SITE CERTIFICATION APPLICATION
ENVIRONMENTAL INFORMATION DOCUMENT

FOR

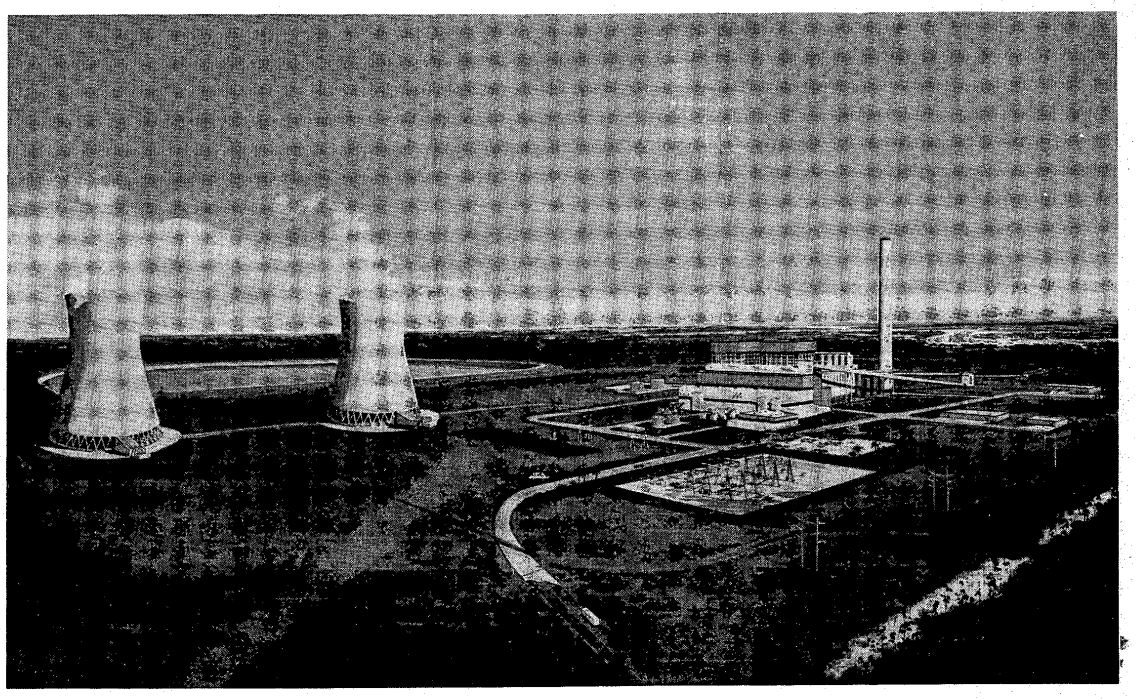
JACKSONVILLE ELECTRIC AUTHORITY

ST. JOHNS RIVER POWER PARK

UNITS 1 & 2

1985-1987

VOLUME 4



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NORCROSS, GEORGIA 30092

1981

JACKSONVILLE ELECTRIC AUTHORITY

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VOLUME 4

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GEOLOGY AND SOILS

E.1 PHYSIOGRAPHY

Florida can be divided into three major transpeninsular physiographic zones: the Northern or Proximal Zone, the Central or Mid-Peninsular Zone, and the Southern or Distal Zone (Figure E-1). The site is located within the Northern or Proximal Zone. The southern boundary of this zone is a line connecting St. Augustine, Palatka, Hawthorne, and Gainesville, representing the southern extent of a continuous upland surface.

The Northern or Proximal Zone is typified by continuous high ground forming a broad upland between the Gulf Coastal lowlands on the west and the Eastern Valley. The Central or Mid-Peninsular Zone is characterized by discontinuous highlands in the form of subparallel ridges separated by broad valleys. The Southern or Distal Zone is distinguished by a broad, flat, gently-sloping and poorly-drained plain.

The proposed site lies in a transitional zone between the northern end of the Eastern Valley and the southern edge of the St. Mary's meander plain (Figure E-2). The St. Johns River which occupies the entire length of the valley, flows eastward toward the Atlantic Ocean along the southern boundary of the site area. The St. Johns River, where it passes the proposed site, is a broad estuary subject to tidal fluctuations.

The topography of the area is controlled by a series of marine terraces which have been modified by fluvial processes. The terraces were formed during periods when the sea was relatively stationary for periods of time at different sea levels higher than the present. When the sea level dropped, the sea floor emerged as a marine terrace. The former shorelines are recognized by low scarps which maintain a fairly uniform elevation. Although the exact history of sea level fluctuation and the origin of

terraces has been debated in the literature (Cooke, 1931, 1941; Flint, 1940, 1941; MacNeil, 1950), it is generally believed that the higher the terrace the older it is (White, 1958). The extent of the marine terrace deposits in the site vicinity is illustrated in Figure E-3.

The proposed site ranges in elevation from 5 to 28 feet above mean sea level. The northwestern part of the property, that which is greater than 10 feet above MSL, is underlain by the Pamlico Marine Terrace. At elevations less than about 10 feet, the property is underlain by the Silver Bluff Marine Terrace (Figure E-3).

Most of the area below the 10-foot contour along the southeastern edge of the site property is wetlands bordering the St. Johns River. Another large wet area occurs in the northwestern corner of the site (Figure E-4).

An elliptical hill, rising to a height of 28 feet above MSL, occurs adjacent to the river in the southeastern part of the site. This may be a remnant of an ancient beach ridge or sand dune.

The entire site area is underlain by medium to fine-grained sand with some silt. The geologic and engineering properties of these surficial sands are discussed in detail in Sections E.4.2 and E.4.4.

E.2 REGIONAL GEOLOGY

Peninsular Florida is part of the Eastern Gulf Coast sedimentary basin. The Florida platform, which includes peninsular Florida and its adjacent continental shelves is considered by many geologists (King, 1959; King, 1950; and Murray, 1961, 1963) to be an extension of the Appalachian and/or the Ouachita structural belts.

The dominant structural feature of Florida is the Peninsular Arch which is underlain by Paleozoic sandstones and shales in northern peninsular Florida and igneous, metamorphic and metavolcanic rocks to the south (Applin, 1951). Figure E-5 illustrates the distribution of basement rocks in Florida and Figure E-6 is a generalized regional geological map of northeast Florida.

A sedimentary province of primarily non-clastic deposition persisted from the end of the Mesozoic Era through the Tertiary. The resultant sedimentary sequence of limestones, dolomites and evaporites ranges in depth from 8,000 feet in northern Florida to 18,000 feet in the south Florida Basin.

The present day land surface is covered with unconsolidated sediments of Pliocene to Recent age. Much of the region's geomorphology is influenced by Pleistocene to Recent marine terraces which are discussed in Section E.1. Site-specific geologic conditions and the engineering properties of soils are discussed in Sections E.4.2 and E.4.4, Surficial Deposits and Subsurface Soils and Rock Conditions, respectively.

E.2.1 Stratigraphy

This study focuses on the Eocene and younger material as they comprise all of the rocks which are encountered at the surface and are penetrated by water wells within the site region. The pre-Eocene stratigraphy is summarized below:

The crystalline basement rocks were assigned an early Paleozoic age by Applin (1951) and a Precambrian age by Rainwater (1970). These rocks range from granites and diorites to basalts, and include metamorphosed volcanic rocks as well. Relatively flat-lying Paleozoic rocks consisting of unmetamorphosed to weakly metamorphosed, non-calcareous shales and sandstones underlie the site region (Applin and Applin, 1944). The Applin Line (Figure E-5) delineates the unmetamorphosed sedimentary rocks to the northwest from the crystalline rocks to the southeast. A petroleum exploration well in Clay County penetrated quartzitic sandstone which is at least 2,000 feet thick extending to a depth of 3610 feet below mean sea level (Applin, 1951).

Mesozoic rocks consist of Jurassic and/or Cretaceous carbonates interbedded with clastic rocks. Geophysical studies have suggested the presence of buried Triassic Basins containing redbeds (Arden, 1974). Regional subsidence in the Jurassic caused the beginning of marine carbonate deposition. An increased supply of terrigenous clastics was provided by the uplift of the Peninsular Arch and the southern Appalachian region, during the early Cretaceous (Rainwater, 1970).

In the late Cretaceous, the supply of clastics diminished. A marine transgression, in conjunction with regional subsidence, expanded the area of carbonate deposition across the Peninsular Arch. Deposition of sandstone and shales was restricted to near shore areas. In general, deposition of shallow marine limestone, dolomite and chalk prevailed (Rainwater, 1970).

E.2.1.1 Cenozoic Era

The shallow marine carbonate deposition, which began in the Cretaceous, continued throughout the Cenozoic Era. Occasional periods of restricted circulation caused precipitation of anhydrite, especially during the Paleocene. Periods of uplift (resulting in regression), caused mud deposition in near-shore environments. Uplift during middle Miocene time

caused an influx of terrigenous sediment throughout Florida. Deltaic and lagoonal units were deposited along a southward prograding shoreline. Marine transgression and carbonate deposition resumed in late Miocene time, followed by renewed uplift and erosion in the Pliocene (Rainwater, 1970).

The following discussion of Eocene and younger stratigraphy refers specifically to the area around the site in Duval County.

E.2.1.2 Eocene

The oldest Eocene formation is the Oldsmar Limestone, a fragmental marine, dolomitic limestone. It underlies all of Duval County and is penetrated by a few water wells in the area. It is overlain by the Lake City Limestone.

The Lake City Limestone of early middle Eocene age is lithologically similar to the Oldsmar Limestone. It consists of alternating beds of limestone and porous dolomite. The Lake City varies in thickness from 425 to greater than 500 feet and lies approximately 800-1000 feet below the surface at Jacksonville (Leve, 1966).

The Lake City Limestone is unconformably overlain by the Avon Park Limestone of late middle Eocene age. The Avon Park Limestone is a predominantly cream-colored, chalky, porous limestone interbedded with hard, impermeable dolomitic limestone and dolomite. It ranges in thickness from 50 to 260 feet (Fairchild, 1972) and lies 600 to 800 feet below sea level in northeastern Florida (Chen, 1965).

The Ocala Group of late Eocene age has been subdivided into three formations: the Inglis, Williston and Crystal River (Table E-1). The three formations have similar lithologies and will be treated as a single unit in this report. The Ocala Group is exposed at the surface in the western part of northern Florida. In Duval County, the Ocala Group lies 350 to 600 feet below the surface (Figure E-7). The Ocala Group is

characterized by interbedded tan to brown, hard crystalline limestone, dolomitic limestone and soft, white to cream colored, chalky coquinal limestone. The upper surface is highly irregular, and sinks, cavities and solution pipes are common in some parts of the Ocala Group. At the proposed site, the top of the Ocala Group is approximately 450 feet below MSL.

E.2.1.3 Oligocene

Deposits of Oligocene age are absent in the site region although they are present as a relatively thin unit in the western Florida panhandle and in the southern one-half of the peninsula (Applin and Applin, 1944).

E.2.1.4 Miocene

The Hawthorn Formation, of middle Miocene age, unconformably overlies the Ocala Group. In Duval County, the formation ranges in thickness from 250 to 500 feet with irregular upper and lower surface. It lies at depths ranging from 50 to 200 feet below the surface (Fairchild, 1972). At the proposed site, the top of the Hawthorn lies about 90 feet below the surface.

The Hawthorn Formation is characterized by phosphate-bearing dark gray and green sandy to silty clay, clayey sand, clay and sandy limestone. Puri and Vernon (1964) consider the Hawthorn Formation to be a deltaic deposit.

E.2.2 Structure

The major structural features of Florida are illustrated in Figure E-8. The Peninsular Arch and Ocala Uplift are dominant regional features trending south-southeast from southeastern Georgia into central Florida. The Peninsular Arch has been a structural high since the Paleozoic (Applin, 1951). During the early Cretaceous, it was a topographic high as well, since beds of this age pinch out against it. Upper Cretaceous beds extend over the arch, indicating inundation by the sea at this time (Puri, 1953).

The Ocala Uplift, a younger and more localized structure than the Peninsular Arch, was active during the late Tertiary (Vernon, 1951). The Ocala Uplift consists of two shallow folds which have crests trending northwest-southeast. Near the Georgia-Florida border, the two folds are separated by a shallow trough about 50 miles wide. Southward, the fold crests converge to within several miles in Leve and Citrus Counties before diverging once again. The east fold merges with the Kissimmee faulted flexure, a large fault block which formed prior to the Miocene, while the west fold gradually merges with the regional dip (Vernon, 1951).

Maher (1965, 1971), Murray (1961), and Applin and Applin (1944) describe and illustrate with maps how various structures have influenced the geometry, type, and distribution of sediment in Florida and adjacent states. Although there have been many up and down movements, the Florida plateau gradually subsided throughout the Cretaceous and Tertiary. The South Florida Basin has subsided southwest of a hinge line trending southeasterly from Manatee County to Palm Beach which Brown (1974) recognizes as a major tectonic boundary. The basin has been accumulating sediment at a faster rate than northern Florida, resulting in a stratigraphic section that thickens from north to south in peninsular Florida. However, the entire region has risen gradually since the Pleistocene (Rainwater, 1970).

The Suwannee "Channel" marks the approximate axis of the Suwannee basin wherein two distinct sedimentary facies were deposited from late Cretaceous through late Eocene time. This structure, which trends northeastward across the Florida line into southeastern Georgia, is described by some geologists as a possible strait or channel connecting the Appalachicola embayment with the southeast Georgia embayment during the above time span (Chen, 1965). The channel occupies the approximate position recognized by Brown (1974) as a plunging half graben. The channel marks the zone between the carbonate-evaporite facies to the southeast and the terrigenous clastic facies to the northwest (Chen, 1965).

Movements associated with the Ocala Uplift led to regional fracturing and the formation of normal dip slip shear faults such as those shown in Figure E-9. These faults are of interest because they apparently control, in part, the course of the St. Johns River (Pirkle, 1971).

A pair of faults at and next to the proposed site are postulated by Leve (1966 and 1978) to explain large vertical (50 to 200 feet) variations in the surface of the Ocala Limestone of Eocene Age. The vertical anomalies are inferred from geological and geophysical logs of area water wells. The fault traces trend in a general north-south direction, one crossing the site, the other several miles to the west. These two postulated faults are blanketed by about 250 to 600 feet of post Eocene deposits and do not extend to the surface (Figure E-10).

No evidence of faulting was found in the subsurface boring program. In fact, the elevation of the top of the Hawthorn Formation of Miocene age did not vary more than 20 feet vertically in any of the bore holes at the proposed site.

E.3 REGIONAL SEISMIC HISTORY

The site is in one of the most seismically stable areas in the United States. The earthquake history of the region is discussed here in terms of foundation suitability for a coal-fired power plant. Figure E-11A and B illustrate those earthquakes which have occurred in Florida and Georgia, while Table E-2 lists those earthquakes which have had perceptible effects ("felt" area) that includes Florida, although they originated elsewhere.

All of the earthquakes that have occurred in Florida and Georgia have had a Modified Mercalli (MM) intensity of VI or less and have caused very minor damage. The Modified Mercalli damage scale is presented as Table E-3.

The closest earthquake to the site was an MM V event near Jacksonville, October 31, 1900 (Figure E-11). An earthquake such as this would be felt at the site. However, damage would be minor and confined to old, unrepaired, poorly built structures. Recent earthquakes include an intensity MM III to IV near Daytona Beach, on December 4, 1975, and an MM V event near Orlando on October 27, 1973 (Figure E-11). The former had an extremely localized "felt" area and the latter would have had an intensity of MM I at the site area as illustrated in Figure E-12. The strongest earthquake noted to date in Florida occurred near Gainesville in 1879 with MM VI intensity. The "felt" area of this earthquake included Tallahassee; Savannah, Georgia; and Daytona Beach. However, the only damage reported was plaster falls in a few older houses in St. Augustine.

The strongest earthquakes to affect the site region were the 1886 Charleston, South Carolina series of MM intensity IX-X, and the 1811-1812 New Madrid, Missouri series of magnitude XII which are 200 and 650 miles from the site, respectively. Although they each had a felt area of 2 million square miles, the effect of their projected shock waves on the site area was slight. Figure E-13, an isoseismal map of the Charleston 1886 earthquake, projects an MM VI shock into the site area. Recent earthquakes

in Georgia include an MM VI event northwest of Augusta on August 2, 1974, and an MM V event near Swainsboro, 250 and 150 miles, respectively, from the proposed site.

Another potential source of seismic activity is the Caribbean seismic belt. The strongest earthquakes from this region were located in Cuba, ±1000 miles from the site with a maximum intensity of MM VIII, and would not be a threat to the proposed site.

In conclusion, the potential for seismic damage at the proposed site is minimal. Within historically recorded times, the Florida peninsula has been a seismically stable area. All of the earthquakes originating within Florida have been minor, and the major earthquakes outside of Florida have been too distant to induce significant ground motions (see seismic risk map in Figure E-14).

E.4 SITE GEOLOGY

E.4.1 Method of Investigation

The site was studied in two discrete phases. The first phase was designed to provide site specific data to plan the more comprehensive Phase II Geology/Soils boring investigation and to delineate any possible major deviations from the regional geology as determined by the literature review. The on-site work during Phase I consisted of 11 subsurface borings to 150 feet (Borings DP-1 through DP-10 and DP-12, Figure E-15A). These data were used in designing the second phase.

The second phase consisted of an extensive review of the available published and unpublished data, a drilling and sampling program consisting of 86 borings ranging from 25 to 150 feet deep, laboratory analyses of representative samples, and an analysis of the data to determine the engineering properties of the site materials (Borings DP-100 through DP-142, DA-1 through DA-43, Figures E-15A and 15B).

In addition, six borings and three probes of depth of water were conducted at the location of the proposed coal unloading facility on Blount Island.

These Phase I and II data and the analyses thereof are discussed in the following sections.

E.4.2 Surficial Deposits

The sediments that overlie the Ocala Group in Duval County range in age from Miocene to Holocene. The Hawthorn Formation of Miocene age lies unconformably upon the Ocala Group. Overlying the Hawthorn Formation are unnamed upper Miocene or Pliocene deposits which are in turn overlain by Pleistocene and Holocene deposits (Leve, 1966). In the site area, the thickness of the sediments overlying the Ocala Group is approximately 470 feet.

The Hawthorn Formation consists mainly of light to medium green-gray sandy silty clay and clayey sand which contain a trace to moderate amounts of black phosphate sand and gravel. In most places, the upper surface of the Hawthorn is marked by the presence of phosphate.

The Hawthorn Formation ranges in thickness from about 250 to 500 feet in Duval County (Leve, 1966). Although the formation generally thickens to the northeast, it varies in thickness locally due to irregular upper and lower surfaces (Fairchild, 1972). Although many of the borings did penetrate the upper surface of the Hawthorn Formation, no borings were deep enough to penetrate its lower surface at the site. A contour map of the depth of the Hawthorn Formation from MSL shows that the upper surface of the Hawthorn is only slightly irregular (Figure E-16). In the site area, the Hawthorn generally occurs at depths of about 85 to 95 feet from the ground surface.

In the site area, the Hawthorn Formation is overlain by about 30 to 45 feet of upper Miocene or Pliocene deposits. These deposits occur at depths of 40 to 65 feet below the ground surface and consist from top to bottom of an upper tan-gray sandy fossiliferous limestone, a partially cemented sand and shell layer, or sand with some shell, a light gray slightly to partially cemented fine sand with traces of silt, and a lower tan-gray fossiliferous limestone, or partially cemented sand and shell. Figures E-17 and E-18 show several boring profiles in both the plant and ash pond areas. In the plant area, most borings were deep enough to penetrate the entire section of upper Miocene or Pliocene deposits and show that the upper limestone, partially cemented sand and shell, or sand with some shell cannot be correlated across the entire site area. Also, it can be seen from the profiles that the lower limestone or partially cemented sand and shell is underlain in some places by a thin layer of partially cemented sand which directly overlies the Hawthorn Formation. All of the upper Miocene or Pliocene deposits can be distinguished from the Hawthorn Formation by their tan-gray (limestone) or light gray (cemented sand) color, by their lack of phosphate, and by their high blow counts.

Overlying the upper Miocene or Pliocene site deposits are 40 to 65 feet of uncemented sediments of Pleistocene and Holocene age. According to Fairchild (1972), these sediments were deposited during the formation of marine terraces and beach ridges. The Pleistocene and Holocene deposits in the site area (from top to bottom) consist primarily of yellow-tan or tan-gray very fine to fine-grained quartz sand locally containing thin green-gray silty clay seams or pockets and traces of silt. In most of the borings, the very fine to fine-grained sand grades into a gray fine to medium-grained quartz sand locally containing traces of coarse sand and blue-green-gray clay seams or pockets. In some of the ash pond area, the gray fine to medium sand changes to a dark gray fine to medium-grained sand with some to a trace of shell and a trace of dark blue-green gray silty clay seams (see Borings DA-3, DA-4, DA-5, DA-10, DA-11, DA-15, DA-16, DA-18, DA-19, DA-20, DA-21, and DA-25 in Figures E-15 and E-17).

The boring profiles of the plant area (Figures E-17 and E-18) indicate that in some places the gray fine to medium sand grades back into very fine to fine sand which in turn changes to a slightly to partially cemented light gray fine sand marking the contact between the Pleistocene-Holocene deposits and the upper Miocene or Pliocene deposits. This contact appears to be in part gradational, particularly where the very fine to fine sand grades into a slightly to partially cemented fine sand with very little or no color or grain size change.

E.4.3 Bedrock

The rock formations that immediately underlie the surficial deposits are described in Section E.2.2. These formations are Eocene in age and include from oldest to youngest the Oldsmar Limestone, the Lake City Limestone, the Avon Park Limestone,and the Inglis, Williston, and Crystal River Formations of the Ocala Group (Leve, 1966).

E.4.4 Subsurface Soils and Rock Conditions

The subsurface soil conditions were investigated to a depth of 150 feet below the ground surface. Lithified rock was encountered at a depth of approximately 500 feet while drilling a deep water well at the site. The condition of the rock was not evaluated since the depth was considered beyond the influence of the power plant construction.

The subsurface soil conditions at the site can be generalized as follows:

From the ground surface to a depth of approximately 15 to 30 feet, the soil is a very loose to loose fine sand. From approximately 15 to 55 feet, the soil is generally a medium dense to dense fine to medium sand. A very dense fine sand layer exists from approximately 55 to 90 feet. The sand in this stratum varies from slightly to totally cemented. Some limestone was also logged in this cemented stratum. At approximately 90 feet there is a gradual transition into a strata of fine sand, clay and silt. These soils have been identified as the upper portion of the Hawthorn Formation.

The sand in the upper 55 feet is a fine to medium, uniformly graded sand with grain size predominantly between 0.1 and 0.5 mm. The percent of silt and clay size particles is typically less than 10 percent. The dry unit weight of the in situ soil is approximately 95 pounds per cubic foot with a natural moisture content of 23 percent. Field and laboratory permeability tests indicate a coefficient of permeability on the order of 10^{-4} centimeters per second. Results of this testing are discussed in Chapter 2, Section 2.5.2, Groundwater and Appendix D. Triaxial strength tests performed on the sands indicated zero cohesion, with an angle of internal friction of between 35 and 39 degrees. Consolidation tests indicate that the silty sands have been preconsolidated to pressures of approximately twice the existing overburden pressure.

The cemented sands between 55 and 90 feet are similar in grain size to the overlying sand. The strength is significantly higher as demonstrated by the standard penetration tests which frequently exceeded 100 blows per foot. The permeability of this stratum varies depending on the degree of cementing and the existance of small voids and cavities.

The upper contact of the Hawthorn Formation is encountered at approximately 90 feet below the existing ground surface. These soils are very fine to fine sand, silt and clay in varying percentages with a trace to some phosphate sand and gravel. Atterberg limits tests resulted in a plasticity index ranging from non-plastic to 28 percent. A triaxial strength test was performed on a soil sample taken at a depth of 103 feet in boring DP-113. The undrained soil strength or total stress properties indicated cohesion of 3 kips per square foot and an angle of internal friction of 9.5 degrees. The drained strength or effective stress properties indicated zero cohesion with an angle of internal friction of 35 degrees. Consolidation tests indicated that these soils have been preconsolidated to approximately one and one-half times the existing overburden pressure.

E.5 COAL UNLOADING FACILITY SUBSURFACE INVESTIGATION

A subsurface and foundation engineering investigation was conducted at the proposed Jacksonville Electric Authority coal unloading facility located on Blount Island. The purpose of this investigation was to demonstrate the suitability of the proposed site for the safe support of the wharf structure and to define the quantities and classification of dredge material.

E.5.1 Method of Investigation

The investigation consisted of an offshore program, soil sampling and laboratory testing. The engineering analyses consisted of evaluation of various pile types to support the wharf structure and the evaluation of the quality of dredged material to be used as backfill.

The planned boring program consisted of nine standard penetration test borings. This program was modified in the field and three borings were eliminated where the present mudline was within two feet of the proposed dredge line. The borings eliminated were BI-7, BI-8, and BI-9. A total of 245 linear feet of soil was drilled. The boring locations and depths are presented in Figure E-19. A skid type rig mounted on a barge was used to drill all borings.

E.5.2 Proposed Wharf Area Deposits

As indicated by the subsurface profile presented in Figure E-20, from mudline to approximate elevation -20, a layer of very loose silty fine sand with silt seams and some organic matter exists. The depth of this layer is variable. It is maximum at boring location BI-3 and minimum at BI-2. The approximate elevation of the mudline is -17 at boring BI-1. It is assumed that material above elevation -17 was dredged in the past. Between approximate elevations -20 and -50, a layer of loose to medium dense fine to medium silty sand exists. This layer has some pockets of very loose

sand, hard clay and cemented silty sand as indicated in the profile presented in Figure E-20. Underlying this layer is a layer of very dense fine sand with layers of cemented silty fine sand and limestone. This layer may be used as the bearing stratum for the pile foundations.

E.5.3 Proposed Dredge Area Deposits

The location of the proposed dredge area is presented in Figure E-19. Subsurface profiles presented in Figures E-20 through E-24 represent the subsurface conditions. The maximum dredge depth is to elevation -38. Below mudline there is a layer of very loose silty fine sand with silty clay seams and some organic matter. The thickness of this layer is variable at different locations as indicated in the profiles. This material (approximately 170,000 cu. yds) is not suitable as backfill due to the presence of organic matter and will be spoiled to an existing Corps of Engineers disposal area. The underlying layer of medium dense to dense fine to medium silty sand with some silty clay lenses also varies depending on the location as indicated by the profiles. This material is suitable as backfill and will be placed on the coal unloading facility site.

