah B. Hopkins Generating Center's Impact Statement

Generally the report is characterized by insufficient data gathering, coupled with the lack of quantitative studies.

The sampling period (January 16 to 18) is not appropriate to adequately assess the adverse effects of thermal and salt additions during the most critical phase of the year. The summer period, accompanied by maximum air and water temperatures, and minimum dissolved oxygen (D.O.) and flow rates, is a more sensitive time, when the operational impact of the effluents will be most acute. Seasonal fluctuations and yearly extremes in flow rates and temperature have not been included for an adequate assessment of the dilution factors. What little diurnal D.O. data is available is not included, making it difficult to quantify the effects on photosynthesis. No mathematical modeling was done to ascertain the recovery rate of the receiving waters with variations in flow.

Field studies on the distribution and diversity of both flora and fauna are inadequate in both time and scope. The descriptive terminology employed, including abundant, common, occasional and rare in the plant species distribution Table II-10, is not sufficiently defined. Neither are the calculations of species dominance and importance in table II-12. There is a need for even more detailed data on the relative distribution of pines and hardwoods in the immediate impact area. This greatly affects run-off, humidity, etc., because of the greater transpiration rates in pines. It is clear that the quantity of streamflow and detrital input can be substantially altered by changes in the type of forest vegetation. The greater sensitivity of the pines of air pollution from the plant is not documented.

The observed animal species list, Table II-11, is absurdly inadequate. There is no indication of either regional or diurnal density and variance. Table II-13, listing observed or expected commercially and/or recreationally valuable animals, contains absolutely no quantitative data or numbers. The method and thoroughness of the survey provides only limited statistical data of questionable validity. Invertebrate surveys were not done. The problem of disease vectors, predator - prey relationships, seasonal succession, and diurnal variation, among other concepts, were completely ignored. No mention was made of the dangers to these vertebrate species by the sulfide laden air, an important consideration in view of the adverse effects sulfuric acid has on vertebrate lung tissue. In the absence of quantitative data, it is difficult to adequately gauge the newly imposed stresses to animal populations.

The phytoplankton and periphyton studies provide no data on seasonal succession, making comparisons to base line data after discharging begins difficult. Baseline data on fish was completely lacking. The problem of intake entrapment was not addressed.

Finally there was no mention of literature addressing itself to the effects of chronic pollution on the reproductive abilities of the fauna and flora. The other heavy metals present, besides Zinc, were ignored. Even the toxicity of the salts is poorly represented. There was absolutely no mention of the synergism of toxicants, such as the mutual enhancement of heat, salinity and heavy metals.

In conclusion, adequate and statistically valid base line data is needed for all seasons to properly detect the environmental impact of the plant. All projected operational parameters should also be evaluated not only during average conditions, but against the most critical environmental conditions which can be expected to occur.

David C. White

RJB/nr

David C. White, M.D., Ph.D.
Professor

Ronald J Bobbie

Ronald J. Bobbie
Graduate Research Assistant

September 17, 1974

THE FLORIDA STATE UNIVERSITY TALLAHASSEE 32306

Department of Oceanography

9 September 1974

MEMORANDUM

To: Mr. Robert Glassen, Power Plant Siting Group

From: John W. Winchester, Professor & Chairman JWW

Subject: Comments on air quality portions of the Application for Power Plant Certification, Arvah B. Hopkins Generating Station, Tallahassee

The application document contains a number of inadequacies although in my opinion none serious enough to warrant delay in authorizing construction to begin.

I find it unfortunate that section 2.8 reports no SO_2 baseline studies. These must be done before the plant operation begins. I have recently received a copy of a letter dated 13 August 1974 from M. K. Hamlin, Environmental Science & Engineering, Inc., to H. S. Oven, Jr., Florida Department of Pollution Control, which indicates plans to carry out such studies. My comments on these plans are being communicated today directly to Mr. Oven.

Section 3.6 dealing with air emissions appears to give an adequate discussion of SO_2 emissions from the oil and gas fuels proposed. However, in my opinion the plant should be built to burn coal and oil mixtures. In that case, the document should examine the air quality implications of such fuel mixtures. The nitrogen oxide emissions discussed in this section neglect to consider organic nitrogen contained in the fuels as a source of NO. This may be appreciable and should be discussed.