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Table E-1
STRATIGRAPHY OF THE CENOZOIC FORMATIONS
OF DUVAL COUNTY

Geologic Age	Stratigraphic Unit	Approximate Thickness (feet)	Lithologic Character
Recent and Pleistocene	Recent and Pleistocene deposits	0-150	Soil, muck, coarse to fine sand, shell, and some clayey sand
Pliocene?	Pliocene or Upper Miocene deposits	20-110	Gray-green calcareous, silty clay and clayey sand; contains shell beds and white soft, friable limestone beds
Miocene	Hawthorn Formation	260-490	Gray to blue-green calcareous phosphatic, sandy clays and clayey sands; contains fine to medium phosphatic sand lenses and limestone and dolomite beds, particularly near the base of the formation
	Ocala Group: Crystal River River Formation	50-300	White to cream chalk, massive fossiliferous marine limestone
	Ocala Group: Williston Formation	20-100	Tan to buff granular, marine limestone
	Ocala Group: Inglis Formation	40-100	Tan to buff granular, calcitic, marine limestone; contains thin dolomite lenses and zones of Miliolidae foraminiferal coquina
Eocene	Avon Park Limestone	50-250	Alternating beds of brown to tan hard, massive dolomite, brown finely crystalline dolomite, and granular calcitic limestone
	Lake City Limestone	425-500+	White to brown, purple-tinted lignitic, granular limestone and gray hard, massive dolomite; contains lignite beds and zones of Valvulinidae foraminiferal coquina
	Oldsmar Limestone	846	Cream to brown massive to chalky granular limestone and tan to brown massive to finely crystaline dolomite

Table E-2

MAJOR EARTHQUAKES THAT HAVE AFFECTED FLORIDA

Year	Date	Time	MM Intensity	Location	N. Lat.[a]	W. Long[a]	Felt Area (Sq. Miles)
1811	Dec. 16	02:00	XII	New Madrid, Mo.	36.6	89.6	2,000,000
1812	Jan. 23	-	XII	New Madrid, Mo.	36.6	89.6	-
	Feb. 07	-	XII	New Madrid, Mo.	36.6	89.6	-
1868	Mar. 26	-	VI-VII[b]	Havana, Cuba	23.1	82.4	-
1880	Jan. 27	22:33	VIII	Vuelto Abajo, Cuba	22.8	80.8	65,000
	Jan. 23	04:00					
1886	Aug. 31	21:51	IX-X	Charleston, S.C.	32.9	80.0	2,000,000
		21:59					

[a] Approximate epicentral location
[b] Seismic origin questionable

Reference: Earthquake Information Bulletin, 1971; Coffman and Von Hake, 1973

Table E-3

MODIFIED MERCALLI SCALE, 1956 VERSION

I. Not felt. Marginal and long period effects of large earthquakes (I Rossi-Forel Scale).

II. Felt by persons at rest, on upper floors, or favorably placed (I-II Rossi-Forel Scale).

III. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake (III Rossi-Forel Scale).

IV. Hanging objects swing. Vibration like passing of heavy trucks; or sensation of a jolt like a heavy ball striking the walls. Standing motor cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes in the upper range of IV wooden walls and frame creak (IV Rossi-Forel Scale).

V. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate (V-VI Rossi-Forel Scale).

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickknacks, books, etc., off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and masonry cracked. Small bells ring (church, school). Trees, bushes shaken visibly, or heard to rustle (VI-VII Rossi-Forel Scale).

VII. Difficult to stand. Noticed by drivers of motor cars. Hanging objects quiver. Furniture broken. Damage to weak masonry, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices. Some cracks in ordinary masonry. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged (VIII - Rossi-Forel Scale).

VIII. Steering of motor cars affected. Damage to ordinary masonry; partial collapse. Some damage to reinforced masonry. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes (VIII+ to IX - Rossi-Forel Scale).

Table E-3 (Continued)

IX. General panic. Weak masonry destroyed; ordinary masonry heavily damaged, sometimes with complete collapse; reinforced masonry seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Serious damage to reserviors. Underground pipes broken. Conspicuous cracks in ground. In alluviated areas, sand and mud ejected, earthquake fountains, sand craters (IX+ Rossi-Forel Scale).

X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly (X Rossi-Forel Scale).

XI. Rails bent greatly. Underground pipelines completely out of service (X Rossi-Forel Scale).

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown in to the air (X Rossi-Forel Scale).

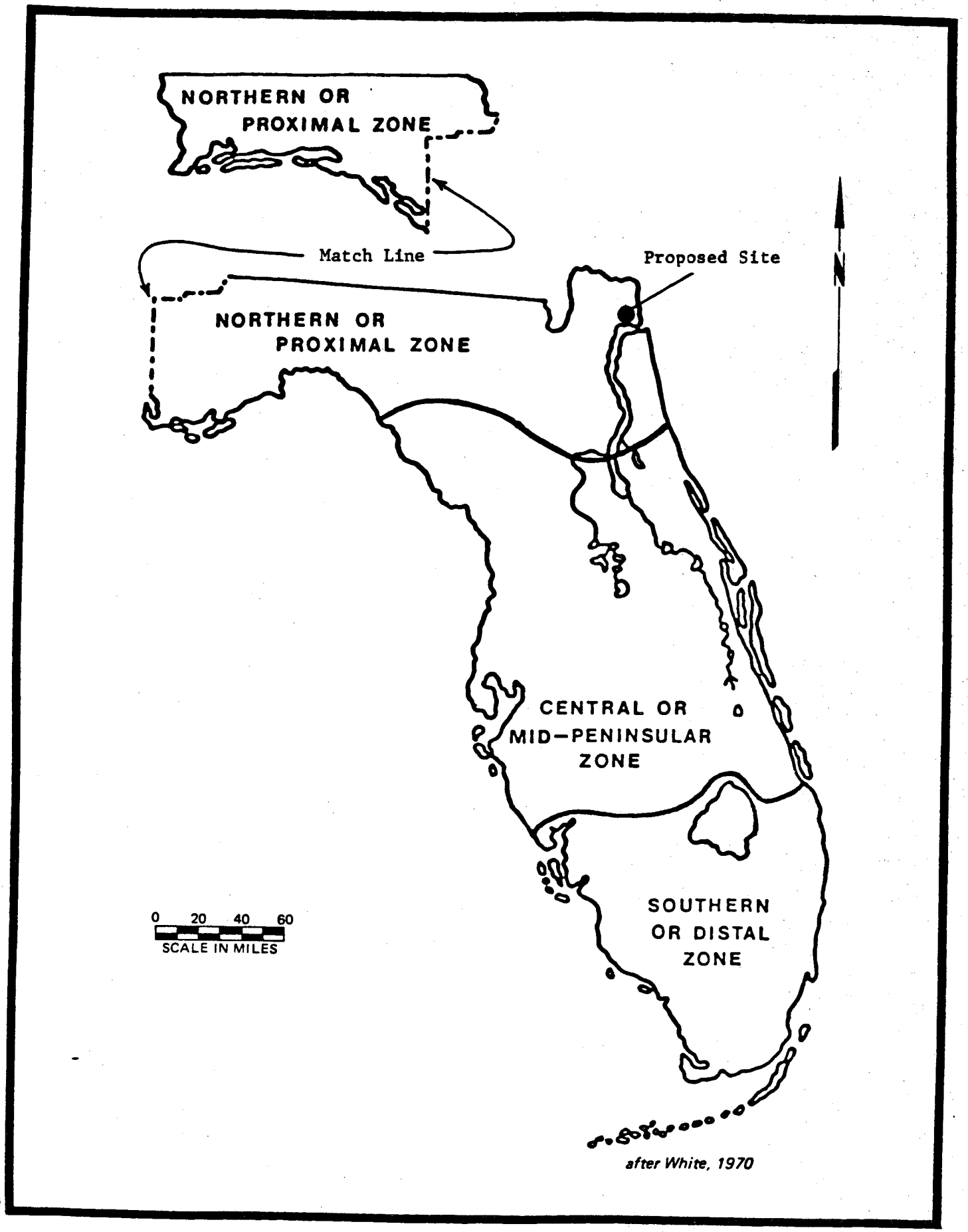


Figure E-1 Physiographic Divisions of Florida

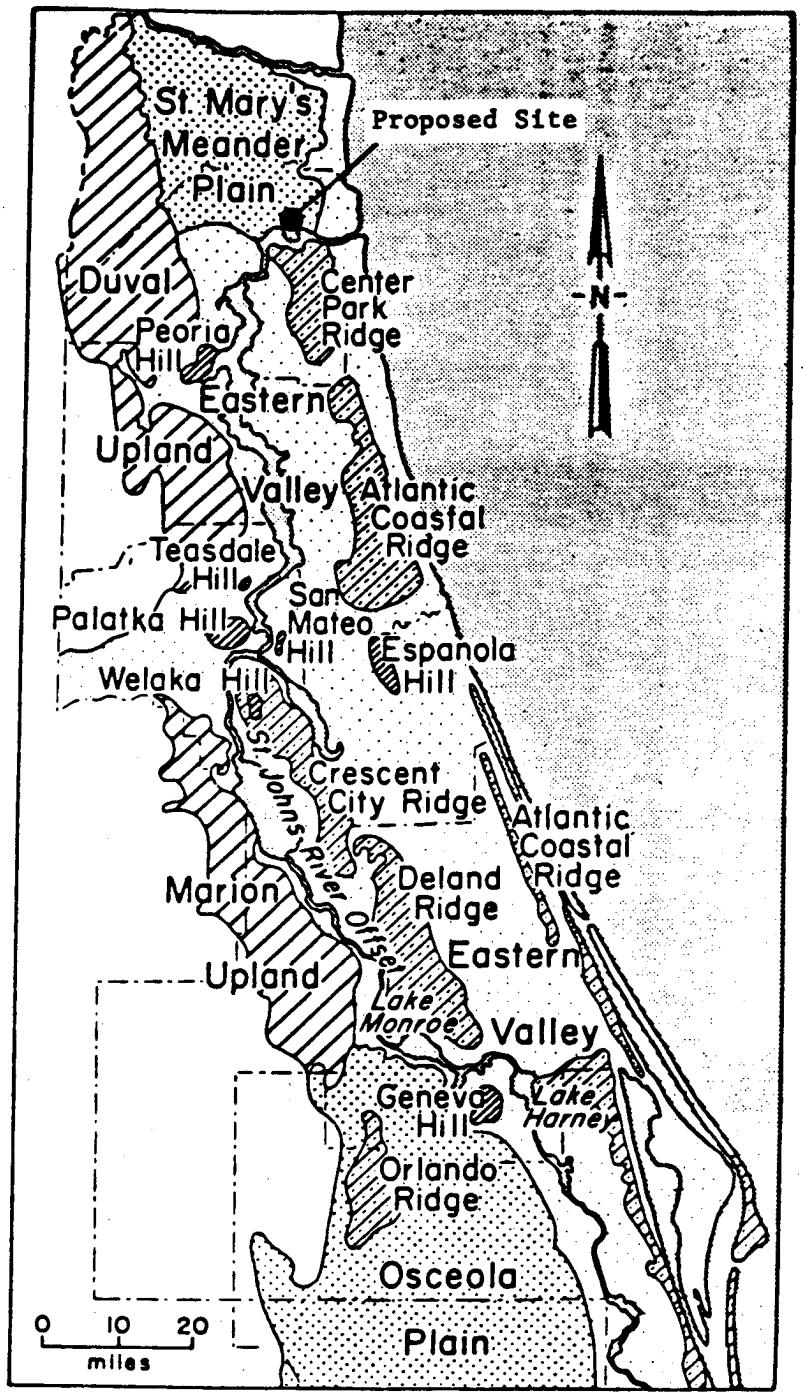


Figure E-2 Major Physiographic Features within the St. Johns Water Management District

Figure E-3 Pleistocene Marine Terraces

from Leve, 1966

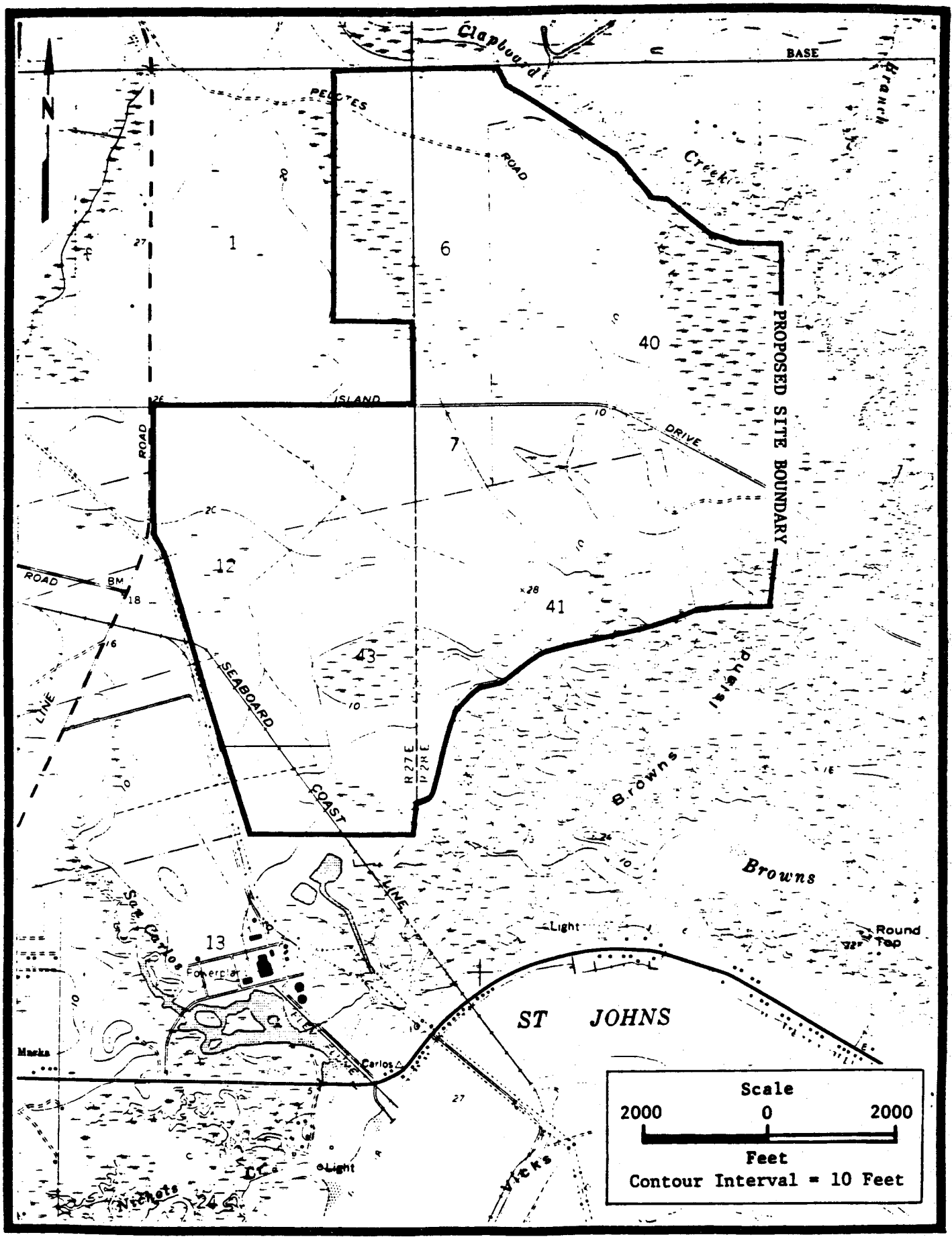


Figure E-4 Site Topographic Map

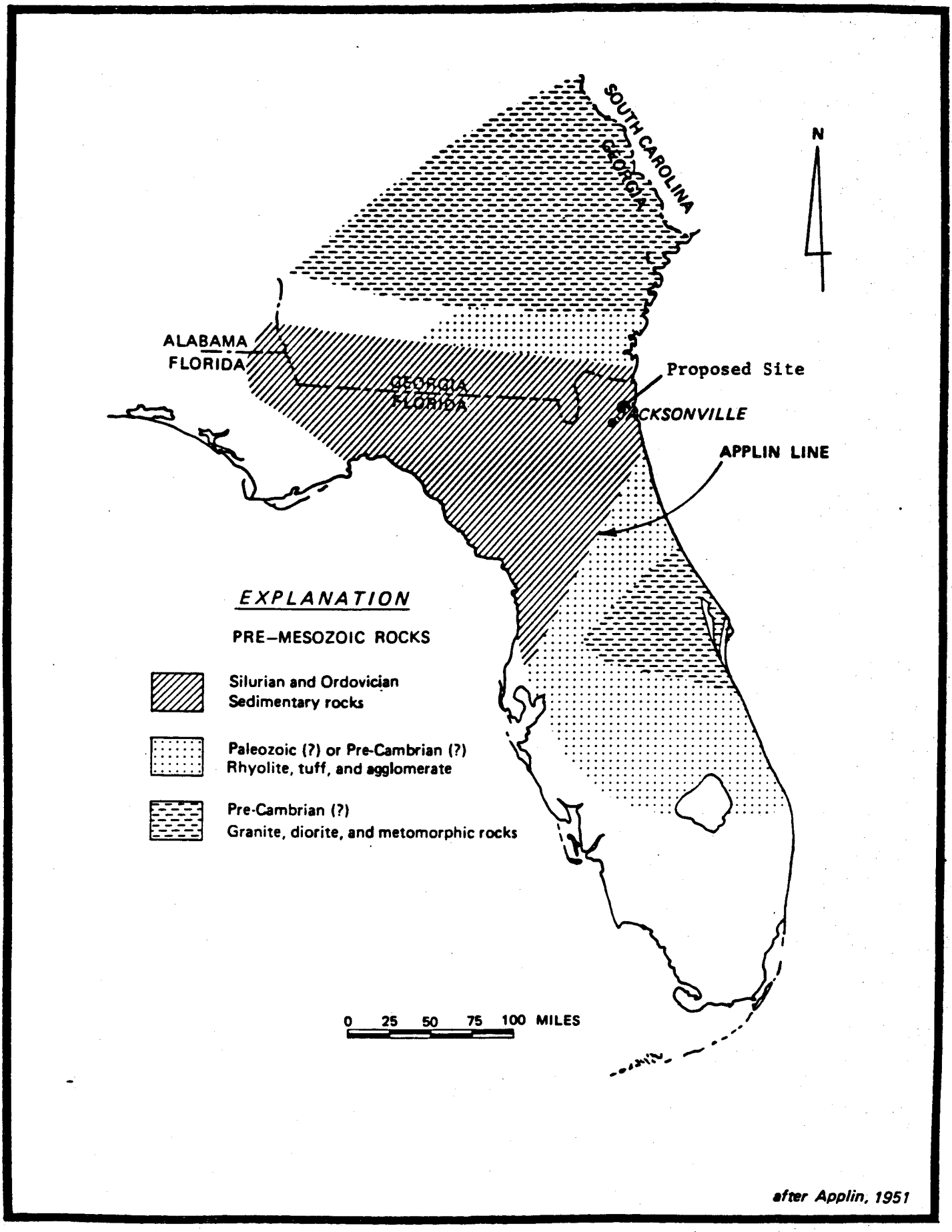
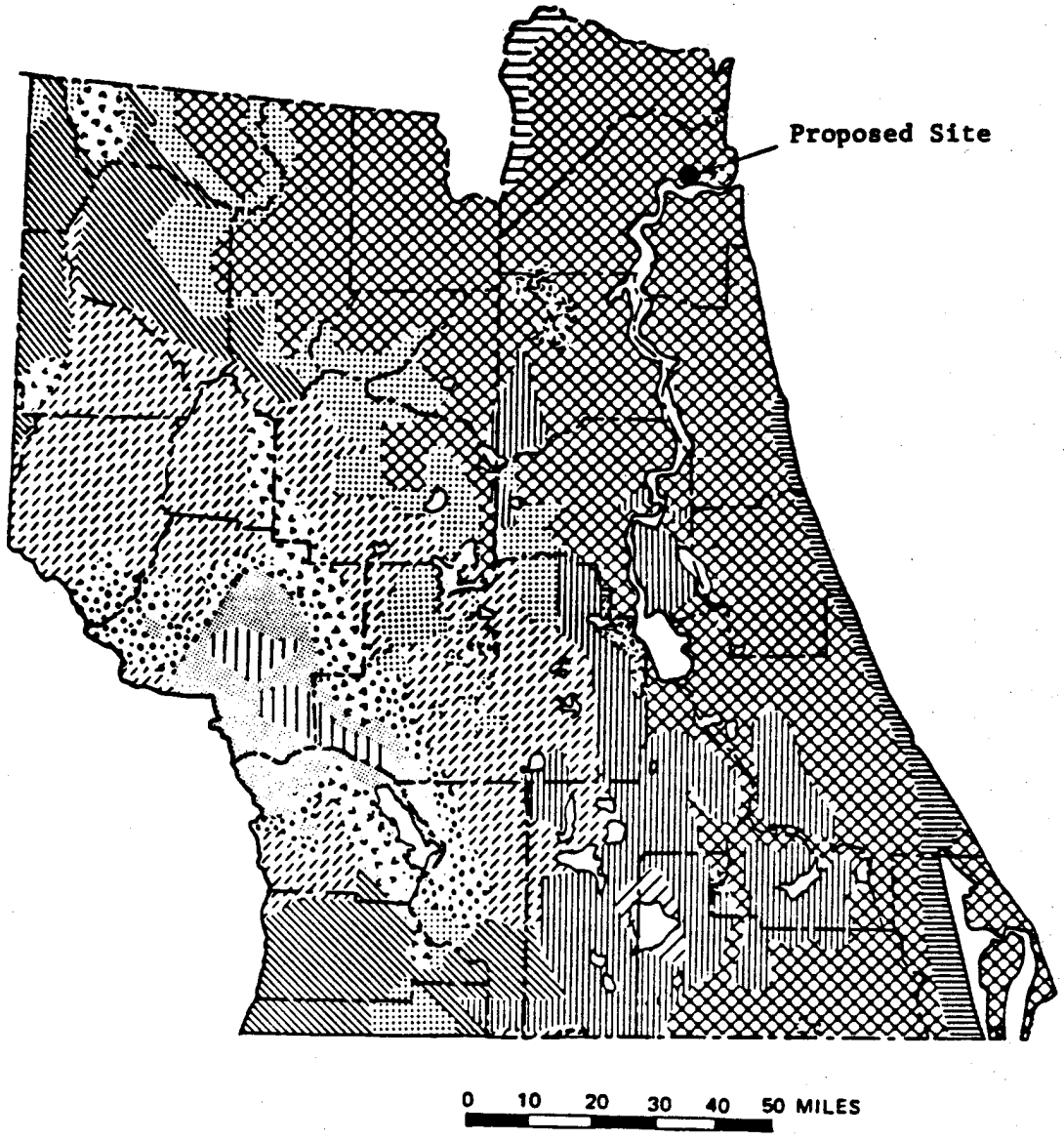


Figure E-5 Distribution of Pre-Mesozoic Rocks in Parts of Florida, Georgia, and Alabama



SERIES	STAGE	FORMATION & MEMBER
RECENT AND PLEISTOCENE		SEVERAL LOWER MARINE AND ESTUARINE TERRACE DEPOSITS
		LAKE FLIRT MARL
PLEISTOCENE		ANASTASIA FORMATION
		FORT THOMPSON FORMATION
MIOCENE	CHOCTA-WHATCHEE	"CHARLTON" FORMATION
		JACKSON BLUFF FORMATION
		ALACHUA FORMATION
		FORT PRESTON FORMATION
		HAWTHORN FORMATION
OLIGOCENE		SUWANNEE LIMESTONE
EOCENE	JACKSON	OCALA GROUP: CRYSTAL RIVER FM.
		OCALA GROUP: WILLISTON FM.
		OCALA GROUP: INGLIS FM.
	CLAIBORNE	AVON PARK LIMESTONE

after Vernon & Puri, 1964

Figure E-6 Generalized Regional Geologic Map

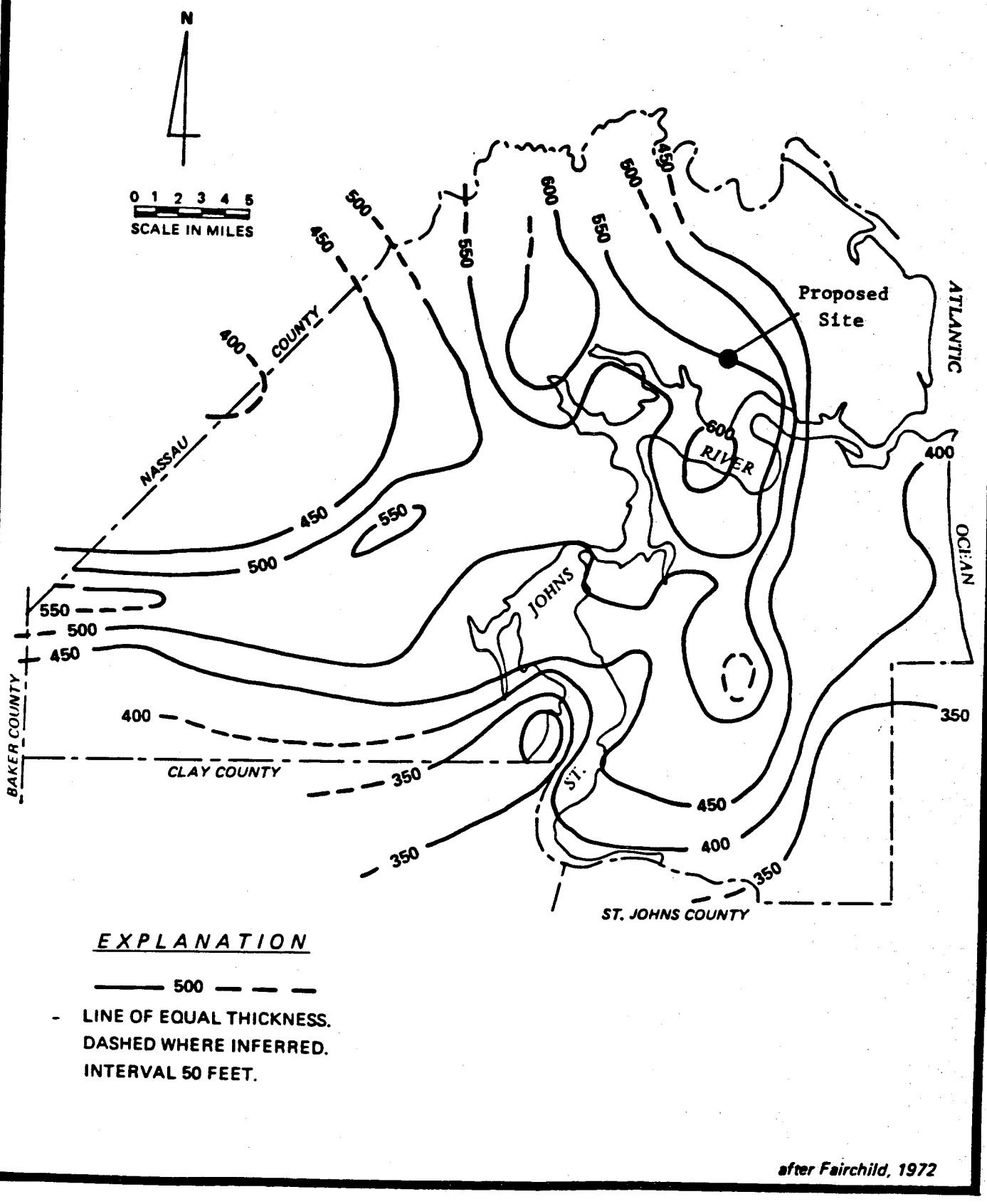
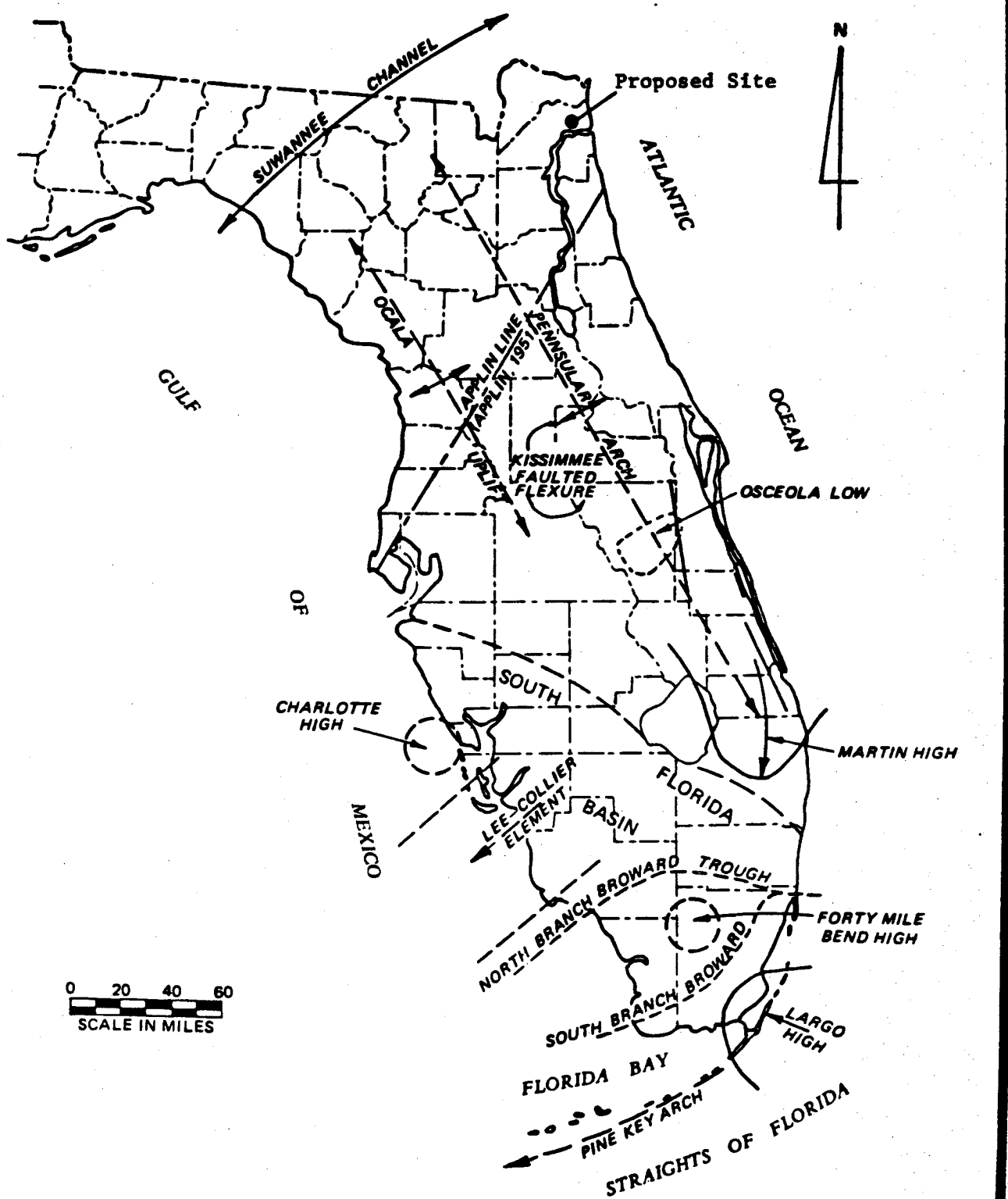


Figure E-7 Map of Duval County Showing the Thickness of the Sediments Overlying the Ocala Group



after Chen, 1965; Vernon, 1951; Vernon, 1970; Lichtler, 1960; Applin, 1951; Winston, 1971.

Figure E-8 Regional Structural Elements

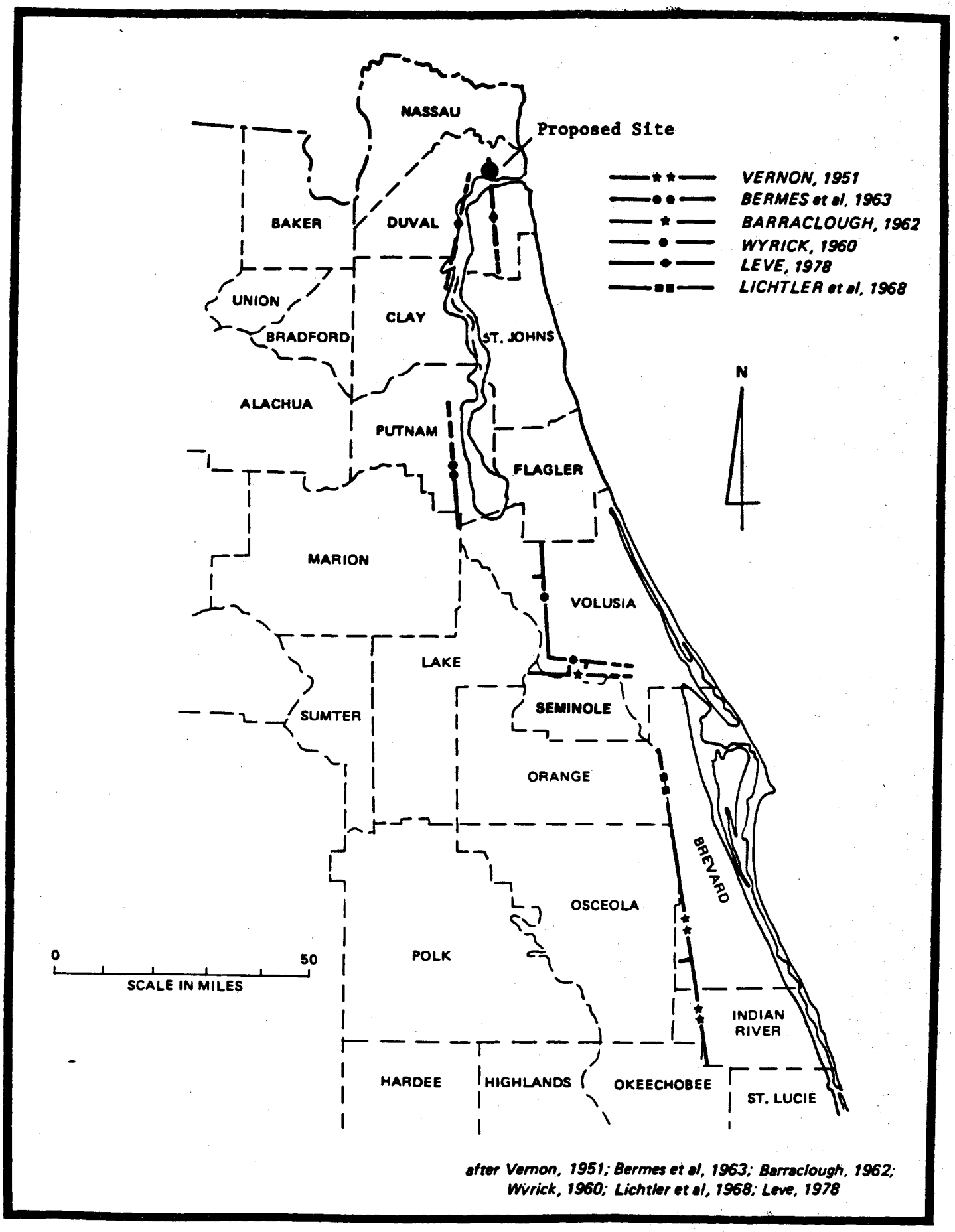


Figure E-9 Faults along the St. Johns River

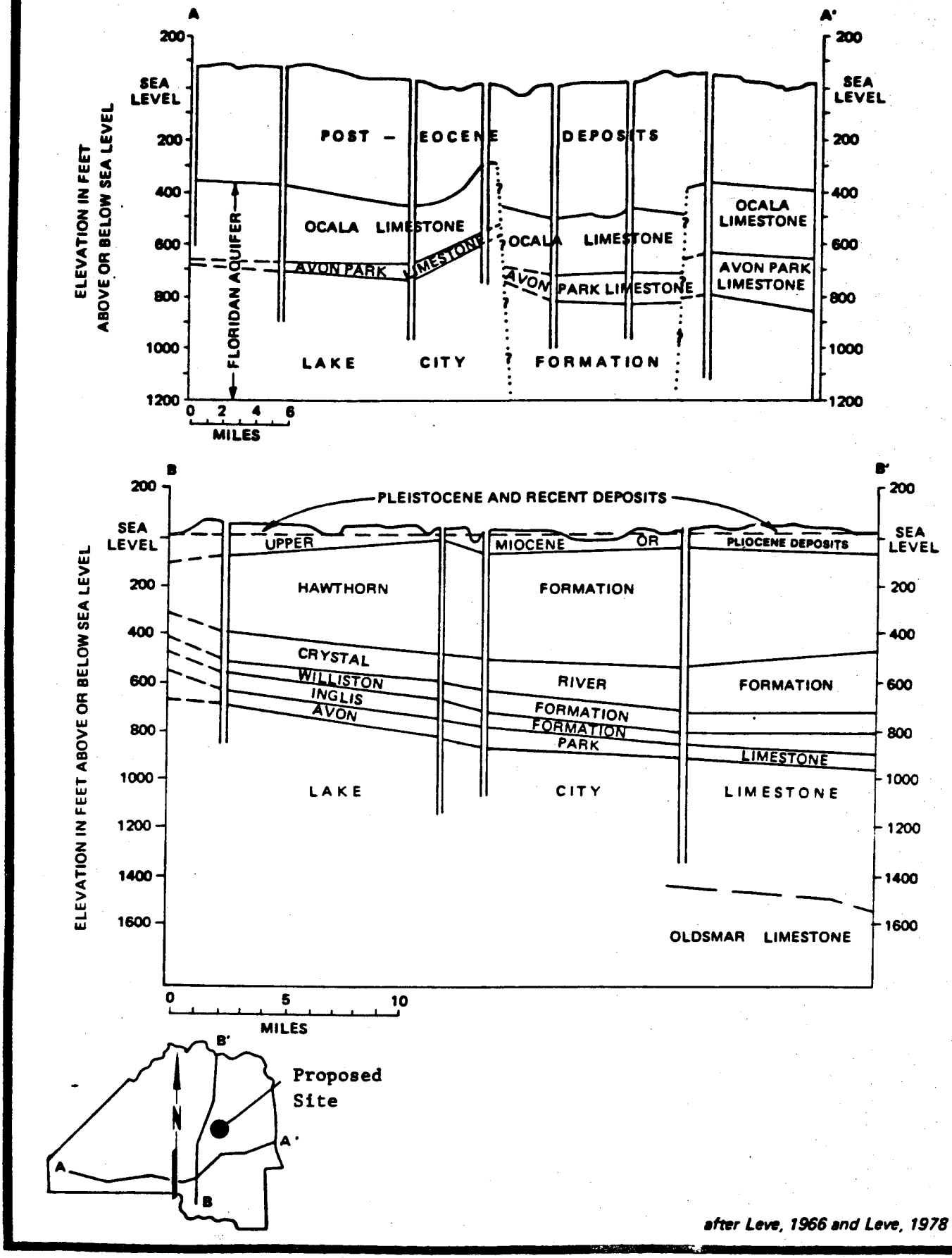


Figure E-10 Geologic Cross-Sections, Duval County

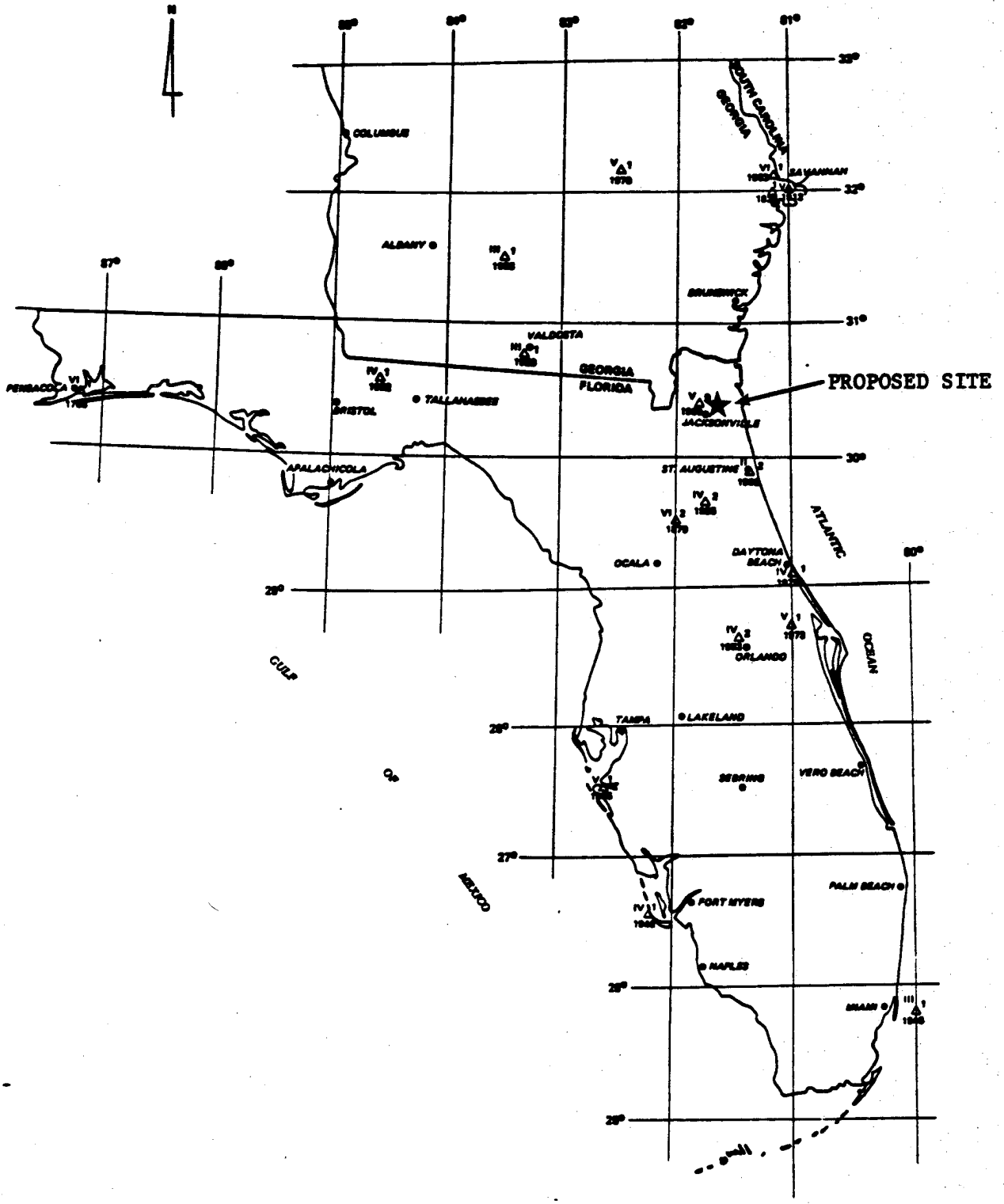


Figure E-11A Seismisity Map of Florida and South Georgia

INTRODUCTION

The earthquake data shown on this map and listed in table 1 are a list of earthquakes that were originally used in preparing the Seismic Risk Studies in the United States (Algermissen, 1969) which have been recompiled and updated through 1977. The data have been reexamined and intensities assigned where none had been assigned before, on the basis of available data. Other intensity values were updated from new and additional data sources that were not available at the time of original compilation. Some epicenters were relocated on the basis of new information. The data shown in table 1 are estimates of the most accurate hypocenter, magnitude, and intensity of each earthquake, on the basis of historical and current information. Known or suspected explosions are listed in table 1 but are not plotted on the seismicity map.

The data in table 1 were used to compile the seismicity map. The latitude and longitude were rounded to the nearest tenth of a degree and sorted so that all identical locations were grouped together and counted. A triangle represents the epicenter plotted to a tenth of a degree. The number of earthquakes at each location is shown on the map by the number to the right of the triangle. A Roman numeral to the left of a triangle is the maximum Modified Mercalli intensity (Wood and Neumann, 1931) of all earthquakes located at that geographic position. The absence of an intensity value indicates that no intensities have been assigned to earthquakes at that location. A year shown below a triangle is the latest year for which the maximum intensity was recorded.

EXPLANATION OF THE TABLES

The data are listed chronologically in table 1 in the following categories: date, origin time, N. latitude, W. longitude, depth, hypocenter quality and referenced data sources, magnitude, and intensity (Modified Mercalli) and intensity source references. Table 1 has some basic limitations in terms of the size (magnitude or intensity) of the earthquakes listed. Prior to 1965 all recorded felt earthquakes are listed, after 1965 only published earthquakes having magnitudes above the 2.5-3.0 range are listed; the lower magnitude levels apply mostly to the eastern United States. The low magnitude events located in recent years with dense seismograph networks have not been included.

Listed below is an explanation of the symbols and codes used in the tables:

1. Leaders (..) indicate information not available.
2. Latitude and longitude are listed to a hundredth of a degree if they have been published with that degree of accuracy, or greater; however, most historical events have been published only to the nearest degree or tenth of a degree and are therefore listed at this accuracy in table 1. An asterisk (*) to the right of the longitude indicates that the latitude and longitude were not given in the source reference, but were assigned by the compilers of the data file. An (x) to the right of the longitude indicates that the event is an explosion, a suspected explosion, or a nontectonic event; these have not been plotted on the map.
3. The letter code in the HYPOCENTER, QUAL column is defined below:
   a. Determination of instrumental hypocenters are estimated to be accurate within the ranges of latitude and longitude listed below; each range is letter coded as indicated:

      A 0.0°-0.1°
      B 0.1°-0.2°
      C 0.2°-0.5°
      D 0.5°-1.0°
      E 1.0° or larger

   b. Determination of noninstrumental epicenters from felt data are estimated to be accurate within the ranges of latitude and longitude listed below; each range is letter coded as indicated:

      F 0.0°-0.5°
      G 0.5°-1.0°
      H 1.0°-2.0°
      I 2.0° or larger

4. The reference identification numbers in the HYPOCENTER, REF and INTENSITY, REF columns indicate the sources of the hypocenter and intensity. They are listed in numerical order in table 2.
5. The magnitudes listed under "USGS" are mb values (Gutenberg and Richter, 1956) published in the Preliminary Determination of Epicenters (PDE) by the National Earthquake Information Service, U. S. Geological Survey and predecessor organizations. Associated with the magnitude values listed under "OTHER" are the source code and type. Type is defined by 1 = ML (Richter, 1958), 2 = mbLg (Nuttli, 1973), and 3 = MS (Bath, 1966). The source codes are listed below:
   BLA - Virginia Polytechnic Institute and State University, Blacksburg, Va.
   SLM - St, Mo. Louis University, St. Louis, Missouri.
6. An asterisk (*) in the INTENSITY, MM column indicates that the intensity was assigned by the compiler on the basis of the available data at the time the catalog was compiled.

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from Stover et al, 1979a and Stover et al, 1979b

Figure E-11B Explanation, Seismicity Map

CHRONOLOGICAL LISTING OF EARTHQUAKES FOR THE STATE OF FLORIDA

DATE			ORIGIN TIME(UTC)			LAT.	LONG.		DEPTH	HYPOCENTER		MAGNITUDE			INTENSITY	
YEAR	MONTH	DAY	H	M	S	(N.)	(W.)		(KM)	QUAL	REF	USGS	OTHER		MM	REF
1780	FEB	06	..	..	..	30.4	87.2	*	..	G	101	..	..	..	VI*	..
1879	JAN	13	04	45	..	29.5	82.0		..	H	38	..	..	..	VI	38
1879	JAN	13	04	55	..	29.5	82.0		..	H	38	..	..	..	...	..
1886	JAN	08	18	34	..	30.4	81.7		..	H	103	..	..	..	...	..
1886	SEP	01	..	..	..	30.4	81.7	*	..	H	69	..	..	..	IV	69
1886	SEP	03	21	..	..	30.4	81.7	*	..	H	84	..	..	..	IV	69
1886	SEP	04	09	..	..	30.4	81.7		..	H	103	..	..	..	IV	69
1886	SEP	05	..	..	..	30.4	81.7	*	..	H	69	..	..	..	IV	69
1886	SEP	08	..	..	..	30.4	81.7	*	..	H	69	..	..	..	IV	69
1886	SEP	09	18	47	..	30.4	81.7		..	H	103	..	..	..	IV	69
1893	JUN	21	07	07	..	30.4	81.7	*	..	H	84	..	..	..	IV	69
1900	OCT	10	..	..	..	30.3	81.7	x	..	H	84	..	..	..	V	84
1900	OCT	10	..	..	..	30.3	81.7	x	..	H	84	..	..	..	III*	..
1900	OCT	10	..	..	..	30.3	81.7	x	..	H	84	..	..	..	III*	..
1900	OCT	10	..	..	..	30.3	81.7	x	..	H	84	..	..	..	III*	..
1900	OCT	10	..	..	..	30.3	81.7	x	..	H	84	..	..	..	III*	..
1900	OCT	10	..	..	..	30.3	81.7	x	..	H	84	..	..	..	III*	..
1900	OCT	10	..	..	..	30.3	81.7	x	..	H	84	..	..	..	III*	..
1900	OCT	31	16	15	..	30.4	81.7		..	H	38	..	..	..	V	38
1902	MAY	21	..	..	..	29.9	81.3	*	..	H	84	..	..	..	...	..
1902	MAY	21	00	..	..	29.9	81.3	*	..	H	84	..	..	..	II	84
1905	SEP	04	09	..	..	27.5	82.6	*	..	H	84	..	..	..	III	84
1930	JUL	19	18	53	..	25.8	81.4	x	..	H	03	..	..	..	V	103
1935	NOV	14	03	10	..	29.6	81.7	*	..	H	69	..	..	..	IV	69
1935	NOV	14	03	30	..	29.6	81.7	*	..	H	69	..	..	..	IV	69
1940	DEC	27	01	..	..	28.0	82.5	x	..	H	13	..	..	..	...	..
1942	JAN	19	19	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1942	JAN	19	..	..	..	26.5	81.0	x	..	I	69	..	..	..	IV*	..
1945	DEC	22	16	25	..	25.8	80.0	*	..	H	18	..	..	..	III*	..
1948	NOV	08	17	44	..	26.5	82.2	*	..	H	21	..	..	..	IV*	..
1952	NOV	18	20	12	..	30.6	84.6		..	H	103	..	..	..	IV	25
1953	MAR	26	..	..	..	28.6	81.4		..	H	103	..	..	..	IV*	..
1953	MAR	26	..	..	..	28.6	81.4		..	H	103	..	..	..	IV*	..
1973	OCT	27	06	21	07.5	28.7	81.0		..	F	46	..	..	..	V	46
1973	DEC	05	11	30	..	30.5	86.5	x	..	I	46	..	..	..	III*	..
1975	DEC	04	11	57	..	29.2	81.0	*	..	I	48	..	2.9	BLA 2	IV	48

LIST OF DATA SOURCES, FLORIDA EARTHQUAKES

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46. Coffman, J. L., von Hake, C. A., Spence, W., Carver, D. L., Covington, P. A., Dunphy, C. J., Irby, W. L., Person, W. J., and Stover, C. W., 1975, United States Earthquakes 1973, U. S. Department of Commerce, National Oceanic and Atmospheric Administration and U. S. Department of Interior, Geological Survey, p. 1-112.
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69. Campbell, R. B., 1963, Earthquakes in Florida, Florida Academy of Science Proceedings, v. 6, no. 1, p. 1-4.
84. Woollard, G. P., 1968, A catalogue of earthquakes in the United States prior to 1925, based on unpublished data compiled by Harry Fielding Reid and published sources prior to 1930, Hawaii Institute of Geophysics, University of Hawaii, Data Report No. 10.
101. Campbell, R. L., 1975, Historical sketches of colonial Florida, a facsimile reproduction of the 1892 edition, A University of Florida Book, The University Press of Florida, Gainsville, p. 110.
103. McClain, R. C. and Meyers, O. H., 1970, Seismic history and seismicity of the southeastern region of the United States, Oak Ridge National Laboratory, Oak Ridge, Tenn., Union Carbide Corp., for the U. S. Atomic Energy Commission, p. 1-43.