The discussion of fog incidence during plant operation is deficient in the following respects: (1) No model calculations are presented for the increase in fog incidence at the Tallahassee Municipal Airport. This calculation should be done in a sophisticated manner taking into account wind direction and other data. It may be that a relatively small perturbation on ambient humidity by the plant could drastically increase the incidence of fog. Therefore, a careful model should be developed for fog prediction. (2) Small droplets of chloride-rich water from cooling tower drift may have an effect on fog droplet nucleation and cause either an increase or a decrease in the tendency of fog formation. The advice of a cloud physics specialist should be obtained in writing a discussion of this point.

Predictions of the impact of particulate matter emissions on air quality should include treatment of (a) fine particles and (b) sulfate content of particulate matter. In addition, the effect of acidification of rain and fog should be treated in a predictive model.

Department of Geology
The Florida State University
Tallahassee, Florida 32306

October 1, 1974

MEMORANDUM

To: Mr. Robert Glassen
Department of Geology, FSU

From: Sherwood W. Wise, Jr.

In accordance with your request, I have reviewed sections 2.1 through 2.5, 3.8, 5.5 through 5.7, and 4.1 through 4.3 of the City of Tallahassee's application for certification of the electric generating facilities at the Arvah B. Hopkins Generating Station. I find these portions of the statement satisfactory with the possible exception of the following:

> Under section 2.5.2 entitled, "Ground Water", some concern seems to be implicit in the draw-down effect on the Floridan Aquifer and in the large amount of water to be drawn from that aquifer, which I understand will exceed six million gallons per day once all the generating units are installed. In view of this fact, I would think that some form of artificial recharge should be considered or at least explored for this area. A second alternative would be the construction of a cooling pond. Considering the permeability of the soil and geologic units in this area, such a cooling pond might also serve to promote recharge of the aquifer. On the other hand, such a cooling pond would necessitate additional clearing and perhaps greater environmental impact than merely bleeding the aquifer of water. Nevertheless, I would think that the idea is worth exploring.
>
> The second point is a general philosophical one; the proposed plant will burn petroleum products which have sky-rocketed in cost during recent years. Considering Tallahassee's proximity to the Gulf and to waterways which extend to the regions of the coal fields of Alabama and the Midwest, I would think that coal fired generating facilities would be feasible for this area. Such a plant located on the Gulf of Mexico would eliminate the need for the proposed generating facility at Tallahassee. Perhaps this is another possibility that merits exploration. I realize that this suggestion is probably beyond the scope of your study.

SWWJr:ldl

APPENDIX III.

Other Agency Comments

STATE OF FLORIDA

Department of State

THE CAPITOL
TALLAHASSEE 32304

~~RICHARD (DICK) STONE~~
SECRETARY OF STATE
Dorothy W. Glisson

ROBERT WILLIAMS, DIRECTOR
DIVISION OF ARCHIVES, HISTORY, AND
RECORDS MANAGEMENT
(904) 488-1480

October 4, 1974

Mr. R. Craig Starns
Power Plant Siting Team
Department of Oceanography
Florida State University
Tallahassee, Florida 32306

Re: Archaeological and Historical Resources within the Proposed Arvah B. Hopkins Generating Station Construction Area

Dear Mr. Starns:

As per your request of September 18, 1974, we have checked our site files relative to the above referenced project. We find that there are no recorded archaeological or historical sites within the project area. The probability of encountering here-to-fore unrecorded cultural resources is moderately high, however, due to the physiographic characteristics of the project area. We recommend that the project sponsor arrange for a professional on-site evaluation of the project area to insure that construction of the generating facility will not adversely impact presently unrecorded cultural resources.

Sincerely,

Daniel T. Penton
Historic Sites Specialist
Archaeological Research
Section

DTP:lr

cc: Dr. Kathleen Deagan

Department of Administration

Division of State Planning

725 SOUTH BRONOUGH

TALLAHASSEE

32304

(904) 488-2401

Earl M. Starnes
STATE PLANNING DIRECTOR

Reubin O'D. Askew
GOVERNOR

L. K. Ireland Jr.
SECRETARY OF ADMINISTRATION

May 24, 1974

RECEIVED DPC
MAY 29 1974
EXECUTIVE DIRECTOR

Mr. Hamilton Oven
Deputy Executive Director
Department of Pollution Control
2562 Executive Center Circle, East
The Montgomery Building
Tallahassee, Florida 32301

Dear Buck:

The Division of State Planning has reviewed the application for electrical power plant site certification of the City of Tallahassee for the Arvah B. Hopkins Generating Station (Units #2 and #3).