CHRONOLOGICAL LISTING OF EARTHQUAKES FOR THE STATE OF GEORGIA

DATE			ORIGIN TIME(UTC)			LAT.	LONG.		DEPTH	HYPOCENTER		MAGNITUDE			INTENSITY	
YEAR	MONTH	DAY	H	M	S	(N.)	(W.)		(KM)	QUAL	REF	USGS	OTHER		MM	REF
1826	OCT	15	..	..	..	32.0	81.1	*	..	H	84	..	..	..	...	..
1903	JAN	24	01	15	..	32.1	81.1		..	G	38	..	..	..	VI	38
1912	JUN	20	..	..	..	32.0	81.0		..	H	38	..	..	..	V	38
1928	MAY	23	10	15	..	30.8	83.3		..	H	01	..	..	..	III*	..
1958	APR	08	17	..	..	31.5	83.5		..	H	29	..	..	..	III*	..
1976	DEC	27	06	57	13.9	32.22	82.46		005	A	95	..	3.7	BLA 2	V	95

LIST OF DATA SOURCES, GEORGIA EARTHQUAKES

38. Coffman, J. L. and von Hake, C. A., 1973, Earthquake History of the United States, U. S. Department of Commerce, National Oceanic and Atmospheric Administration, No. 41-1 (through 1970), p. 1-208.
95. Minsch, J. H., Stover, C. W., Person, W. J. and Simon, R. B., 1978, Earthquakes in the United States, October-December 1976, U. S. Department of Interior, Geological Survey Circular 766-D, p. 1-38.

from Stover et al, 1979a and Stover et al, 1979b

Figure E-11B Continued Explanation, Seismicity Map

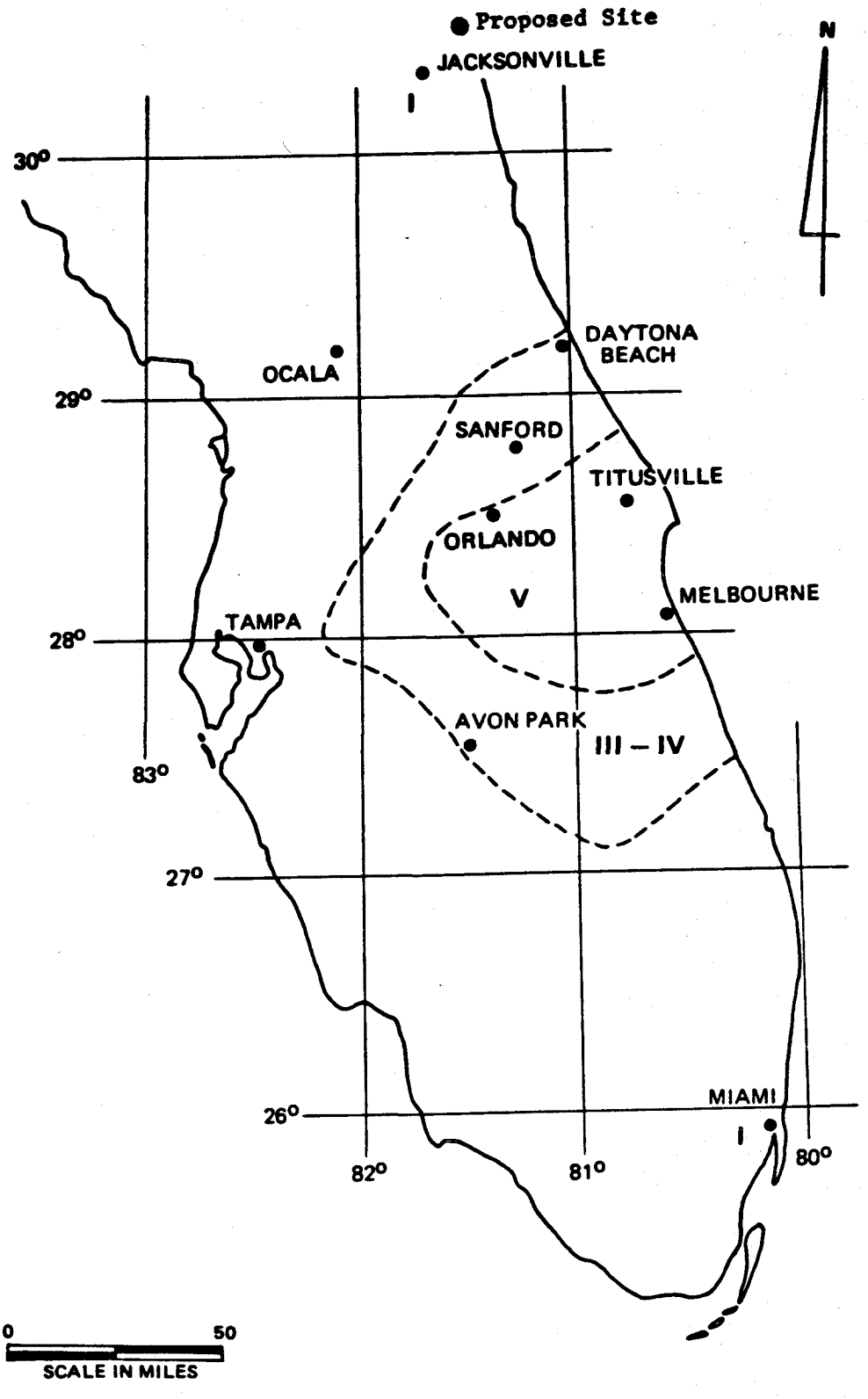
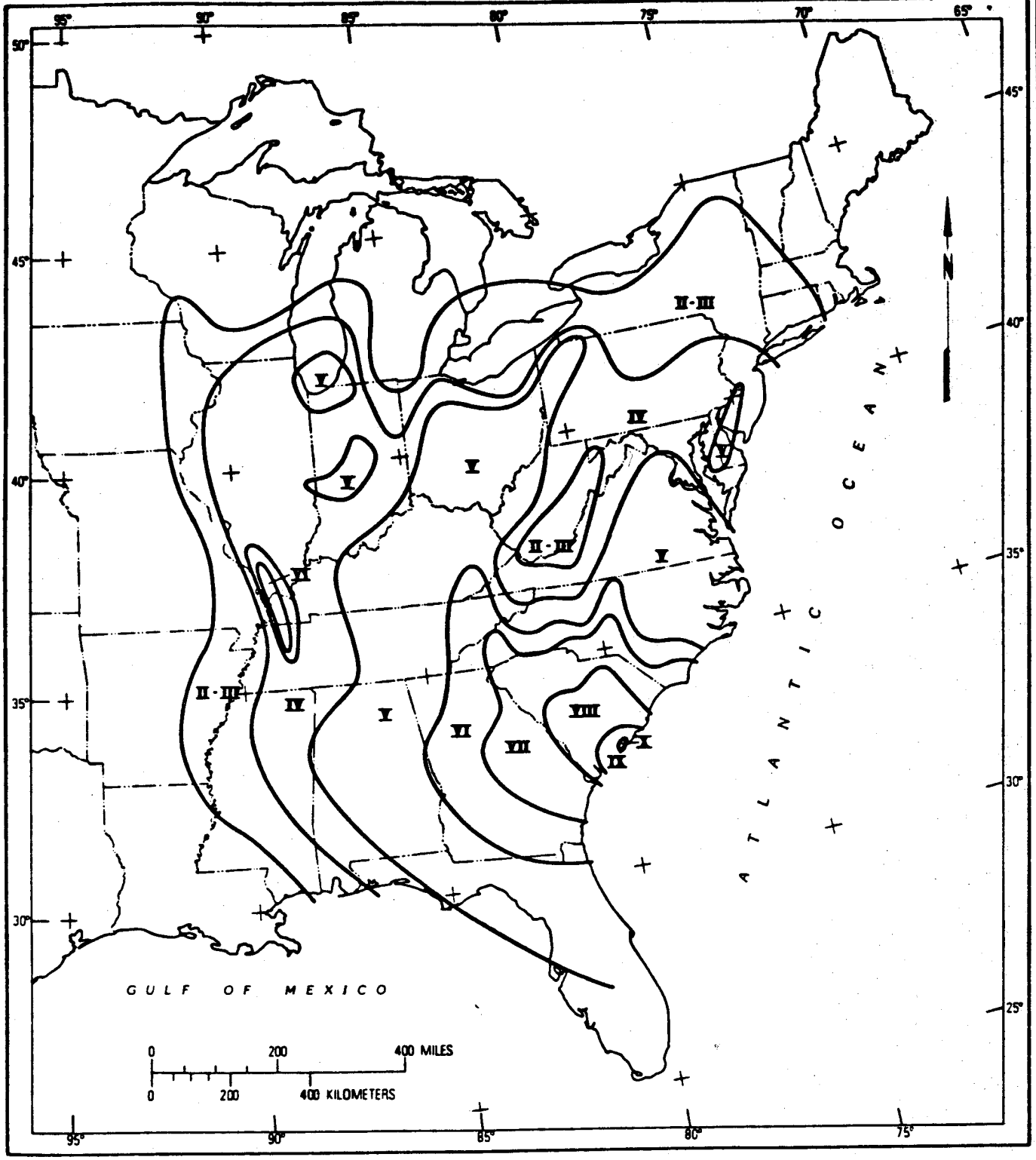
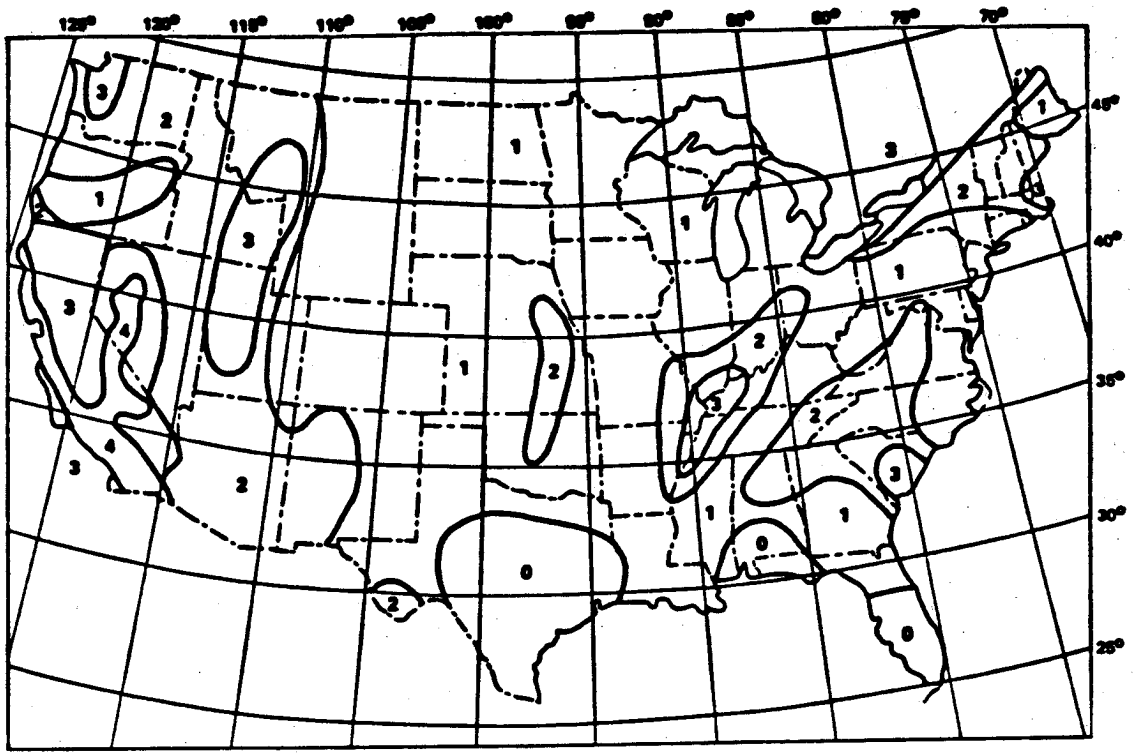


Figure E-12 Modified Mercalli Isoseismal Map of the Florida Earthquake, October 27,1973



from Bollinger in Rankin, 1977

Figure E-13 Modified Mercalli Isoseismal Map of Charleston, S.C. Earthquake, August 31, 1886



ZONE 0 No damage.

ZONE 1 Minor damage; distant earthquakes may cause damage to structures with fundamental periods greater than 1.0 second; corresponds to intensities V and VI of the M.M. Scale.

ZONE 2 Moderate damage; corresponds to intensity VII of the M.M. Scale.

ZONE 3 Major damage; corresponds to intensity VIII and higher of the M.M. Scale.

ZONE 4 Those areas within Zone No. 3 determined by the proximity to certain major fault systems.

Modified Mercalli Intensity Scale of 1931

after Algermissen, 1969

Figure E-14 Seismic Risk Map

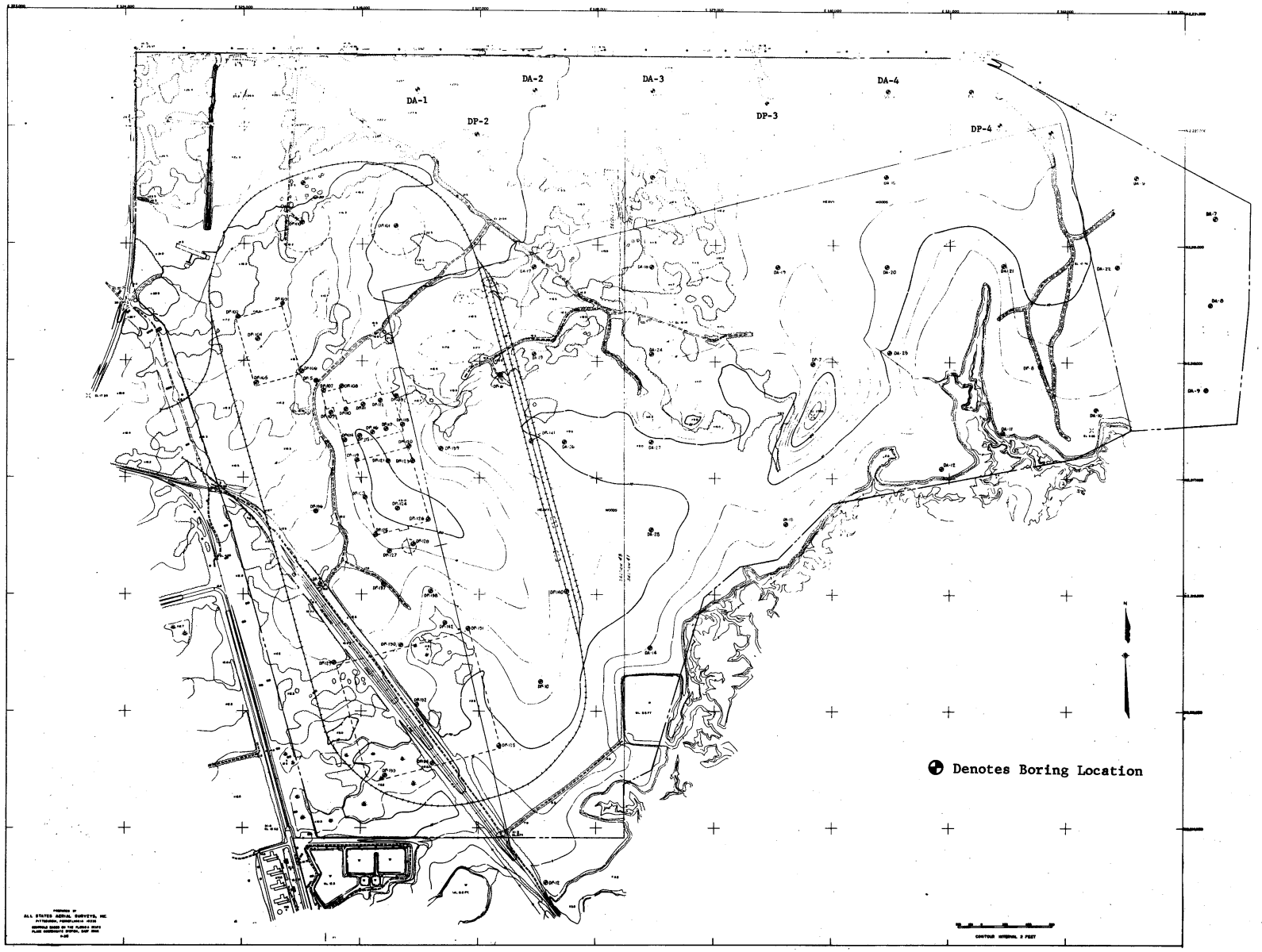


Figure E-15A Boring Map, Southern Portion of Proposed Site

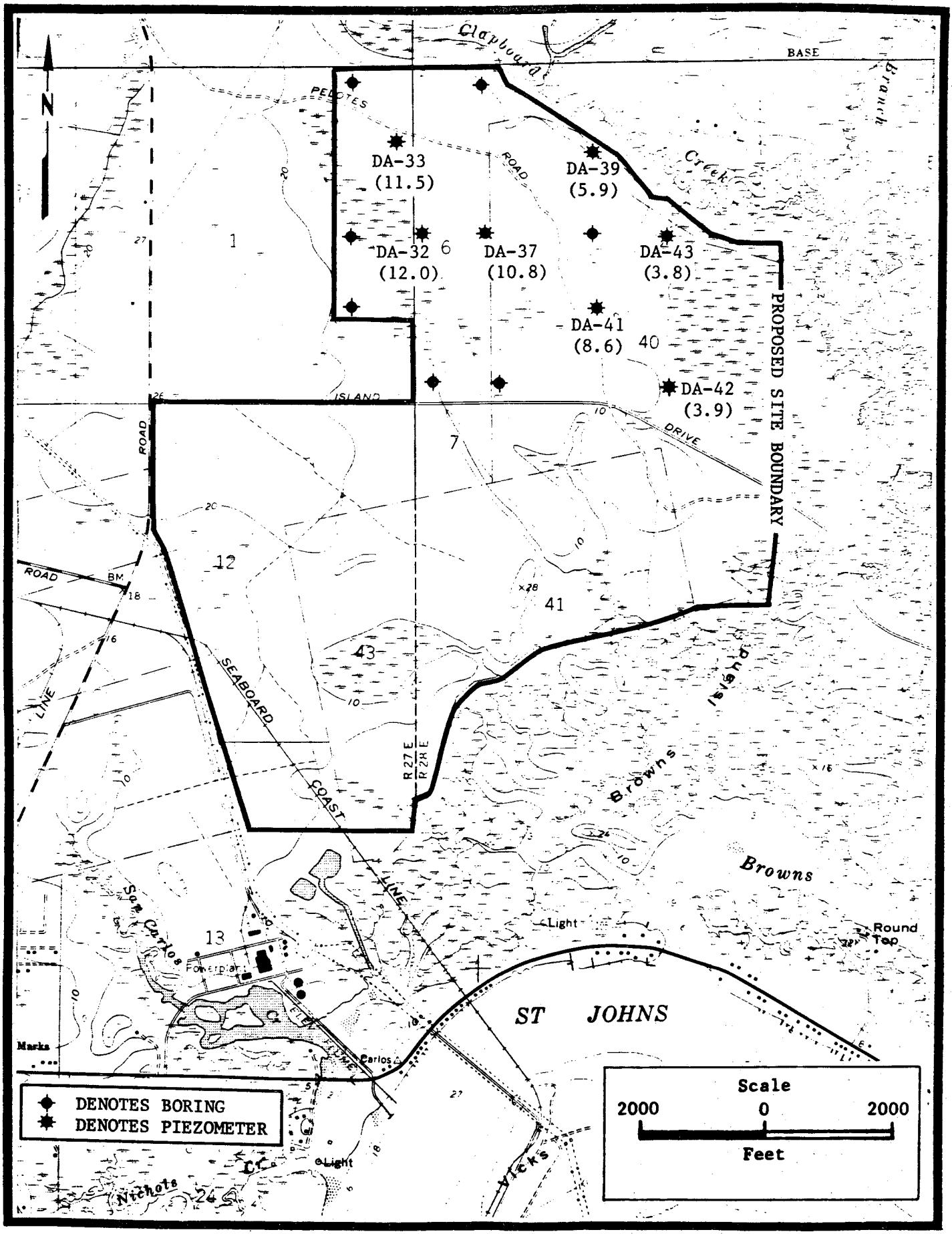


Figure E-15B Boring Map-Northern Portion of Proposed Site

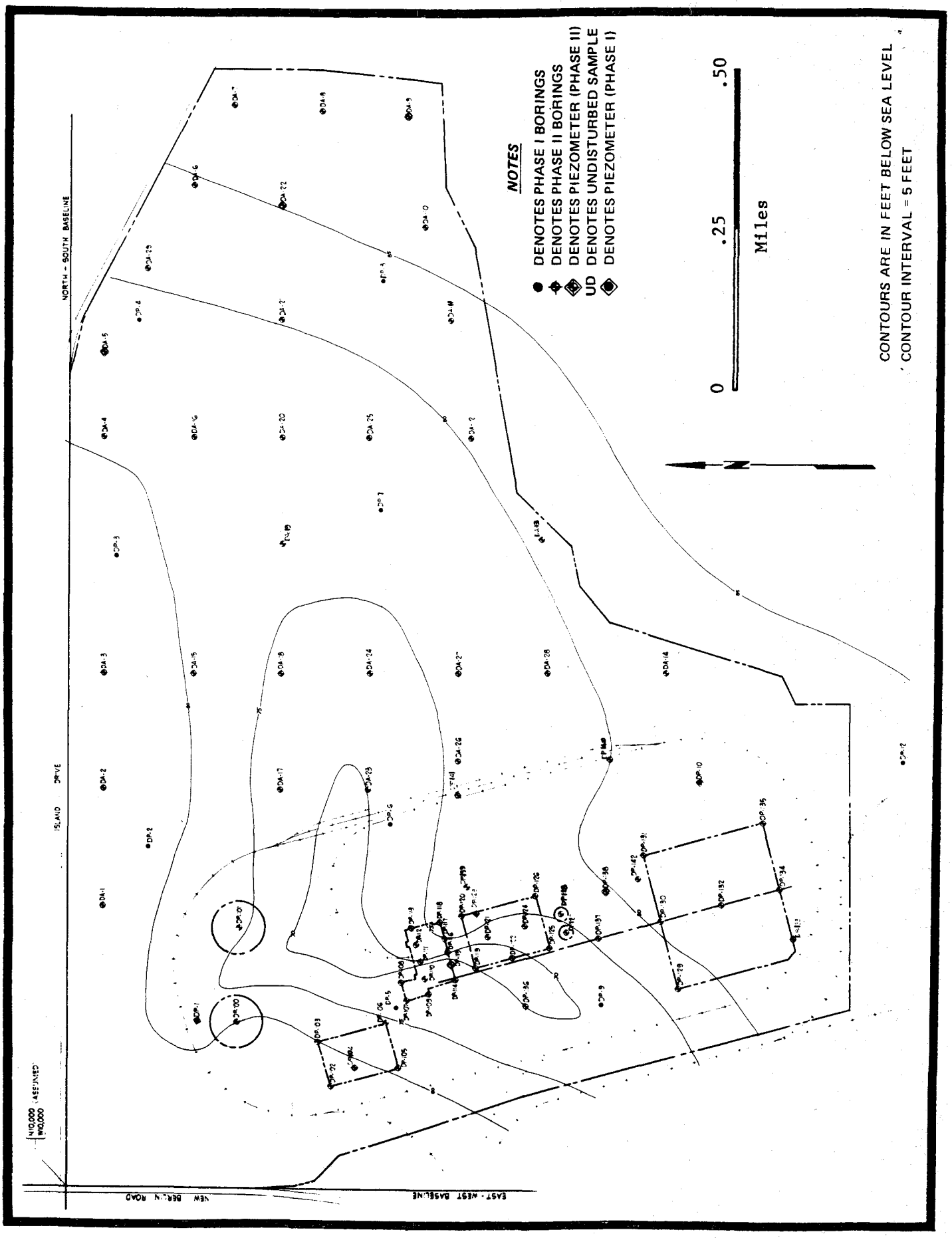
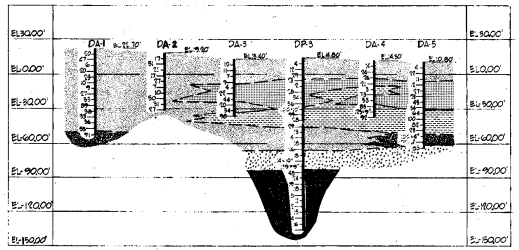
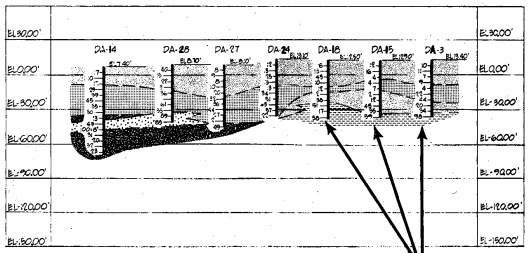


Figure E-16 Proposed Site Contour Map of Top of Hawthorn Formation

SK-3332-C-9



SECTION-F



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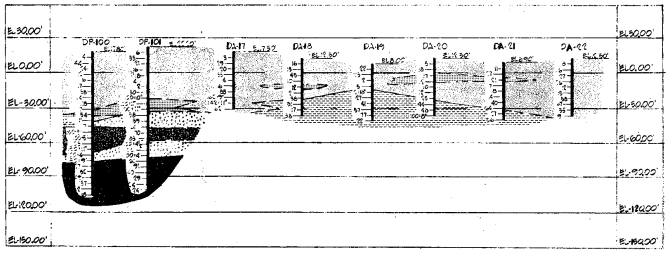
Blow counts



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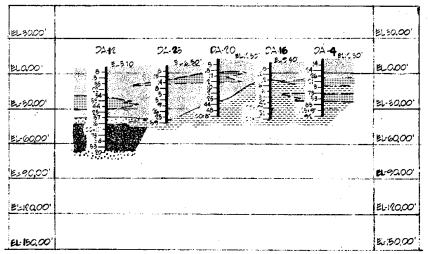

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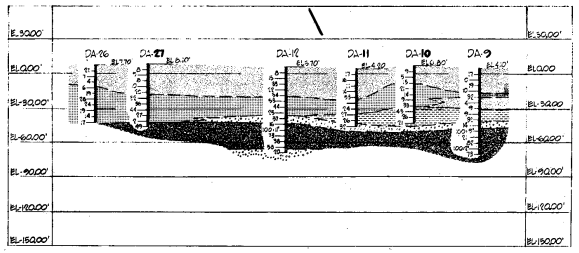

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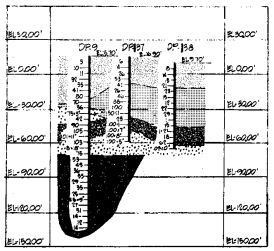

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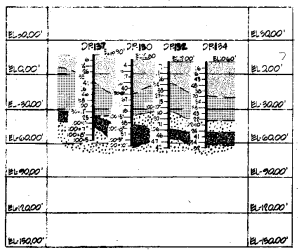

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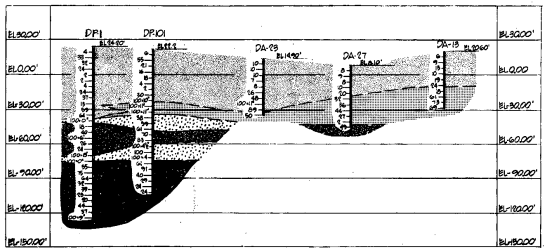

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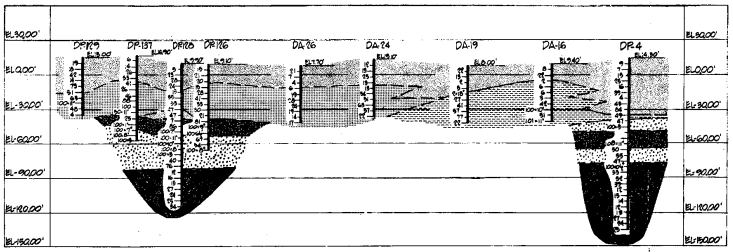


SECTION-N

KEY

- Very fine to fine sand, trace silt, trace seams silty clay, yellow, tan or gray-tan
- Fine to medium sand, trace coarse sand trace blue-gray silty clay seams, gray
- Slightly to partially cemented fine sand, some to trace silt, light gray
- Fine to medium sand, some to trace shell, dark gray with trace dark blue-gray silty clay seams
- Limestone, cemented fine sand and shell, or fine sand with some to trace shell, gray to tan
- Very fine to fine sand, silt and clay in varying percentages, trace to some phosphate sand and gravel, light to medium green-gray; Hawthorn Formation

NOTES

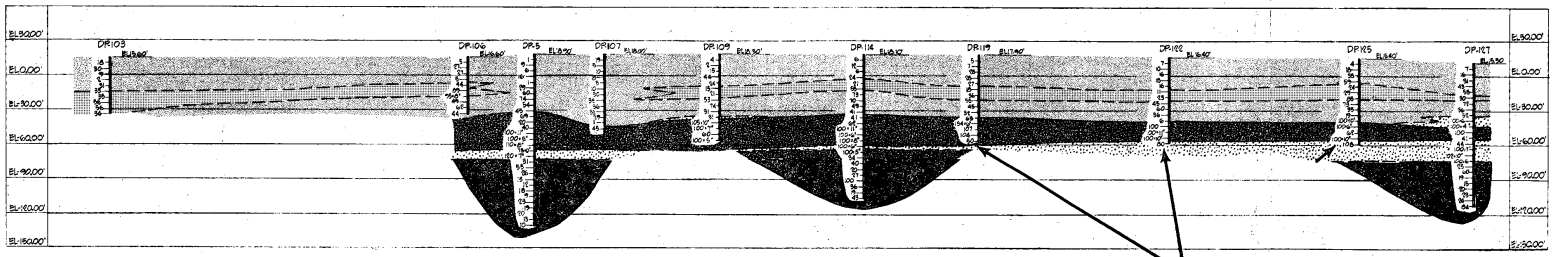
Dashed line indicates inferred or gradational contacts

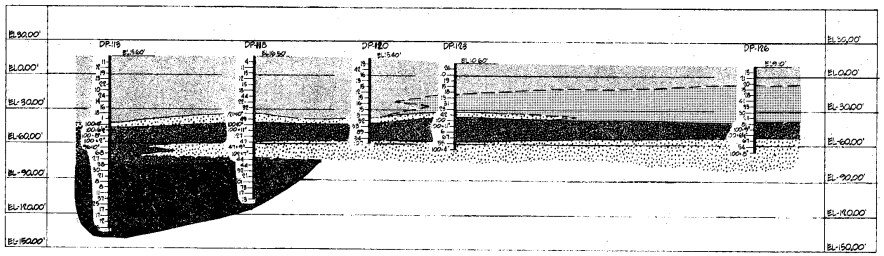
Vertical exageration = 17:1

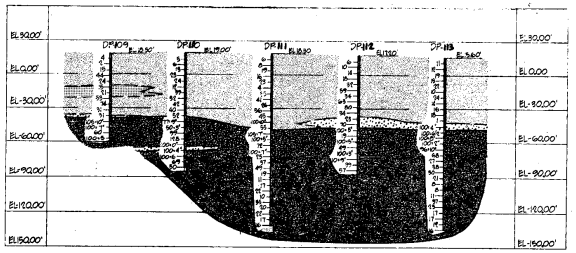
Boring locations shown on Figure E-15A

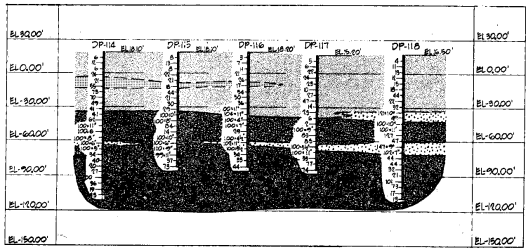
Figure E-17 Proposed Site Soil Boring Profiles Plant Area

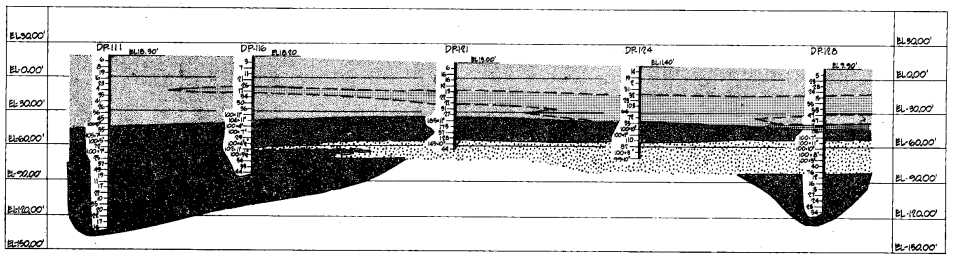
SK-3332-C-8











KEY

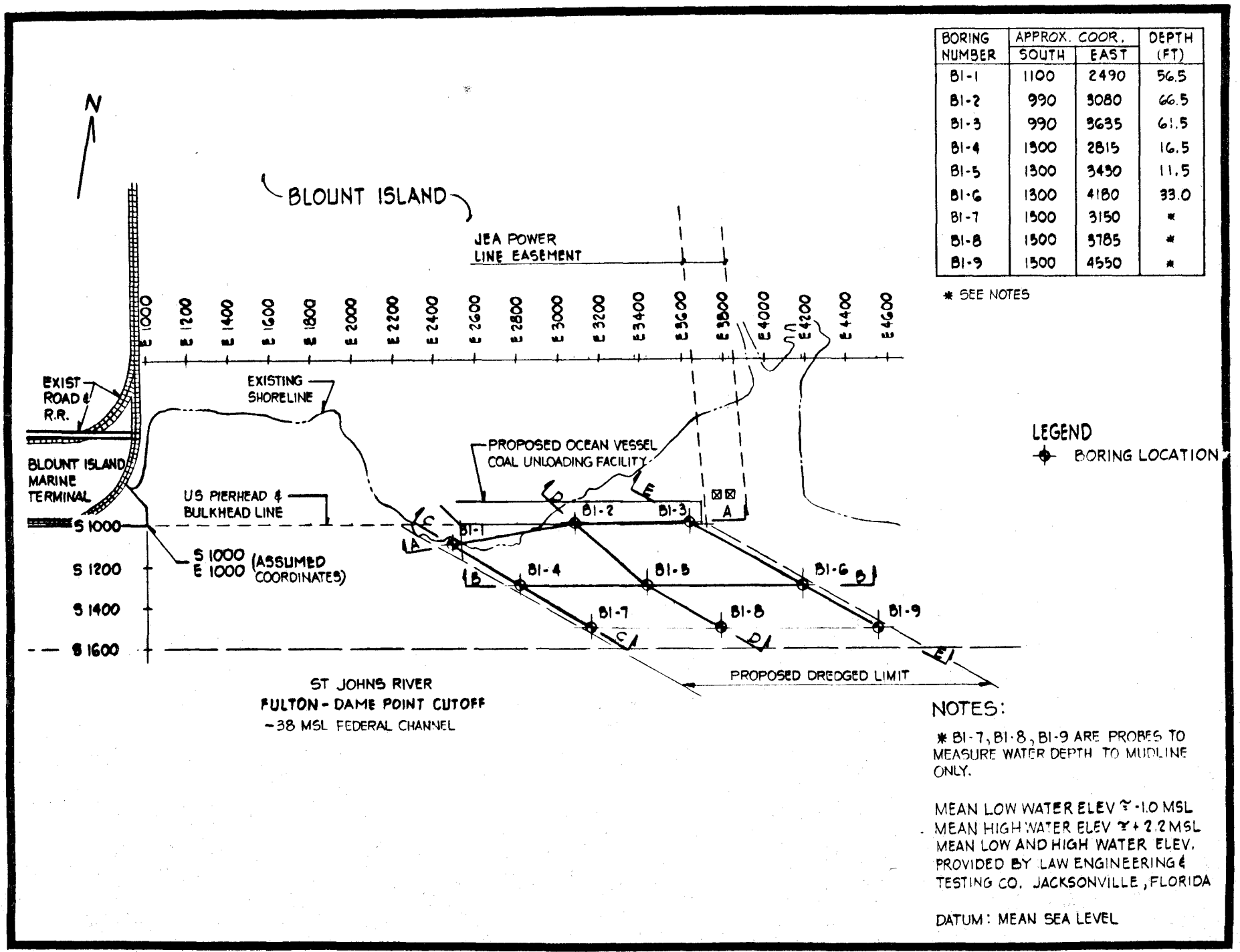
- Very fine to fine sand, trace silt, trace seams silty clay, yellow, tan or gray-tan
- Fine to medium sand, trace coarse sand trace blue-gray silty clay seams, gray
- Slightly to partially cemented fine sand, some to trace silt, light gray
- Limestone, cemented fine sand and shell, or fine sand with some to trace shell, gray to tan
- Very fine to fine sand, silt and clay in varying percentages, trace to some phosphate sand and gravel, light to medium green-gray; Hawthorn Formation

NOTES

Dashed line indicates inferred or gradational contacts

Vertical exegeration = 2:1

Figure E-18 Proposed Site Soil Boring Profiles Plant and Ash Disposal Areas



BORING NUMBER	APPROX. COOR. SOUTH	APPROX. COOR. EAST	DEPTH (FT)
BI-1	1100	2490	56.5
BI-2	990	3080	66.5
BI-3	990	3635	61.5
BI-4	1300	2815	16.5
BI-5	1300	3490	11.5
BI-6	1300	4180	33.0
BI-7	1500	3150	*
BI-8	1500	3785	*
BI-9	1500	4550	*

* SEE NOTES

LEGEND

⊕ BORING LOCATION

NOTES:

* BI-7, BI-8, BI-9 ARE PROBES TO MEASURE WATER DEPTH TO MUDLINE ONLY.

MEAN LOW WATER ELEV ≅ -1.0 MSL
MEAN HIGH WATER ELEV ≅ +2.2 MSL
MEAN LOW AND HIGH WATER ELEV. PROVIDED BY LAW ENGINEERING & TESTING CO. JACKSONVILLE, FLORIDA

DATUM: MEAN SEA LEVEL

Figure E-19 Coal Unloading Facility Boring Locations

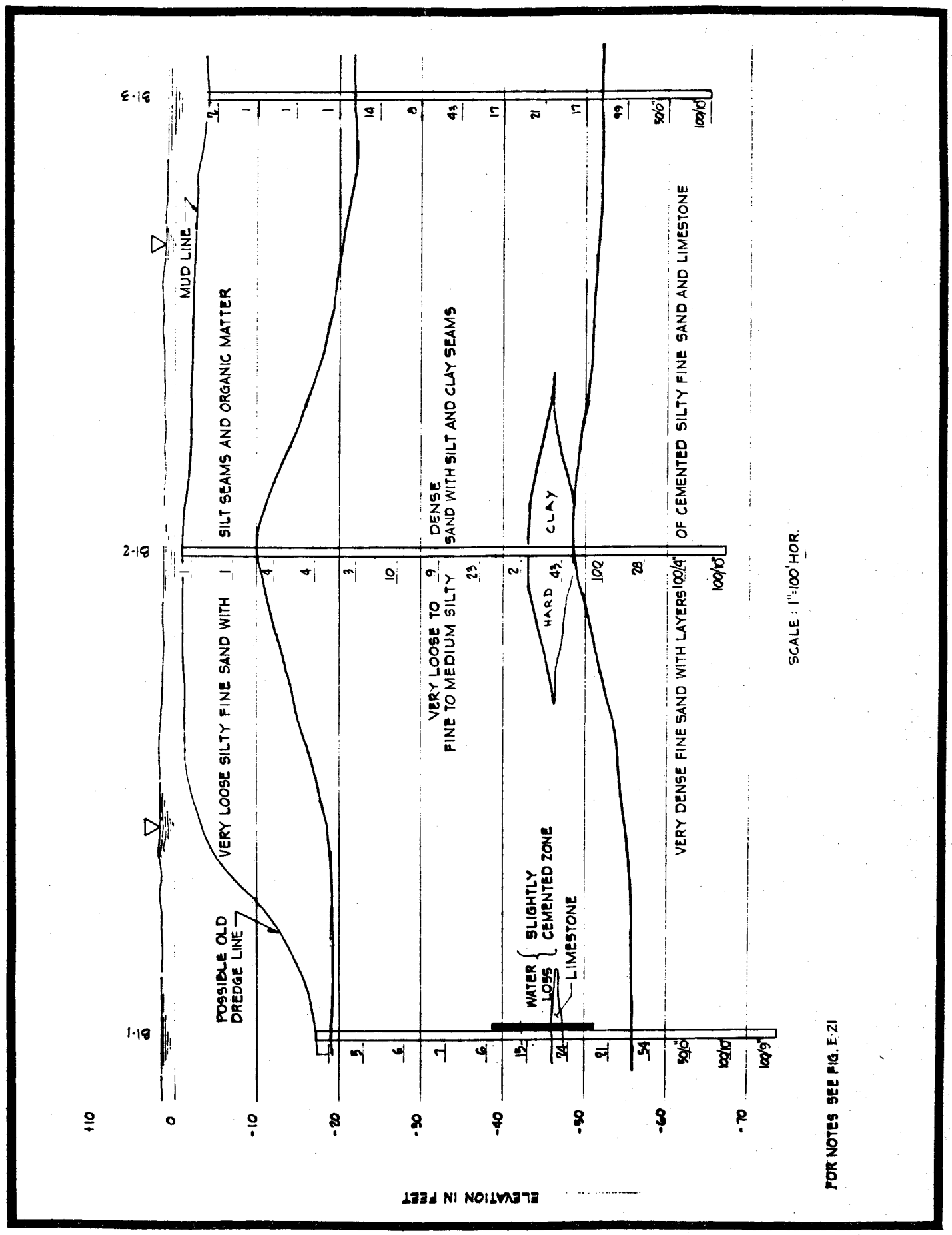


Figure E-20 Subsurface Profile - Section A-A

Figure E-21 Subsurface Profile - Section B-B

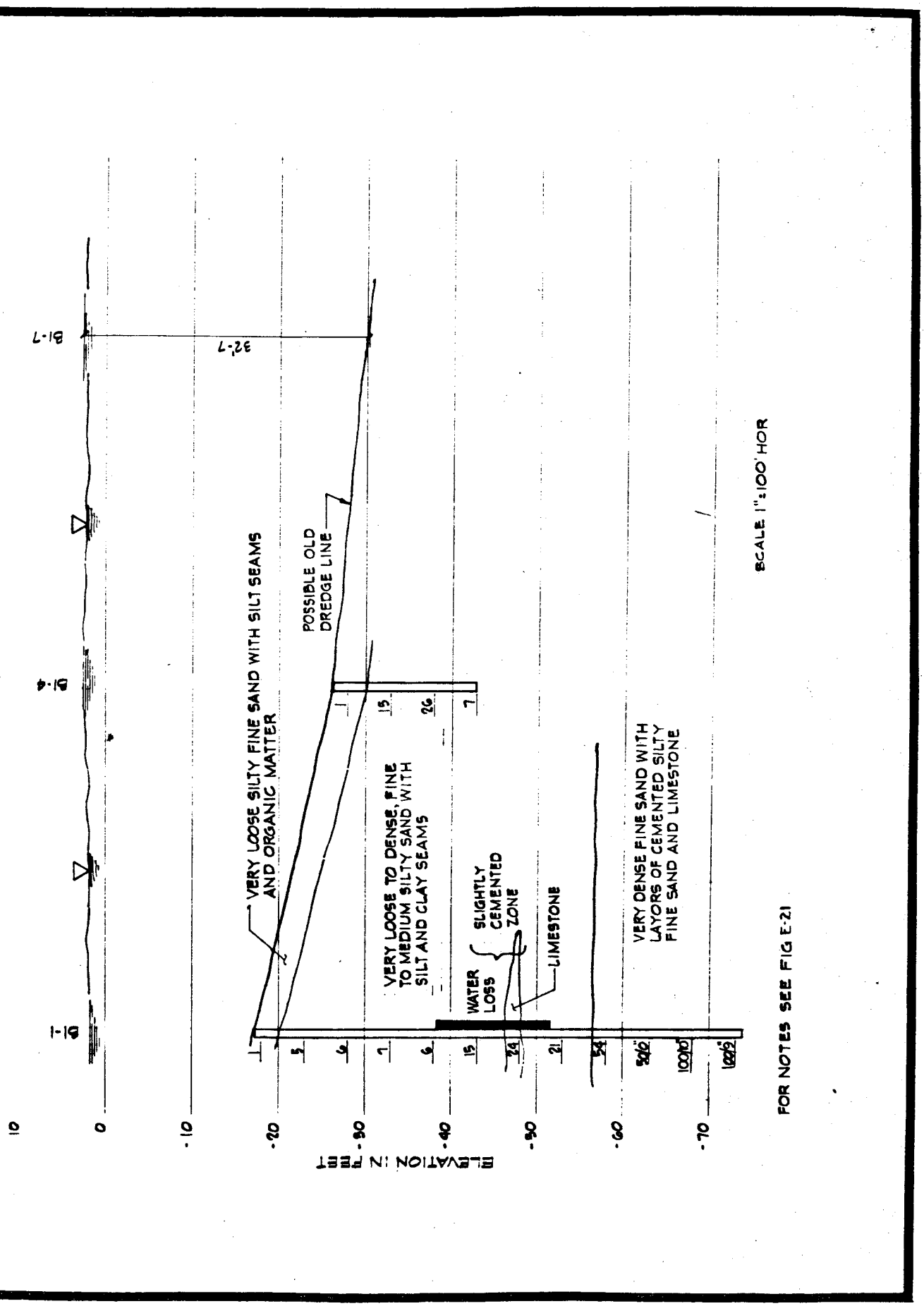


Figure E-22 Subsurface Profile - Section C-C

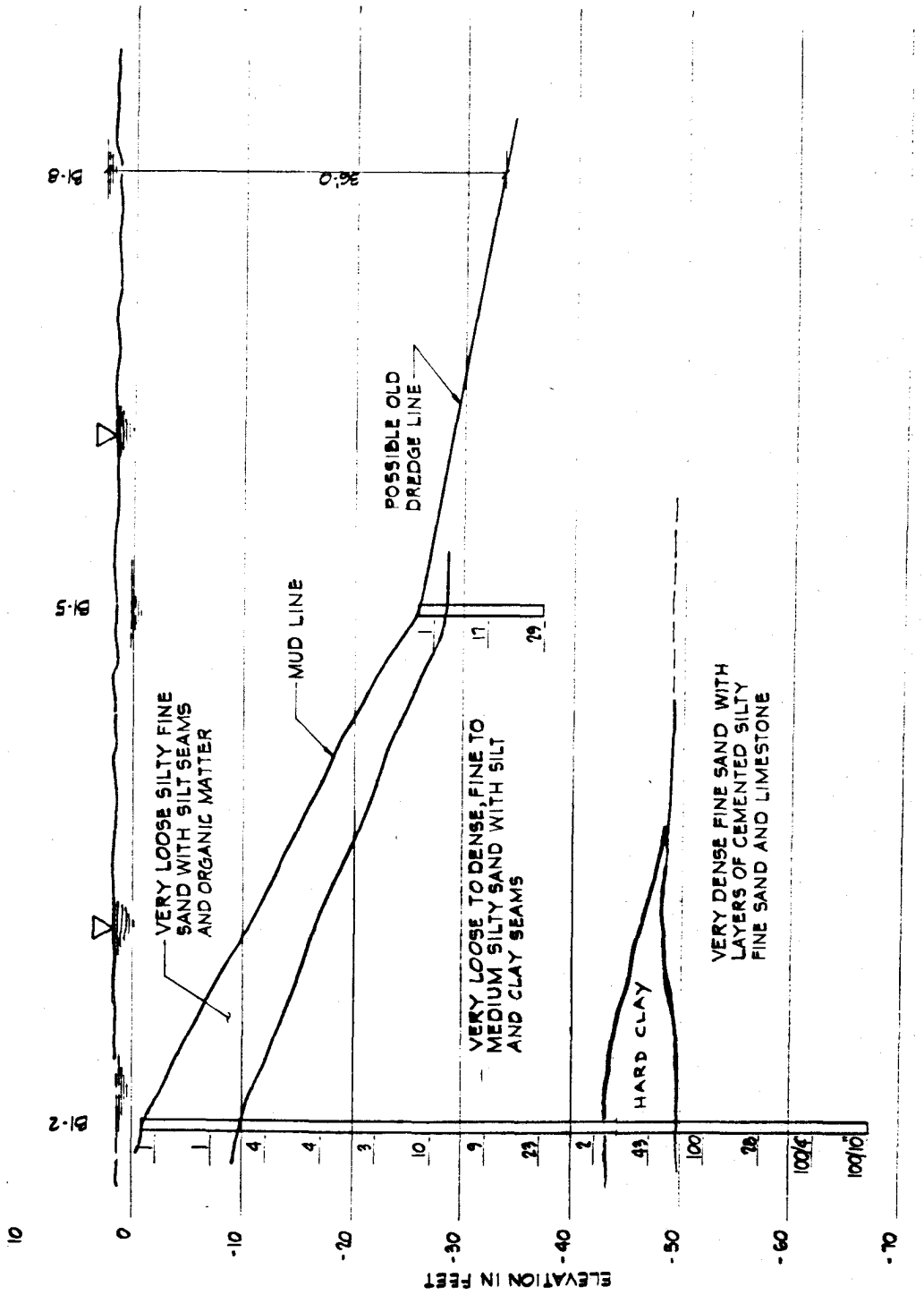


Figure E-23 Subsurface Profile - Section D-D

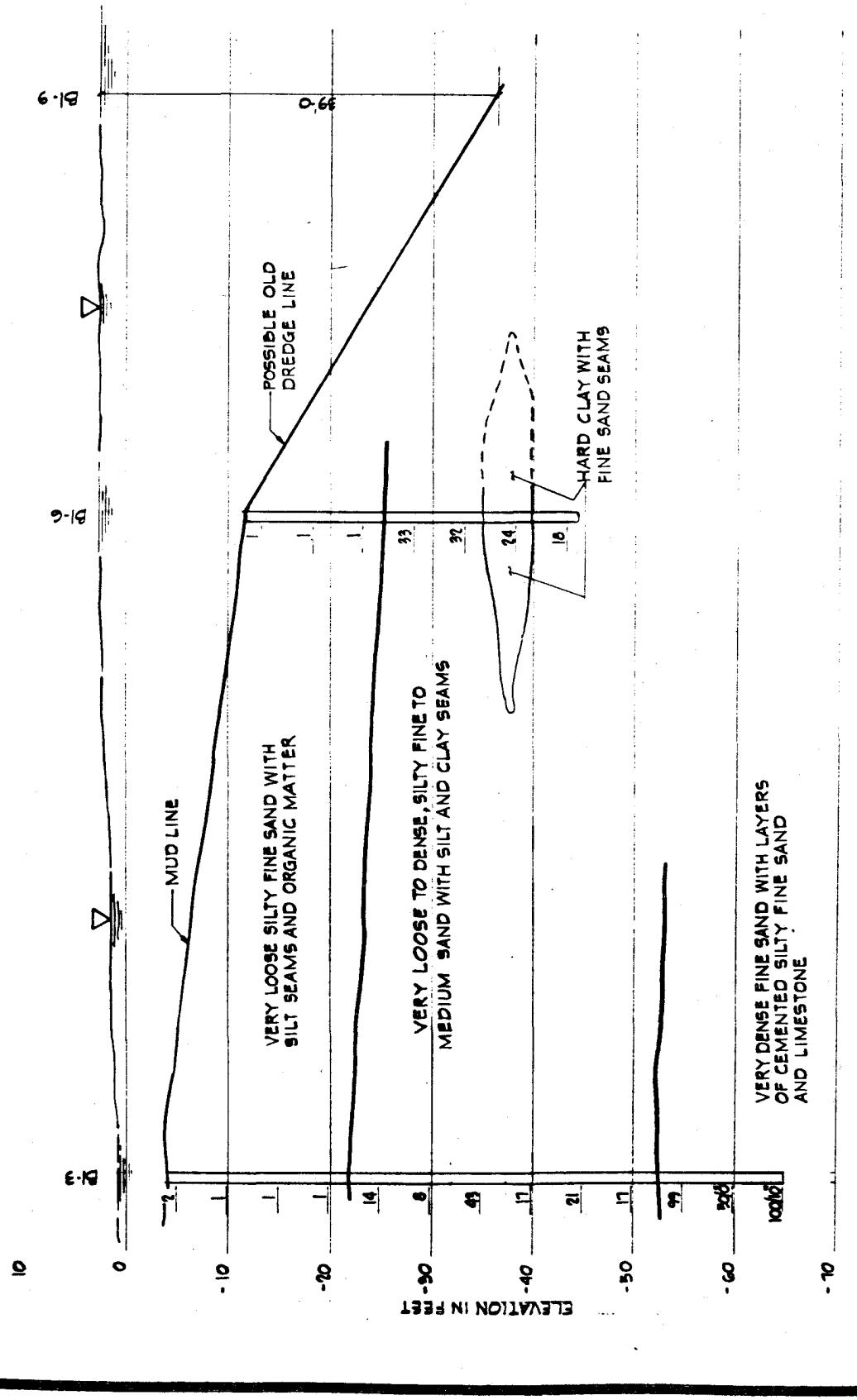


Figure E-24 Subsurface Profile - Section E-E

F

METEOROLOGY/AIR QUALITY

APPENDIX F

AIR QUALITY/METEOROLOGY

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APPENDIX F

AIR QUALITY/METEOROLOGY

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F-2 Drift Modelling Data Processing

F.1 INTRODUCTION

This appendix contains text, tables and figures that describe the cooling tower plume and drift modelling methodology which supports Chapter 5, Section 5.4, and contains tables presenting average wind and stability conditions at Jacksonville (Table F-4) in support of Chapter 2, Section 2.6.