Based upon current information, there appears to be a need for these planned expansions, and we cannot foresee any adverse environmental impact of significance resulting therefrom. These planned expansions are, therefore, considered suitable.

Sincerely,

Earl M. Starnes
Director
Division of State Planning

EMS/kj

FLORIDA PUBLIC SERVICE COMMISSION

SERVING THE PUBLIC INTEREST

COMMISSIONERS:
BILL BEVIS, CHAIRMAN
WILLIAM T. MAYO
MRS. PAULA F. HAWKINS

700 SOUTH ADAMS STREET
TALLAHASSEE 32304
TELEPHONE 904-488-1001

RECEIVED DPC

MAY 16 1974

EXECUTIVE DIRECTOR

May 15, 1974

Mr. Hamilton S. Oven, Jr.
Deputy Executive Director
Department of Pollution Control
2562 Executive Center Circle, East
Montgomery Building
Tallahassee, Florida 32301

Re: Application for Site Certification
City of Tallahassee - Hopkins #2 & #3

Dear Mr. Oven:

Pursuant to 403.507 F.S., the Florida Public Service Commission has analyzed the above referenced application. The application considers the addition of 2-238 MW units at the existing site of the Hopkins Generating Station. The net generating capability of these units is shown as 235 MW each in the City's ten-year site plan. The first unit is scheduled to be operational in 1977, the second in 1982.

It is our conclusion that sufficient justification exists for the addition of these units to serve Tallahassee's service area.

Forecast of projected load growth have been reviewed and upon consideration of recent historical trends are found to be reasonable.

The present generating capability is not adequate to meet projected loads after 1974. The City has planned to meet its projected loads largely by the addition in 1977 of a unit with a net capability of 235 MW and a similar unit in 1982. During the interim years these additions will be augmented by the installation of two combustion turbine units totalling 56 MW net capability. In addition to offsetting load growth in the years between the addition of the two base units, they will also serve to offset the effect of retiring 31.2 MW net capability at the City's Purdom Plant.

The City's plan takes advantage of the economies of scale accruing from the addition of units in the 200-250 MW range. However, the size of these units in relation to its existing plant and the time required to place them in operation results in back to back peaks and valleys for generating capability versus peak load. The City has made firm committments for purchase and sale of capacity with Florida Power Corporation that will accommodate this situation.

In the two years prior to the completion of Hopkins Unit #2, the City's generating capability will be augmented by firm purchases from Florida Power Corporation in order to maintain an adequate reserve margin. During the first two years of operation of Hopkins Unit #2, the City will sell firm capacity to Florida Power Corporation. This will economically utilize the initial excess capacity normally occurring after the addition of a relatively large unit to a small system.

The attached table, Load and Capability Data, summarizes the relationships of capability and load for the period through 1983 and points out the effect of purchase and sale of power on the City's capability.

If you have any questions regarding our analysis, please contact me.

Very truly yours,

T. Mabry Ervin

T. MABRY ERVIN
Executive Director

TME/FS/cd

Attachment

CITY OF TALLAHASSEE

Load and Capability Data
(Megawatts)

Period	Summer Peak Load	Net Generating Capability	Reserve MW	Reserve % of Peak	Firm Purchases (Sales)	Reserve after Purchases MW	Reserve after Purchases % of Peak
1974	226	277.7	51.7	22.9	-	51.7	22.9
1975	254	277.7	23.7	9.3	40.0	317.7	25.1
1976	275	277.7	2.7	1.0	75.0	352.7	28.3
1977	308	512.7(1)	204.5	66.5	(130.0)	382.7	24.3
1978	344	512.7	168.7	49.0	(90.0)	422.7	22.9
1979	386	512.7	126.7	32.8	-	126.7	32.8
1980	432	529.5(2)	97.5	22.6	-	97.5	22.6
1981	485	557.5(3)	72.5	15.0	-	72.5	15.0
1982	542	772.5(4)	230.5	42.5	-	230.5	42.5
1983	607	772.5	165.5	27.3	-	165.5	27.3

NOTES:

(1) Addition of Hopkins Unit #2

(2) Retirement of 11.2 MW at Purdom Plant and addition of 28 MW CT generator

(3) Addition of 28 MW CT generator

(4) Retirement of 20 MW at Purdom Plant and addition of Hopkins Unit #3

FILE COPY