F.2 COOLING TOWER PLUME LENGTH MODELLING

F.2.1 Plume Model

Program PLUME uses the following equations to simulate the growth of the cooling tower plume: an equation of motion, a temperature change equation, a cloud water content equation and an equation for saturation specific humidity. The equation of motion in the PLUME program assumes steady-state conditions and takes into account the buoyant plume acceleration, the drag to liquid water drops, and the drag due to entrainment of environmental air. The temperature change in the plume is determined by the heat gain due to latent heat release, the heat loss due to dry adiabatic expansion and entrainment, the heat gained by a phase change of liquid water to ice, and the heat lost as the plume evaporates water in order to saturate entrained air. The equation for cloud water content includes the gains due to condensation, and the losses due to entrainment and rainout. The saturation specific humidity is expressed by the Goff-Gratch Formulas (WMO International Tables, 1962). These equations are solved to yield vertical profiles of plume temperature, vertical velocity, water vapor and cloud water content.

If the cloud is still saturated at final plume rise, the model calculates dispersion coefficients based on the Pasquill Stability Class (which is computed from the vertical change of temperature at plume level) and disperses the cloud using the calculated cloud parameters and a standard Gaussian plume method suggested by Turner (1970).

F.2.2 Plume Model Data Processing

The analysis of the visible plumes by PLUME requires vertical profiles of temperature, dewpoint, wind speed, and direction. For this anaysis one year (1964) of Jacksonville, Florida radiosonde data was used. The year 1964 was selected because it lies within the five year (1964-1968) data base used for the cooling tower drift analysis (Appendix F, Section F.2).

Radiosonde observations are made at Jacksonville at 7:00 a.m. and 7:00 p.m. EST. Only those soundings from which there were at least two levels of data between the surface and 1,000 meters (AGL) were considered in the analysis.

Figure F-1 summarizes the various steps used in processing the data. Program PLUME calculates the following parameters for each sounding: the height and downwind distance of final plume rise, the plume radius, plume moisture content, and the downwind distance at which the plume is no longer visible.

In order to screen the meteorological situations during which the cooling tower plume would not be visible, program CLOUD was run to remove the periods during which the plume would not be visible as a result of low cloud ceiling heights (ceilings below level of final plume rise), ground fog, moderate and heavy precipitation, or low (less than 1/2 mile) visibility from the PLUME output data file. Following this screening by CLOUD, there remained 572 observations out of the original data base of 730 on which to study the plume length frequency distribution.

Program PLUMEFRQ was then run to provide seasonal morning versus afternoon summaries of the occurrence of plume lengths for each of 16 wind directions. Seven categories of plume heights and lengths were defined based on a preliminary run of PLUME. The height and length categories are as follows:

CLASS	1	2	3	4	5	6	7
Length (m)	0-250	250-500	500-1000	1000-1500	1500-2000	2000-5000	>5000

In addition, PLUMFRQ calculated the total cumulative frequency of plume occurrence at each distance along a given direction by summarizing the frequencies beginning at the outermost distance and continuing into the smallest distance. This yielded the total frequency of a plume in a 22.5 degree sector at a given distance.

A final computer program (CLUSTER) was run to combine the effects of the plumes from the two cooling towers and to generate maps of the final cumulative frequency distributions. The physical meaning of these final output maps merits explanation. The final frequency maps represent the percent of time a plume occurs in a 22.5 degree sector of a circle centered between the cooling towers. Thus, the frequencies do not necessarily represent the total amount of plume shadowing because a plume occurring in a 22.5 degree sector does not imply total overhead sky coverage within that sector, especially at large distances. However, the frequency maps do allow qualitative assessment to be made of the effects of operation of the two cooling towers as a function of season and time of day.

F.2.3 Cooling Tower Specifications

The cooling tower plume exit temperatures and velocities are computed for each meteorological situation. The calculations for plume exit temperature and velocity are based on data provided by a cooling tower manufacturer (Dickey, 1973). The exit temperatures generally range from 25°C to 45°C and the exit speeds range from about 4.5 to 6.5 meters per second (m/sec). The initial cloud water contents and condensed water contents were set equal to 1.0 grams per kilogram (g/kg) (ESC, 1977), based on aircraft measurements of cooling tower plumes. The cooling towers were assumed to be 150 m in height and 66 m in diameter at the top.

F.3 COOLING TOWER DRIFT MODELLING

F.3.1 Program DRIFT

The model first divides the initial droplet-size spectrum at the tower outlet into subranges, each represented by an average droplet diameter and a drift mass fraction associated with that particular droplet subrange. Each drop is assumed to leave the tower at the exit plume centerline (center of the cooling tower) and follow the plume as it moves subject to ambient meteorological conditions. The drop falls free of the plume as soon as its vertical separation from the plume centerline due to gravitational settling is greater than the local plume radius. At each downwind step increment, the model performs a set of computations describing the changes in plume characteristics that occur over that step. In response to the changing plume conditions for each step, a change in droplet radius is calculated along with its new settling velocity and its new relative displacement from the centerline. The droplet trajectory from breakaway to the ground is determined by the settling velocity of the droplet and the constant horizonal component of the wind.

The output from DRIFT consists of total water and salt deposition at 20 downwind distances for each meteorological condition investigated. The units of deposition are milligrams per meter squared per hour ($mg/m^2/hr.$). These results are independent of wind direction; that is, the wind direction is assumed to be directly upwind of the receptors and all receptors lie on a line coincident with the plume centerline. The wind direction, which determines the spatial distribution of output results, as well as the other meteorological parameters (stability, temperature, wind speed, relative humidity) are factored into the final results separately with a subsequent computer program using five years of surface meteorological data.

F.3.2 DRIFT Modelling Input Data

Five years (1964-1968) of surface meteorological data from Jacksonville, Florida were used as input. The basic hourly meteorological data base included temperature, wind speed, wind direction, relative humidity, cloud cover and ceiling height. The four meteorological parameters which are required by program DRIFT are wind speed and direction, temperature, relative humidity, and atmospheric stability. Cloud cover and ceiling height were used in conjunction with the solar angle and wind speed to calculate stability based on the STAR method (Turner, 1964).

Table F-1 summarizes the cooling tower input parameters required by program DRIFT. The parameter values were based on engineering design assumptions resulting from a waste heat optimization study for the project (Ebasco, 1980). The salt concentration of water is based on 1.5 cycles of concentration and an assumed maximum value for the makeup water from the St. Johns River. The plume velocities and exit temperatures were calculated for each different meteorological situation. The drift droplet mass distribution shown in Table F-2 is based in part on measurements of the drop size distribution at the mouth of the natural draft tower at the Chalk Point Generating Station (ESC, 1977), and from conceptual engineering design information (Ebasco, 1980).

F.3.3 Data Processing for DRIFT Modelling

Figure F-2 illustrates the various steps used in the drift modelling. Prior to running DRIFT, program SURFACE was executed. Program SURFACE read five years (1964-1968) of surface data recorded from Imeson Airport in Jacksonville and sorted the four meteorological variables (wind speed, temperature, relative humidity, stability) into one of four subranges, creating 256 different meteorological combinations. In addition, the wind direction was categorized into one of sixteen 22.5 degree sectors, yielding a total of 4,096 different categories into which each of the observations were classified. The categories for the four meteorological variables were

defined after inspection of preliminary runs of SURFACE using one year of data and varying the limits for the categories of the four meteorological parameters. The range of the categories and the midpoints used for calculation purposes by program DRIFT and their relative percent of occurrence are presented in Table F-3.

The output of SURFACE was a 256 x 16 x 5 unit matrix with the percent frequency of occurrence of each meteorological condition for each season of the year, as well as the annual total for all 16 wind directions. The raw drift deposition results for each of the 256 meteorological categories were then weighted by the actual frequency of occurrence of each of the meteorological categories for the 16 wind directions. This 256 x 16 matrix (256 meteorological categories, 16 wind directions) was merged with the 256 x 20 matrix (256 meteorological categories, 20 distances) from the DRIFT program output by multiplying the values through each meteorological combination to create a 16 (directions) x 20 (distances) matrix. This matrix represents the meteorological weighted deposition over a polar coordinate grid field for a single cooling tower. The results were combined for the two towers using program CLUSTER. Program CLUSTER produced a 3 km x 3 km rectangular grid with drift results computed at 0.125 km increments in the same manner as the plume length frequency maps were generated.

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Table F-1 (Revision I)

COOLING TOWER EXIT PARAMETERS[a] (1 UNIT)

Height	150 m
Tower Top Radius	33 m
Makeup	17,200 gal/min.
Flow Rate	243,500 gal/min.
Drift Rate	0.002 percent
Salt Concentration	0.03172 (annual average) kg/l 0.05145 (maximum) kg/l
Total Drift	4.87 gal/min

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a Based on Ebasco Services Incorporated generic engineering design estimates for a 600 MWe unit.

Table F-2

DROP SIZE DISTRIBUTION AT MOUTH OF COOLING TOWER

Drop Diameter Range (um)	Drop Diameter Mid Point (um)	Percent of Total Mass
10-30	20	12.5
30-50	40	27.5
50-70	60	12.7
70-90	80	8.2
90-110	100	5.2
110-130	120	3.2
130-150	140	2.4
150-180	165	2.8
180-210	195	3.0
210-240	225	2.3
240-270	255	1.7
270-300	285	1.3
300-350	325	1.4
350-400	385	2.6
400-450	425	2.4
450-500	475	2.3
500-600	550	1.4
600-700	650	1.3
700-800	750	1.3
800-900	850	1.1
900-1000	950	1.0
1000-1100	1050	.9
1100-1200	1150	.7
1200-1300	1250	.4
1300-1400	1350	.4

Source: ESC, 1977

Table F-3

SUMMARY OF METEOROLOGICAL PARAMETERS USED FOR DRIFT MODELLING

Variable	Class 1			Class 2			Class 3			Class 4		
	Range	Mid Pt	PCT[a]	Range	Mid Pt	PCT[a]	Range	Mid Pt	PCT[a]	Range	Mid Pt	PCT[a]
Wind Speed (m/s)	0-1.8	.9	10.1	1.9-3.5	2.7	33.2	3.6-5.5	4.5	36.5	> 5.5	7.0	20.3
Temperature (^{o}F)	< 55	40.	17.5	56-70	62.5	29.2	71-80	75.	34.5	> 80	90.	18.9
Relative Humdity (%)	< 55	40.	18.0	56-70	62.5	27.0	76-90	82.5	30.8	> 90	95.	23.5
Pasquill Stability	A,B,C		21.4	D		52.7	E		13.8	F,G		12.1

Pasquill Stability Class is related to the following qualitative interpretation of atmospheric stabilities:

Stability	Class
Very unstable	A
Unstable	B
Slightly unstable	C
Neutral	D
Slightly stable	E
Stable	F
Very stable	G

a Percent occurrence

TABLE F-4

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED,
WIND DIRECTION, AND STABILITY CLASS

JACKSONVILLE, 1970-1974
(8 OBSERVATIONS/DAY)

Note: Windspeed class numbers have following interpretation:

1 = 0.67 m/s	(1-3 mph)
2 = 2.46 m/s	(4-7 mph)
3 = 4.47 m/s	(8-12 mph)
4 = 6.93 m/s	(13-18 mph)
5 = 9.61 m/s	(19-24 mph)
6 = 12.52 m/s	(24 mph)

Table F-4 (Continued)

WIND FREQUENCY DISTRIBUTION FOR
PASQUILL STABILITY CLASS A

	Windspeed Class					
Wind Direction	1	2	3	4	5	6
N	.0002	.0002	.0000	.0000	.0000	.0000
NNE	.0001	.0001	.0000	.0000	.0000	.0000
NE	.0003	.0002	.0000	.0000	.0000	.0000
ENE	.0003	.0003	.0000	.0000	.0000	.0000
E	.0003	.0003	.0000	.0000	.0000	.0000
ESE	.0005	.0006	.0000	.0000	.0000	.0000
SE	.0002	.0004	.0000	.0000	.0000	.0000
SSE	.0000	.0001	.0000	.0000	.0000	.0000
S	.0003	.0003	.0000	.0000	.0000	.0000
SSW	.0003	.0004	.0000	.0000	.0000	.0000
SW	.0001	.0002	.0000	.0000	.0000	.0000
WSW	.0002	.0005	.0000	.0000	.0000	.0000
W	.0003	.0007	.0000	.0000	.0000	.0000
WNW	.0001	.0002	.0000	.0000	.0000	.0000
NW	.0002	.0003	.0000	.0000	.0000	.0000
NNW	.0004	.0003	.0000	.0000	.0000	.0000

Table F-4 (Continued)

WIND FREQUENCY DISTRIBUTION FOR
PASQUILL STABILITY CLASS B

Wind Direction	Windspeed Class 1	2	3	4	5	6
N	.0022	.0024	.0008	.0000	.0000	.0000
NNE	.0008	.0011	.0009	.0000	.0000	.0000
NE	.0006	.0010	.0011	.0000	.0000	.0000
ENE	.0009	.0016	.0012	.0000	.0000	.0000
E	.0007	.0026	.0018	.0000	.0000	.0000
ESE	.0006	.0013	.0014	.0000	.0000	.0000
SE	.0012	.0022	.0014	.0000	.0000	.0000
SSE	.0004	.0010	.0009	.0000	.0000	.0000
S	.0013	.0024	.0015	.0000	.0000	.0000
SSW	.0009	.0014	.0009	.0000	.0000	.0000
SW	.0017	.0025	.0023	.0000	.0000	.0000
WSW	.0012	.0029	.0019	.0000	.0000	.0000
W	.0017	.0027	.0024	.0000	.0000	.0000
WNW	.0010	.0023	.0012	.0000	.0000	.0000
NW	.0014	.0027	.0012	.0000	.0000	.0000
NNW	.0012	.0014	.0009	.0000	.0000	.0000

Table F-4 (Continued)

WIND FREQUENCY DISTRIBUTION FOR
PASQUILL STABILITY CLASS C

Wind Direction	Windspeed Class 1	2	3	4	5	6
N	.0012	.0027	.0034	.0001	.0000	.0000
NNE	.0006	.0014	.0021	.0005	.0000	.0000
NE	.0006	.0013	.0039	.0005	.0000	.0000
ENE	.0005	.0016	.0064	.0018	.0000	.0000
E	.0003	.0010	.0092	.0028	.0001	.0000
ESE	.0002	.0009	.0062	.0019	.0000	.0000
SE	.0006	.0016	.0055	.0017	.0000	.0000
SSE	.0009	.0011	.0024	.0003	.0000	.0000
S	.0012	.0023	.0041	.0006	.0000	.0000
SSW	.0006	.0017	.0040	.0009	.0001	.0000
SW	.0010	.0025	.0051	.0012	.0001	.0000
WSW	.0012	.0027	.0079	.0012	.0000	.0000
W	.0010	.0037	.0074	.0019	.0002	.0000
WNW	.0009	.0014	.0037	.0010	.0001	.0000
NW	.0011	.0020	.0042	.0006	.0000	.0001
NNW	.0007	.0010	.0022	.0002	.0000	.0000

Table F-4 (Continued)

WIND FREQUENCY DISTRIBUTION FOR
PASQUILL STABILITY CLASS D

Wind Direction	Windspeed Class 1	2	3	4	5	6
N	.0027	.0053	.0121	.0047	.0001	.0001
NNE	.0009	.0030	.0075	.0084	.0005	.0001
NE	.0007	.0033	.0092	.0156	.0023	.0003
ENE	.0009	.0034	.0094	.0125	.0011	.0000
E	.0013	.0042	.0103	.0125	.0007	.0000
ESE	.0006	.0027	.0077	.0077	.0003	.0001
SE	.0007	.0021	.0090	.0108	.0006	.0001
SSE	.0007	.0027	.0064	.0042	.0005	.0001
S	.0016	.0048	.0122	.0075	.0005	.0000
SSW	.0010	.0030	.0088	.0055	.0003	.0000
SW	.0008	.0041	.0130	.0101	.0012	.0000
WSW	.0009	.0032	.0089	.0094	.0010	.0002
W	.0011	.0044	.0079	.0123	.0026	.0005
WNW	.0011	.0032	.0040	.0084	.0023	.0003
NW	.0011	.0027	.0060	.0075	.0017	.0001
NNW	.0009	.0027	.0051	.0041	.0002	.0000

Table F-4 (Continued)

WIND FREQUENCY DISTRIBUTION FOR
PASQUILL STABILITY CLASS E

Wind Direction	Windspeed Class 1	2	3	4	5	6
N	.0147	.0149	.0048	.0000	.0000	.0000
NNE	.0048	.0051	.0011	.0000	.0000	.0000
NE	.0062	.0069	.0013	.0000	.0000	.0000
ENE	.0086	.0121	.0017	.0000	.0000	.0000
E	.0076	.0104	.0036	.0000	.0000	.0000
ESE	.0068	.0085	.0045	.0000	.0000	.0000
SE	.0087	.0124	.0050	.0000	.0000	.0000
SSE	.0075	.0077	.0024	.0000	.0000	.0000
S	.0149	.0178	.0034	.0000	.0000	.0000
SSW	.0102	.0138	.0020	.0000	.0000	.0000
SW	.0126	.0165	.0038	.0000	.0000	.0000
WSW	.0124	.0156	.0062	.0000	.0000	.0000
W	.0176	.0164	.0062	.0000	.0000	.0000
WNW	.0149	.0118	.0036	.0000	.0000	.0000
NW	.0112	.0113	.0040	.0000	.0000	.0000
NNW	.0096	.0082	.0032	.0000	.0000	.0000

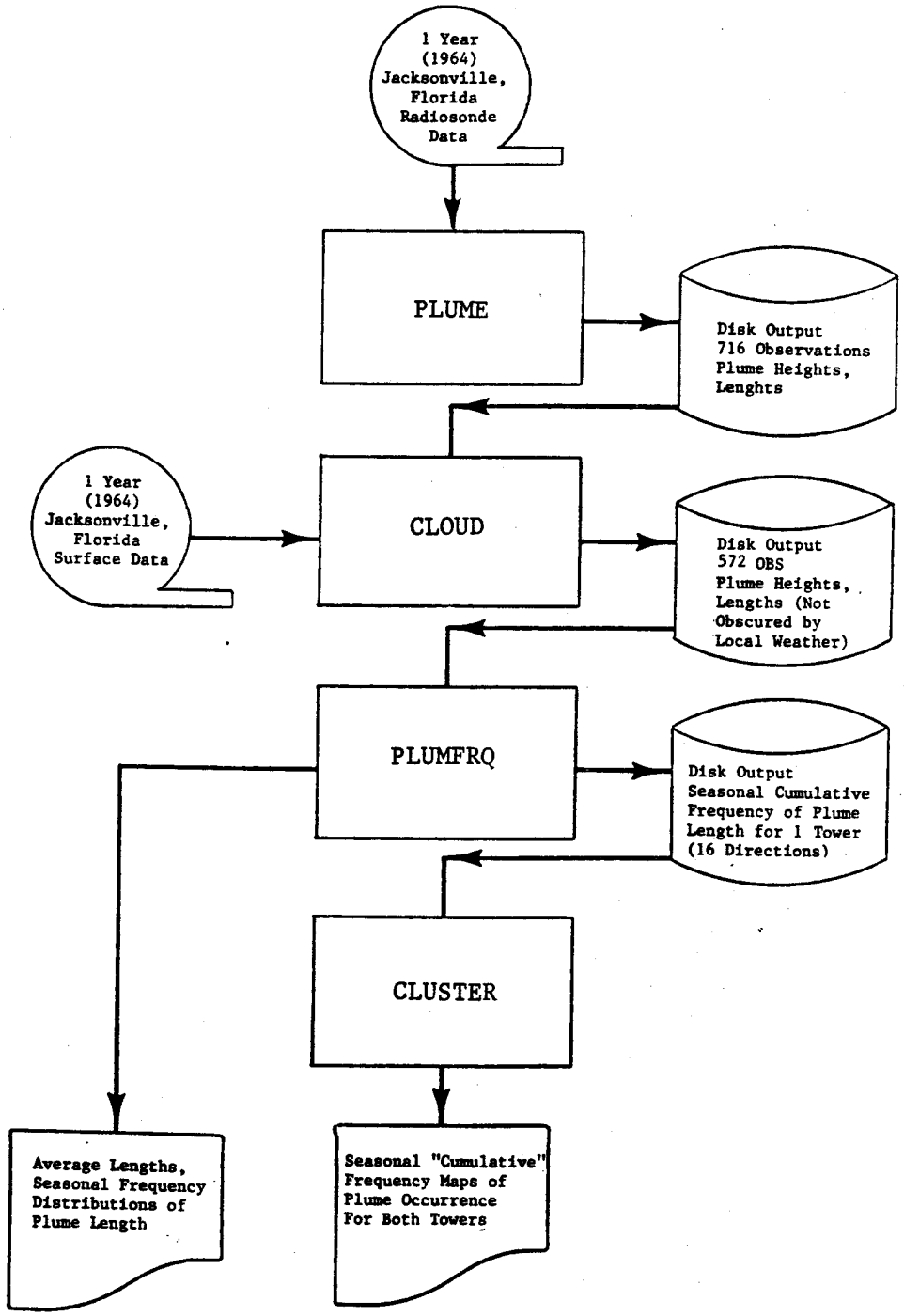

Figure F-1 Plume Modelling Data Processing

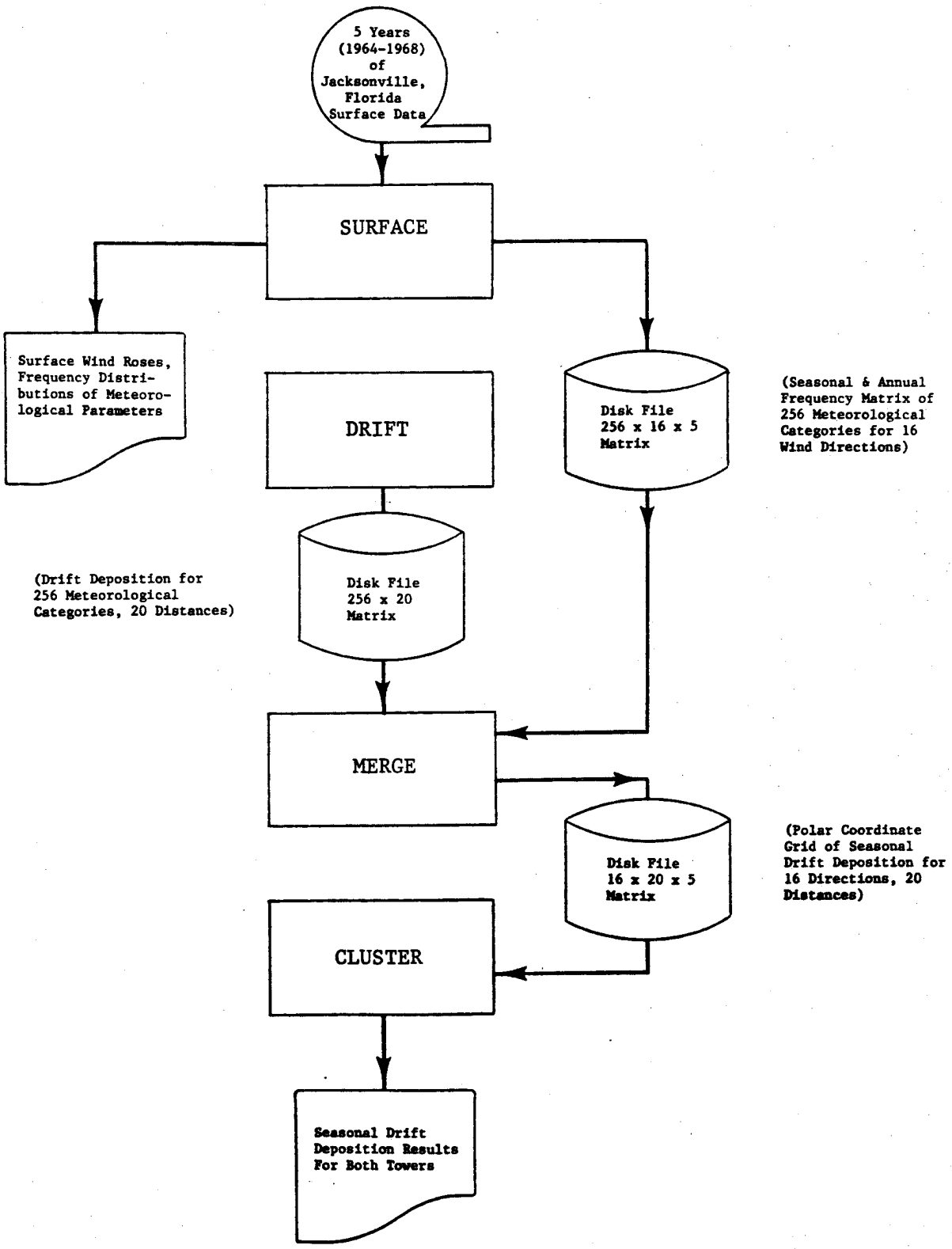

Figure F-2 Drift Modelling Data Processing

G

REGIONAL LAND USE

APPENDIX G

REGIONAL LAND USE

Appendices G, H, J + K

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REGIONAL LAND USE

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G.1 LAND USE

Land use patterns for the region focus on the seven counties that makeup Region IV, the Northeast Florida Planning Region, including Baker, Clay, Duval, Flagler, Nassau, Putnam and St. Johns counties. For the region, 11 types of land uses and cover are inventoried (Florida Resources Analysis Center, 1980). The 11 categories are: open and recreation; residential; industrial, commercial, and institutional; transportation and utility; agricultural; upland natural; wet natural; open water and coastal; marine; mixed urban and transitional; and strip mines and quarries.

The regional analysis employs information from the Jacksonville Area Planning Board and the Florida Resource Analysis Center. The Resource Analysis Center uses land use data that is stored and documented by the U.S. Geological Survey Land Use Data Analysis (LUDA) program.

G.2 PRESENT LAND USE (REGION)

Land use in the Northeast Region is predominately agricultural with approximately 233,650 acres devoted to this use as can be seen in Table G-1 and Figures G-1 through G-10. At present, agricultural uses indicate a downward trend with an increase in urban-related uses. The major agricultural land use in the region is commercial forest followed by pasture lands, cropland, citrus groves and other uses.

Residential land use (approximately 102,930 acres) is the largest of all the urban-related uses (Figure G-4). Low density developments are mostly located near the St. Johns River and transportation crossings throughout the region. Medium and high density residential areas are found in various areas along the coast and near downtown Jacksonville. Some of the other higher density areas are St. Augustine, Jacksonville Beach, and Atlantic Beach.

Industrial land uses (approximately 6,980 acres) are predominant along rail and highway routes as well as waterfronts which are suitable for port-related uses. The major industries are food, fabricated metals, paper and printing/publishing.

Recreational uses in the region tend to be attracted to the coast or river. Kingsley Plantation, a state historic and recreational site, is located on Fort George Island, in close proximity to the beaches. This plantation was re-established in 1814 when Zephaniah Kingsley obtained a Spanish land grant and established both a thriving plantation and shipping firm at Fort George. The main house of the plantation is possibly the oldest in Florida. The Kingsley Plantation was visited by over 35,000 people in 1979 (Jacksonville Area Planning Board, 1979b). Also located on Fort George Island is the Rollins Bird and Plant Sanctuary.

There are a number of areas that receive recreational use that are not designated as parks. One such area is located 7 miles from the site on the Chicopit Bay and St. Johns River. The other site is located along Reed

Island back over to Shipyard Creek and is actually the shoreline of the Dames Point Cutoff. These two areas are used for fishing, sun bathing, picnicking, etc.

G.3 FUTURE LAND USES (REGION)

The Northeast Region is expected to experience further growth in urban-related land uses. According to the Jacksonville Area Planning Board (1979a), agricultural land use is presently declining. This decline is expected to continue due in part to the national trend toward intensification of agricultural farmland usage (Table G-2).

The future growth of urban-related land uses in the region will likely occur in a more restricted fashion. City land use controls will probably be directed at several problem areas. The most critical area, according to the Jacksonville Area Planning Board (1978) and its Regional Citizens' Advisory Committee, is that of water supply. Future development will have to be controlled so that aquifers and their recharge areas are protected. According to the Jacksonville Area Planning Board (1979), the recharge area for the majority of northeast Florida is in Baker and Clay Counties as well as the western portions of Putnam and Duval Counties. Urban sprawl in itself is considered a problem as scattered development makes it more difficult to provide public services. Urban sprawl patterns have been demonstrated by all the various urban land uses. The Citizens Advisory Committee (1978) wants to place controls on future development for reasons of efficiency in the provision of services and energy consumption, as well as aesthetic appeal. Their goal is basically to establish a future land use pattern that will promote the health, safety, and welfare of the residents as well as to accommodate a diversity of lifestyles that will protect their natural, environmental, historical and archeological characteristics.

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Jacksonville Area Planning Board, June, 1979b (Draft Copy). Regional Recreation and Open Space Plan. Northeast Florida Regional Planning Council, Jacksonville, Florida 32202.

Jacksonville Area Planning Board, April, 1978. Regional Land Use Plan - Region IV. Northeast Florida Region and Planning Council. Jacksonville, Florida 32202.

Table G-1

PRESENT LAND USE ACREAGE - N.E. FLORIDA REGION

Land Use Classification	Baker	Clay	Duval	Flagler	Nassau	Putnam	St. Johns	Total N.E. Region
Residential[a]	2,678	11,382	58,247	1,774	7,316	10,304	11,234	102,934
Commercial & Services	84	845	5,754	244	416	534	740	8,617
Industrial	83	674	4,819	110	300	545	446	6,978
Transportation[b]	3,849	4,284	20,677	3,296	5,167	4,288	54,564	47,125
Communication & Utilities	321	175	843	39	42	1,145	176	2,741
Institutional	315	67,991	26,378	188	255	729	673	96,530
Recreational[c]	161	1,884	6,660	264	1,861	525	791	12,146
Mixed	-	-	318	-	63	430	11	822
Extractive	182	3,891	2,214	-	76	666	-	7,029
Total Developed	7,674	91,126	125,909	5,916	15,495	19,166	19,637	284,922
Total Land Area	374,144	379,520	490,048	311,872	416,000	498,368	387,008	2,856,960
Developed as % of Total Land	2.1	24.0	25.7	1.9	3.7	3.8	5.1	10.0
Agriculture	357,562	346,971	288,240	282,378	348,452	379,452	333,306	233,652
Agriculture as % of Total Land	95.6	91.4	58.8	90.5	83.8	76.2	86.1	81.8

[a] Includes local streets right-of-way.
[b] Includes an estimated 11,316 acres of rights-of-way.
[c] Excludes national forest and/or swamp lands and game management areas or refuge.

Note: Columns may not total exactly due to rounding.
Source: Jacksonville Area Planning Board, 1977a.

Table G-2

FUTURE LAND USE NEEDS - N.E. FLORIDA REGION[a]
(1980 to 2005)

1979 Population	630,600		1980-85	1985-90	1990-95	1995-00	2000-05	Total (1980-2005)
Projected Population Increase			49,400	46,000	46,600	44,500	47,050	233,575
Land Use	1979 Existing Acreage	% of Total	Projected Additional Acreage					
Residential	102,934	29	1,976	1,840	1,864	1,780	1,883	9,343
Commercial	8,617	4	296	276	280	267	283	1,402
Industrial	6,978	13	856	797	808	771	816	4,048
Recreational	12,146	25	1,691	1,575	1,595	1,523	1,611	7,995
Transportation	47,125	22	1,482	1,380	1,398	1,335	1,412	7,007
Other	100,094	7	445	414	419	401	424	2,102
Total Needed	-	-	6,746	6,282	6,364	6,077	6,429	31,898

[a] Includes Baker, Clay, Duval, Flagler, Nassau, Putnam and St. Johns Counties

Note: Columns may not total exactly due to rounding
Source: Jacksonville Area Planning Board, 1979a

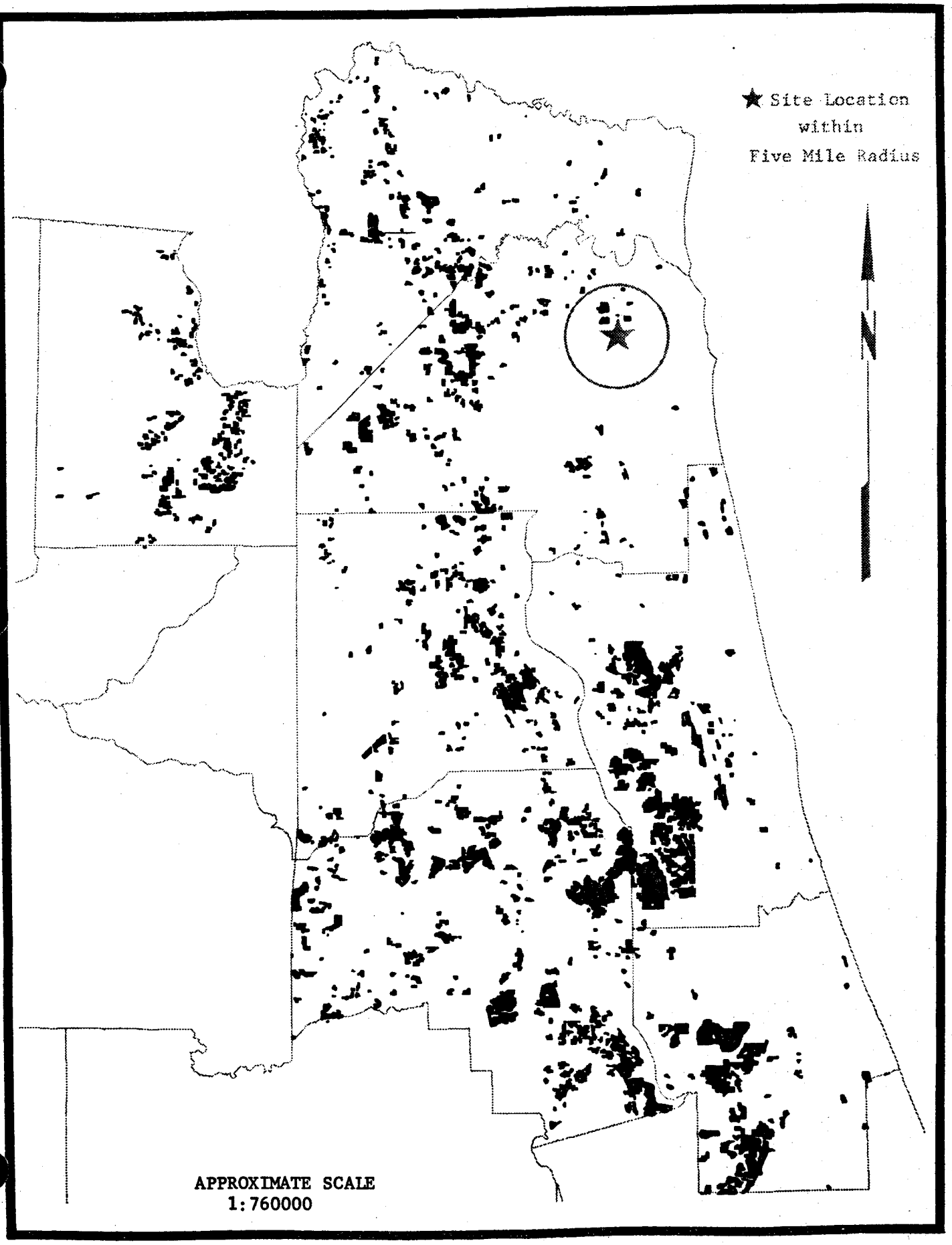


Figure G-1 Northeast Florida Region-Land Cover-Agriculture

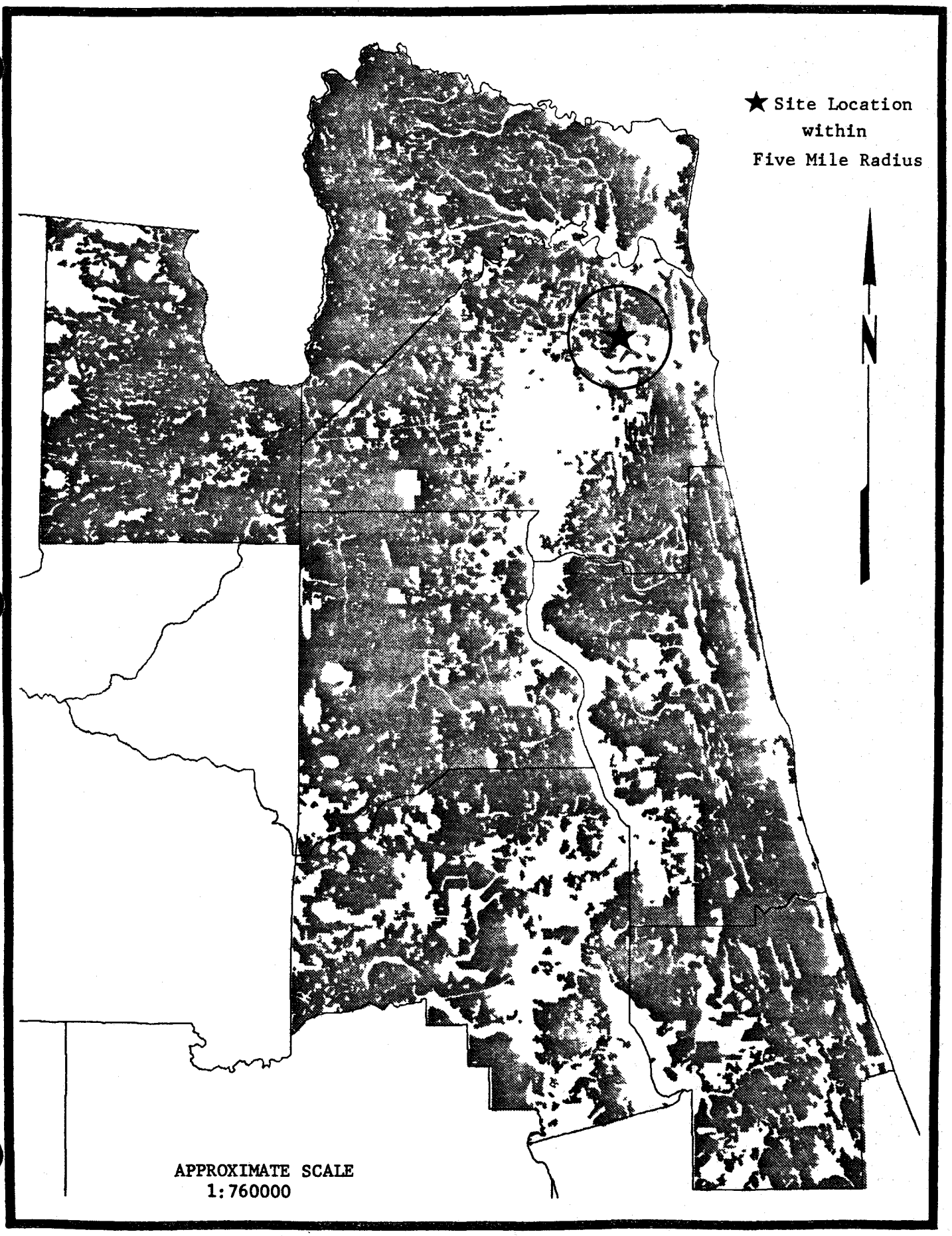


Figure G-2 Northeast Florida Region-Land Cover-Upland Natural

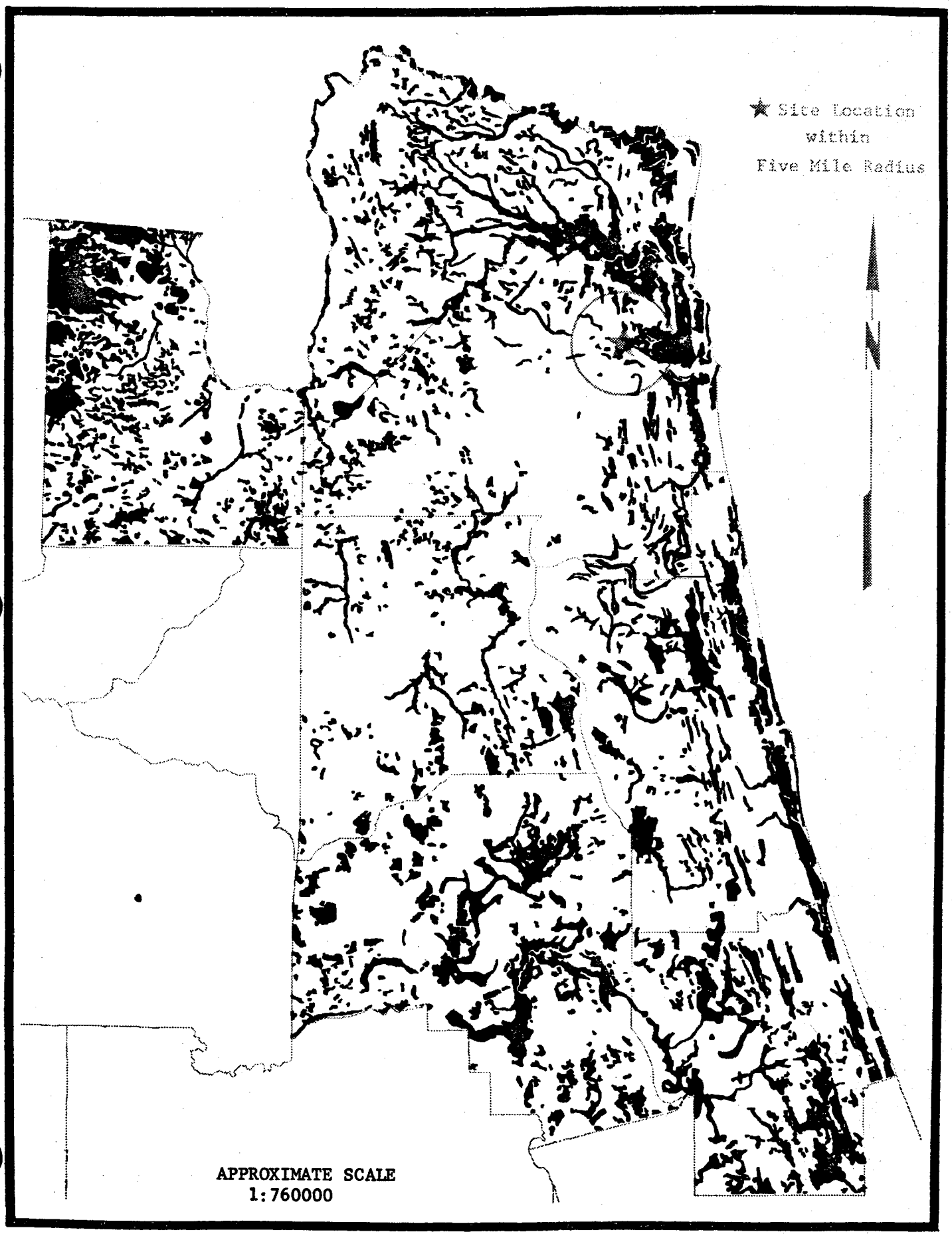


Figure G-3 Northeast Florida Region - Land Cover - Wet Natural and Coastal

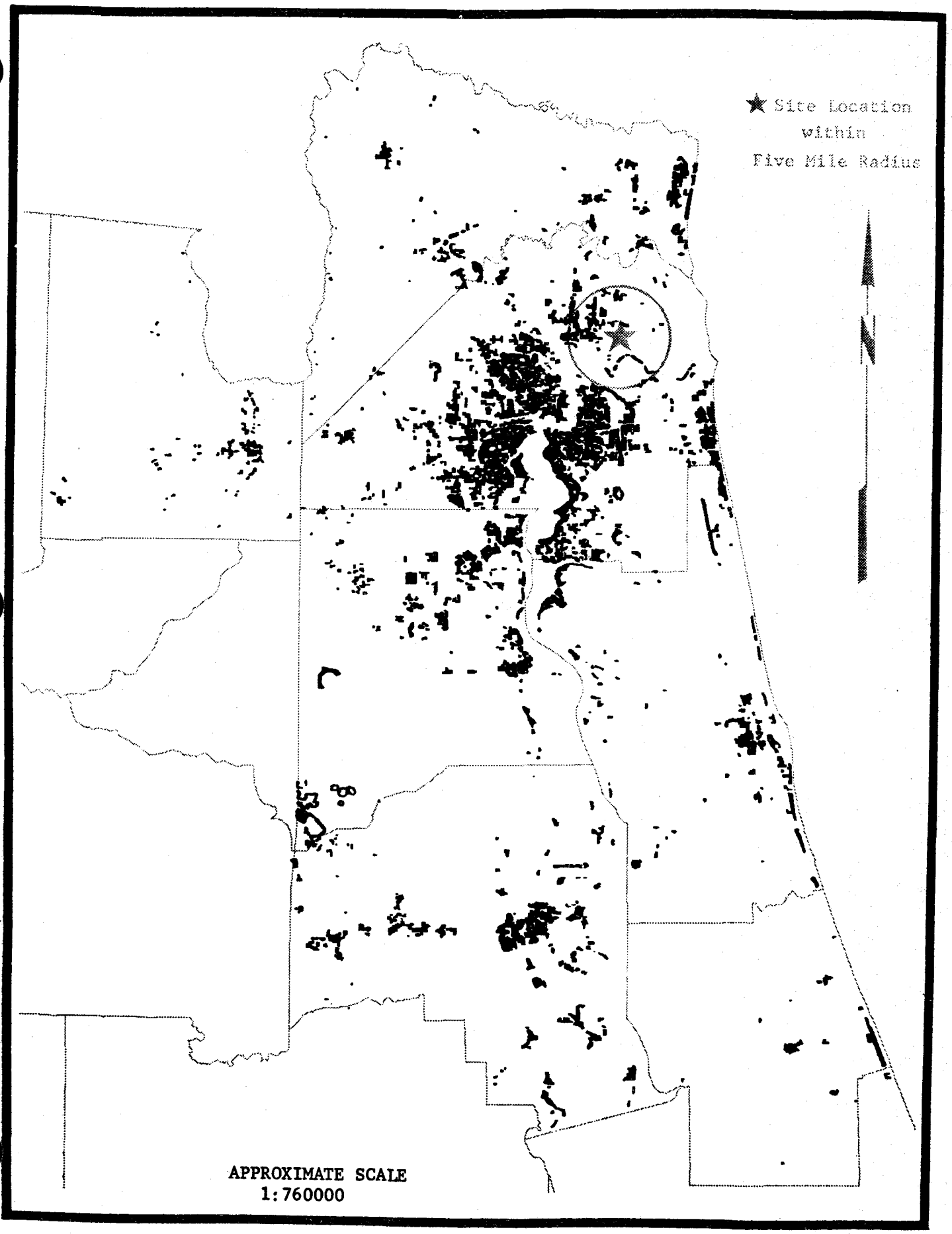


Figure G-4 Northeast Florida Region-Land Cover-Residential

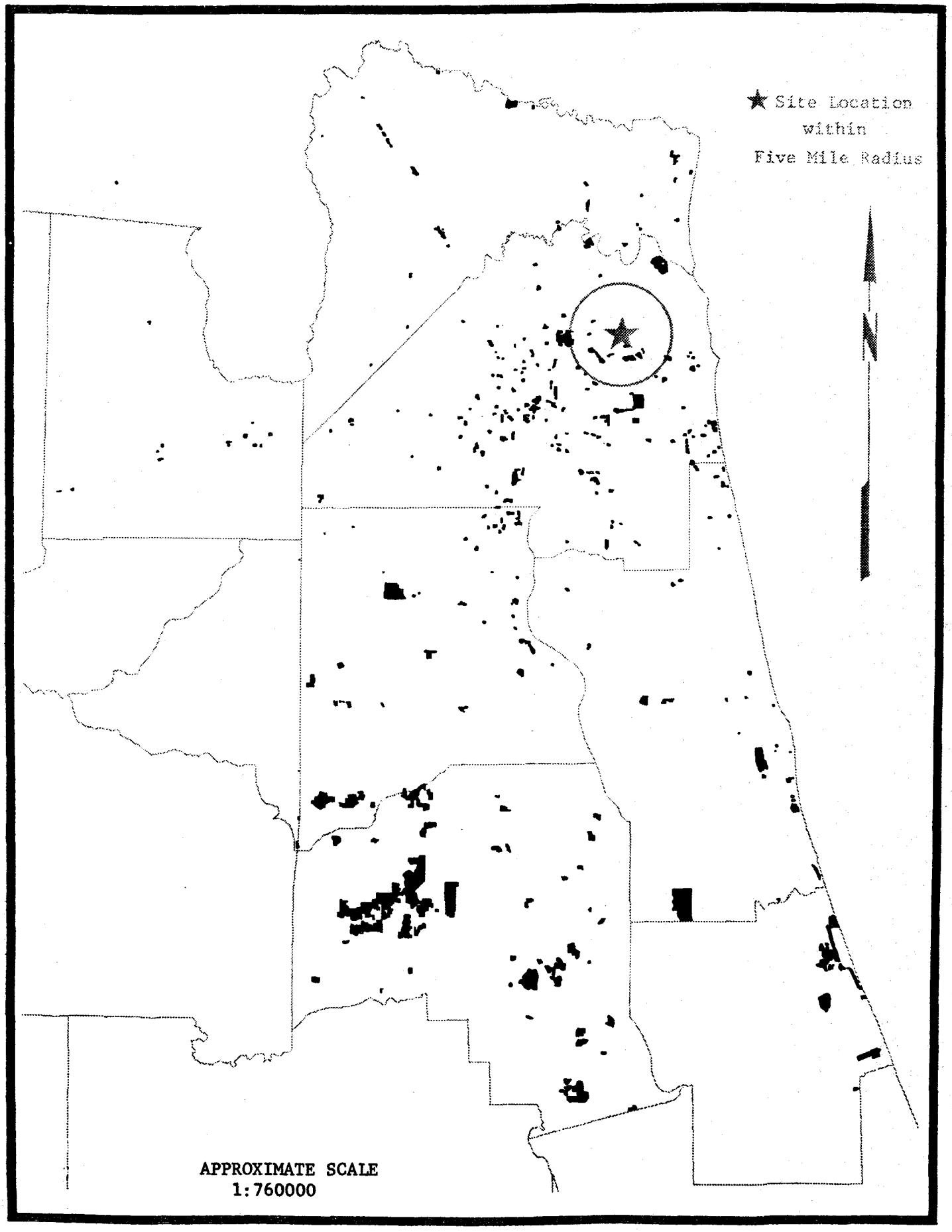


Figure G-5 Northeast Florida Region-Land Cover-Mixed Urban & Transitional Open Space

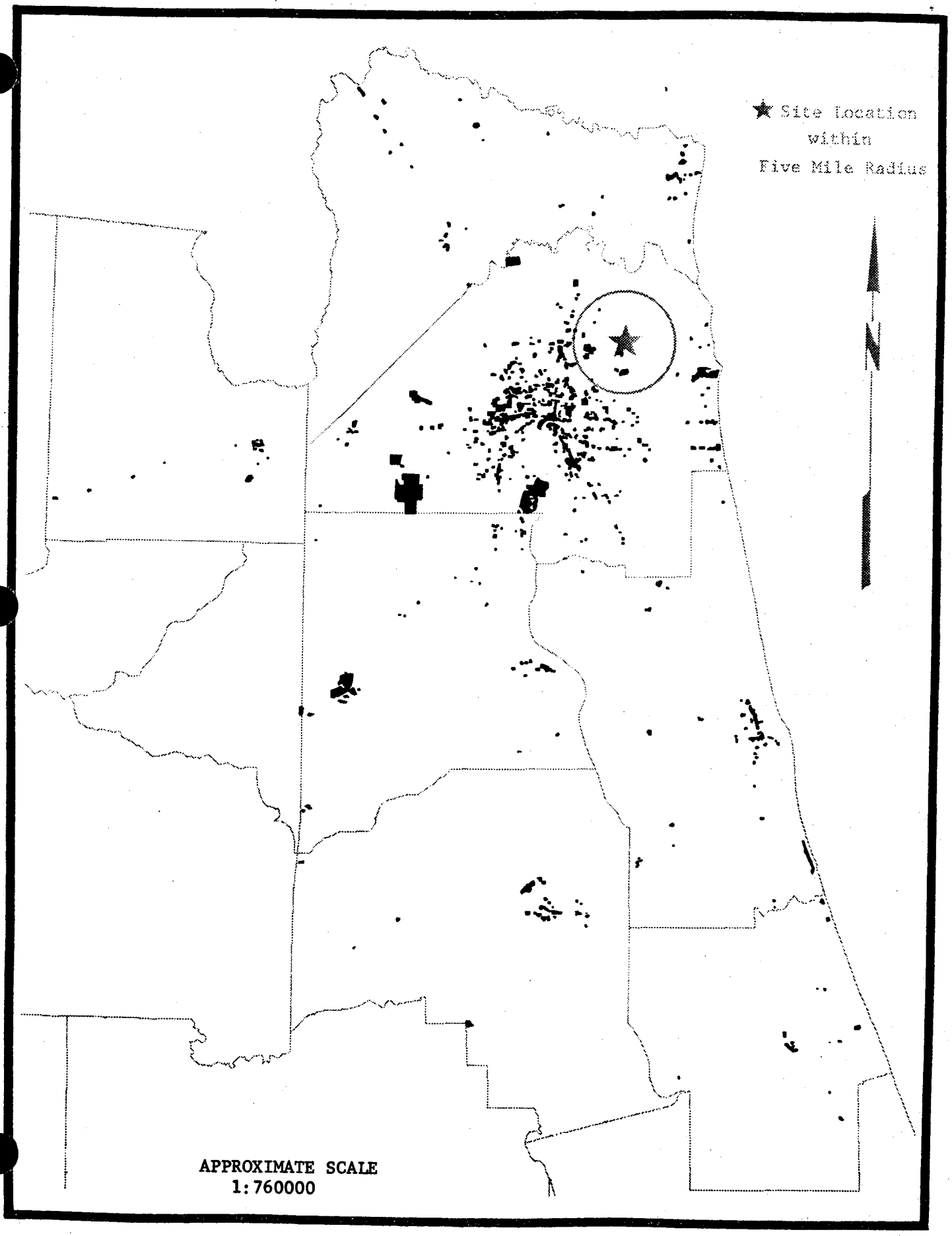


Figure G-6 Northeast Florida Region-Land Cover-Industrial, Commercial & Institutional

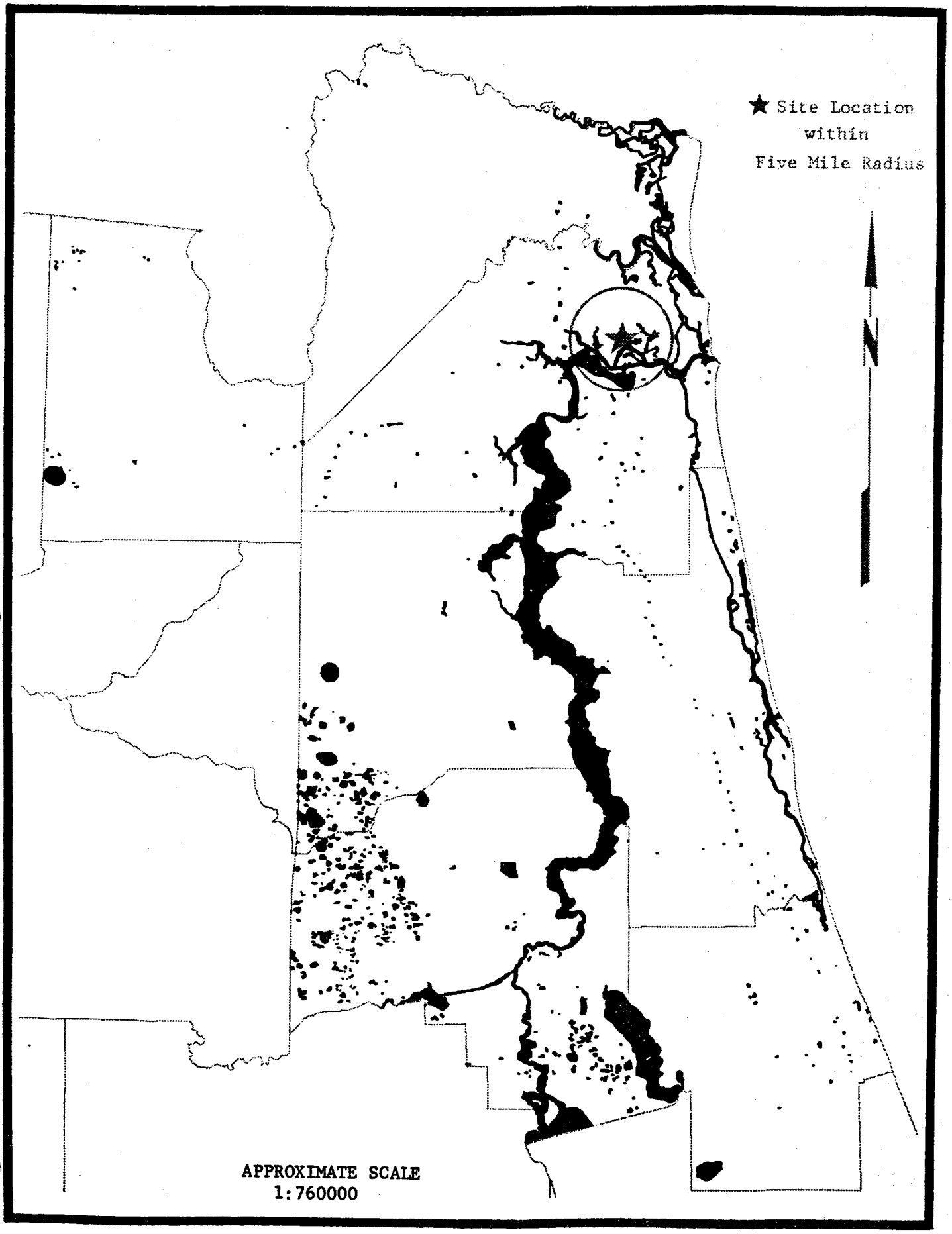


Figure G-7 Northeast Florida Region-Land Cover-Open Water

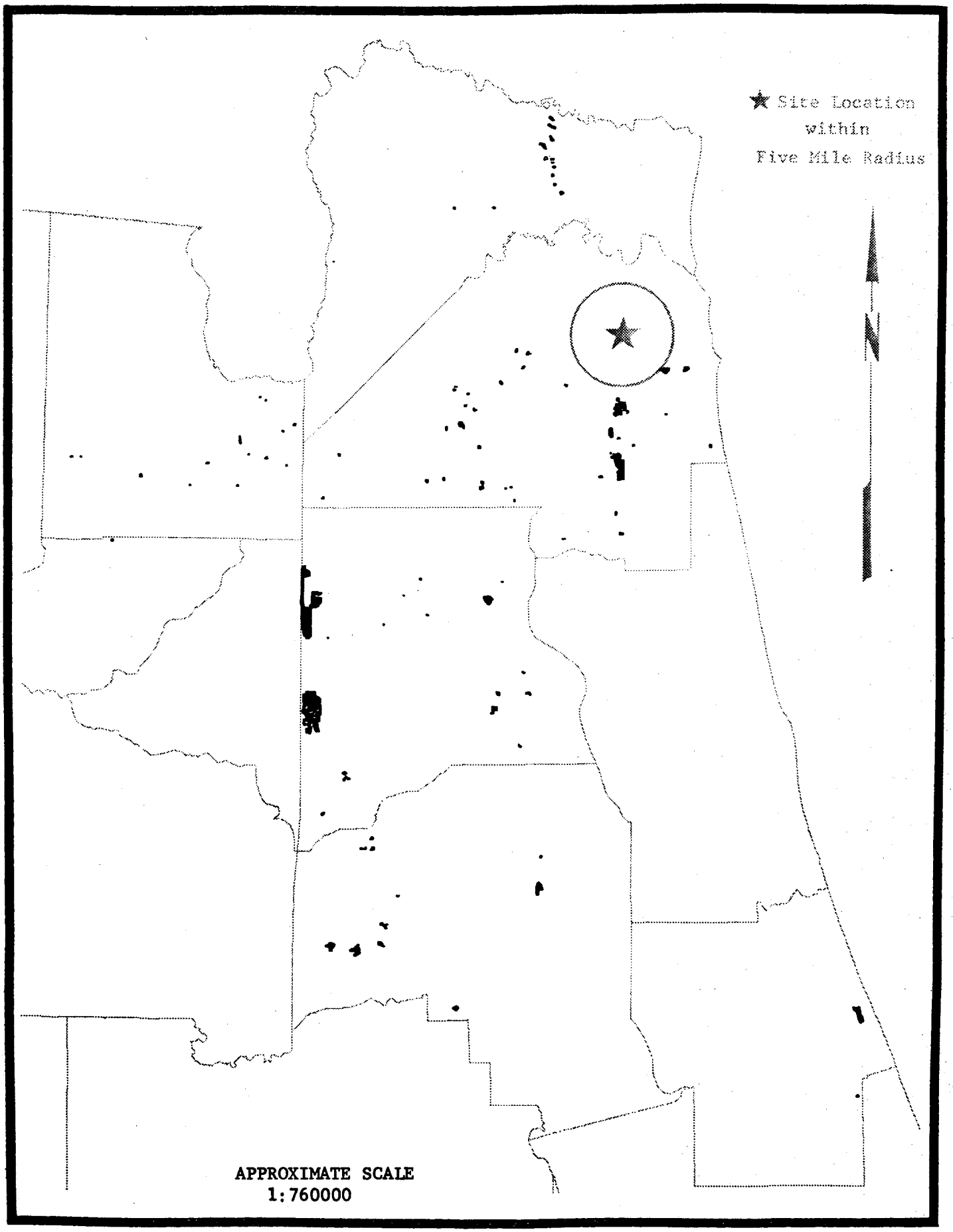


Figure G-8 Northeast Florida Region-Land Cover-Strip Mines & Quarries

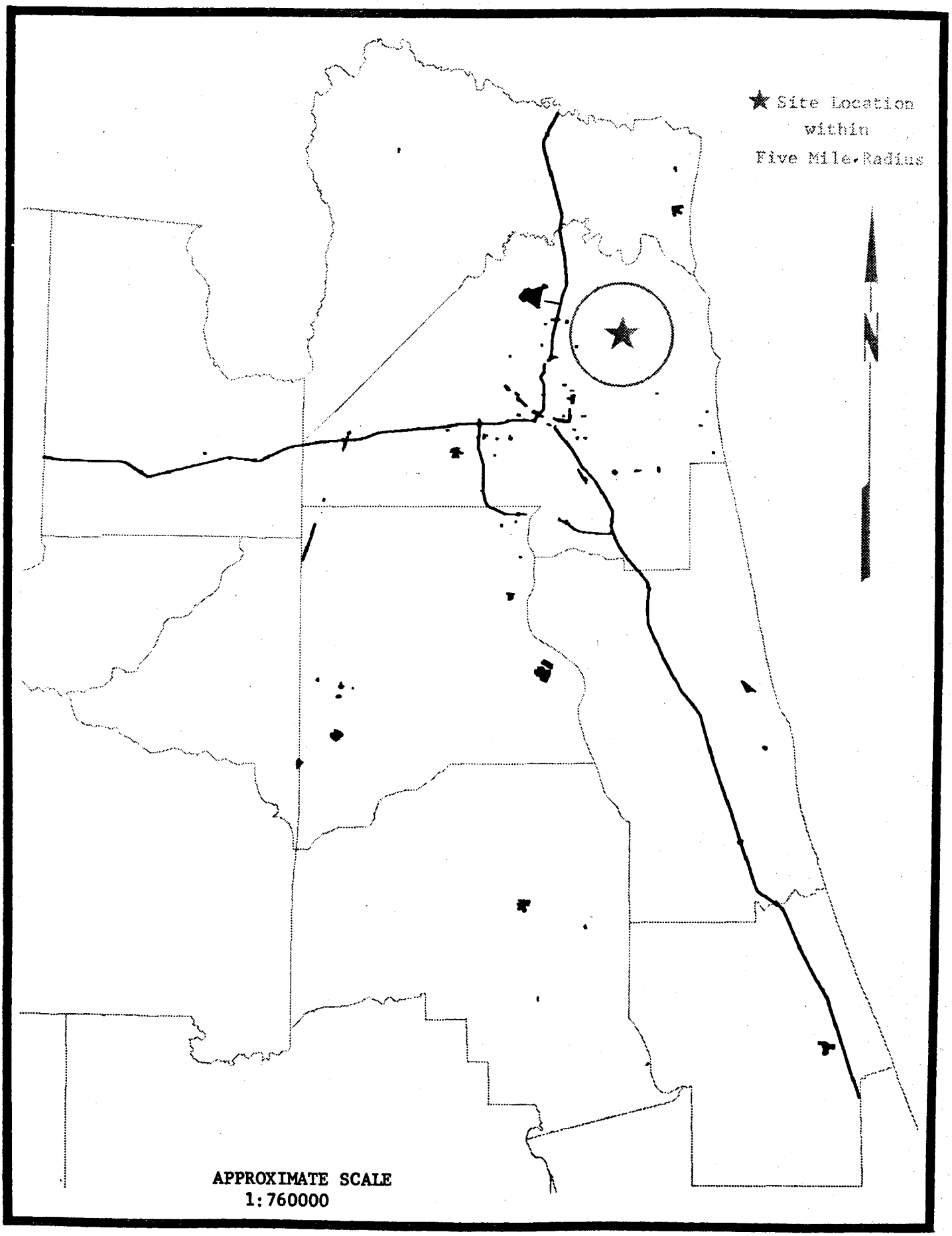


Figure G-9 Northeast Florida Region-Land Cover-Utility & Transportation

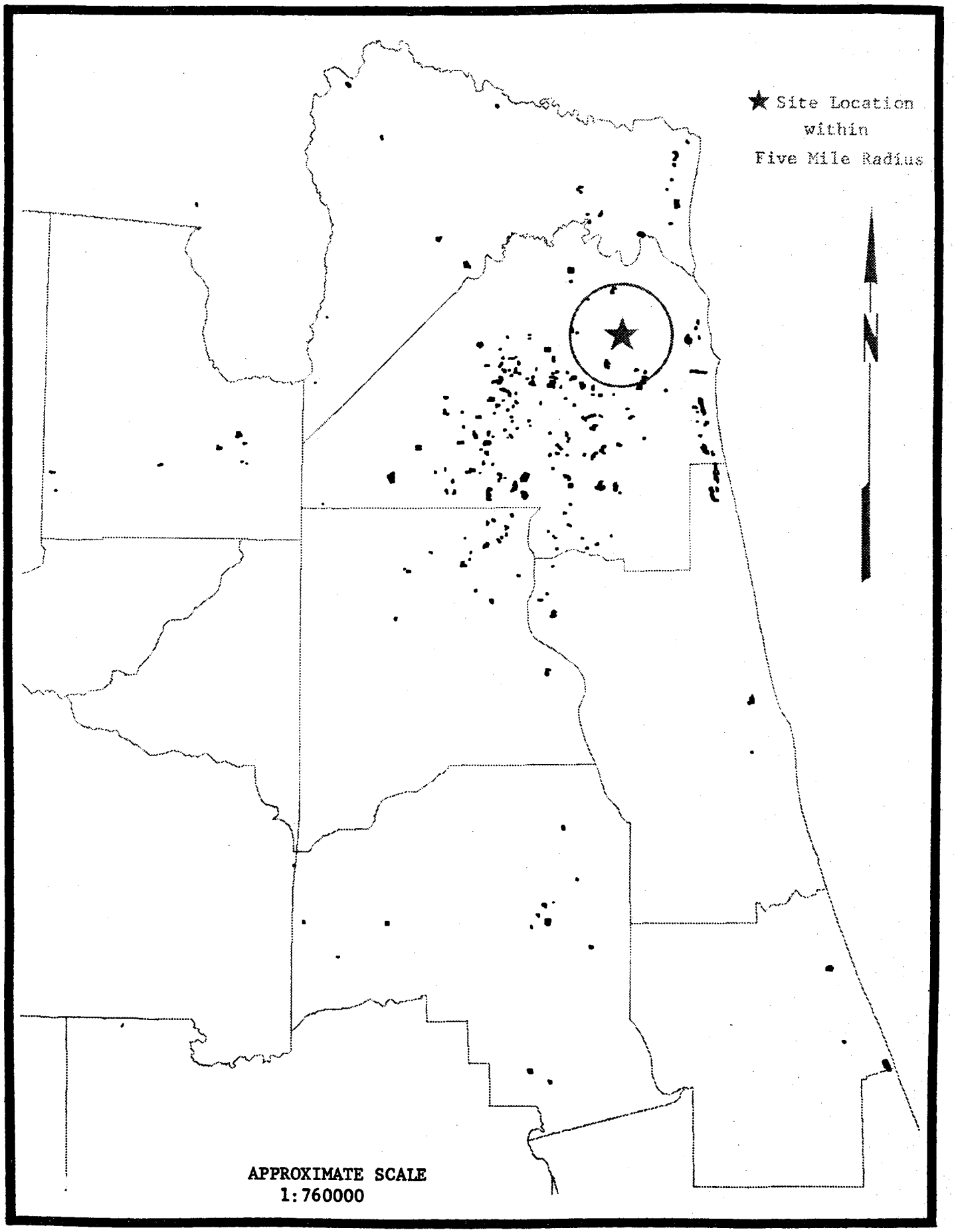
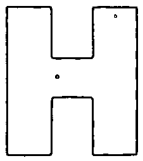


Figure G-10 Northeast Florida Region-Land Cover- Recreation



SOCIOECONOMICS

APPENDIX H

SOCIOECONOMICS

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APPENDIX H

SOCIOECONOMICS

H.1 BASELINE SOCIOECONOMIC DATA

This section examines specific characteristics of the demography and economy of the delineated study area. Due to the construction and operational activities associated with the proposed plant, Duval County is considered the primary impact area of this study. The six surrounding counties of Baker, Clay, Flagler, Nassau, Putnam and St. Johns are considered a secondary impact area.

H.1.1 Population Characteristics

Table H-1 presents the current estimate and projected population levels for the 7-county study region for the years 1970-2020. For the census year 1970, Florida's population had a median age of 32.5 years (U.S. Department of Commerce, 1970). Of the seven counties in the study region, only Flagler County exceeded the state average, while Clay and Nassau Counties had the youngest populations in 1970. These figures reflect the large number of young families living in the Jacksonville/Duval County area, which had a 1970 median age of 26.0 years. Table H-2 presents the estimated and projected median age for the region for the period 1970-2000. In general, these data indicate a young population in the Jacksonville/Duval County area. However, due to longer life spans, increasing numbers of single households, and the trend toward fewer children, the median age for the region, as with the rest of the nation, is expected to show a steady increase over the next 20 years (Northeast Florida Regional Planning Council, 1979).

Population distribution and densities within five miles of the proposed site are depicted in Figure H-1. These data are the result of applying the estimated 1980 average household size in Duval County of 2.86

persons (Jacksonville Area Planning Board, 1978) to the number of housing units identified by actual count from 1980 aerial photographs of the area. The assumption of eight units per building was utilized where apartment complexes were identified. Based on this procedure, the current (1980) population within a five mile radius of the proposed site is approximately 20,800. Average annual growth rates were computed from Duval County census tract projections provided by the Jacksonville Area Planning Board for each census tract within the five mile radius of the proposed plant. These annual growth rates were applied to the figures derived through the above mentioned procedure to develop population projections for the five mile area through the year 2005 (Table H-3).

As can be seen from Figure H-1, the most densely populated areas within five miles of the proposed site are south of the St. Johns River. The majority of the area within five miles of the proposed plant is relatively sparsely populated and lies north of the St. Johns River, allowing the river to serve as a buffer between the proposed plant and the more heavily populated areas.

H.1.2 Employment Characteristics

Regional, state and national employment levels for the time period 1970 to 1978 are presented in Tables H-4 through H-7. As can be seen in these tables, the region had a total employment level of approximately 220,930 in 1970 which climbed to a 1978 level of approximately 273,440, resulting in a rate of change of 1.238 (Northeast Florida Regional Planning Council, 1979). ("Rate of change" is a ratio measure of 1978 employment levels to 1970 employment levels. This allows the analyst to gauge the magnitude of change which has occurred during that specific time period for a specific industrial sector. The interpretation of the "rate of change" is as follows: greater than 1.000, a growing sector; equal to 1.000, a stable sector; less than 1.000, a declining sector. See Table H-8.) In comparing the study region to the nation for this time period, the region expanded its total employment base at a rate slightly greater than the

nation as a whole. However, the employment base for the state of Florida during the same period grew at a rate slightly higher than the study region. In terms of individual counties within the region, Flagler and Clay Counties exhibited the greatest growth in employment levels with rates of change of 2.775 and 2.679, respectively. Although Duval County had, by far, the greatest increase in total employment, its rate of change (1.174) was the lowest in the region for this time period (Northeast Florida Regional Planning Council, 1979).

The size of the civilian labor force in the study region in 1970 varied from a high of 220,070 in Duval County to a low of 1,470 in Flagler County. By 1978, the civilian labor force of Duval County had increased to an estimate of 232,630. Although the civilian labor force of Flagler County more than doubled by 1978, it was still the lowest in the seven county region. Table H-9 presents the current estimate and projected civilian labor force of the region for the years 1970-2005 (Northeast Florida Regional Planning Council, 1979).

Unemployment trends for the region, state and nation for the years 1973 to 1979 are presented in Table H-10. During this period, the national unemployment rate increased from 4.9 percent in 1973 to 8.5 percent in 1975 and began dropping to 5.8 percent in 1979 (U.S. Department of Labor, 1980). With the exception of 1973, the unemployment rate for the state of Florida was consistently higher than the national rate during this period. However, the study region had unemployment rates below national levels for the same period (Florida Department of Commerce, 1980). Data presented on Table H-10 indicate the unemployment rate of the study region is tied quite closely to the unemployment rate of Jacksonville/Duval County.

The average gross weekly earnings of production and/or nonsupervisory workers for the Jacksonville Standard Metropolitan Statistical Area (SMSA), state and nation for the years 1970 and 1978 are presented in Table H-11. Although earnings data were not available for the study region on an individual county basis, the Jacksonville SMSA was determined to be quite

adequate for this analysis since the Jacksonville SMSA consists of Baker, Clay, Duval, Nassau, and St. Johns Counties and comprises approximately 95 percent of the total employment of the region (Northeast Florida Regional Planning Council, 1979).

In 1970, the national average gross weekly earnings for production and/or nonsupervisory workers was approximately $120. Although the average for the state of Florida of about $119 was slightly below the national average, the Jacksonville SMSA was higher with an average a little over $122. By 1978, average gross weekly earnings for the nation increased by 70 percent while the Jacksonville SMSA increased by 98.9 percent during the same period. The state also had a higher than national average gross weekly earnings by 1978, exhibiting a 74.6 percent increase over the 1970 level (U.S. Department of Labor, 1980).

Sector Analysis

The sector analysis consists of an evaluation of the employment levels of specific industrial sectors within the region and compares them to state and national trends. The sectors considered in evaluating the employment base of the study region are as follows: agriculture; mining; construction; manufacturing; transportation, communication and public utilities; wholesale and retail trade; finance, insurance and real estate; service; and government. Throughout this analysis, data from Tables H-4 through H-7 are utilized. All regional employment data are presented in Tables H-4 and H-5 (Northeast Florida Regional Planning Council, 1979). State and national employment data are presented in Tables H-6 and H-7 (U.S. Department of Labor, 1980) while regional, state and national "rates of change" are presented in Table H-8.

Agriculture

Agricultural employment data generally include employment in fisheries and forestry, as well as commercial agriculture. In 1970, agricultural employment in the study region constituted about 0.3 percent of the

region's total employment. By 1978, agricultural employment increased its share of the region's total employment to 1 percent. However, this increase was due primarily to increases in fisheries and forestry employment, not actual agricultural employment (Jacksonville Area Planning Board, 1980a). Employment in production agriculture (crops and livestock) in the region follows the national trend of decreasing numbers. National employment trends indicate a steady decline in agricultural employment from 1970 to 1978. The state of Florida as a whole also had a considerable decline in agricultural employment from 1970 to 1978. Although the agricultural employment category in the study region exhibited a rate of change ratio of 3.810 during this period, with fisheries and forestry employment accounting for the actual increase, it still accounted for a smaller proportion of total regional employment than it did state and/or national levels. For instance, in 1970, agriculture constituted about 4.8 percent of national employment and 6.9 percent of the total employment in the state of Florida. By 1978, agriculture accounted for 3.9 percent of national employment and 3.5 percent of state employment, compared to 1 percent of regional employment.

Actual agricultural production in the region includes special crops such as vegetables, fruits, melons and nursery plants. Beef cattle and dairy cattle production has been on a steady decline for the past decade, while swine and poultry production has also been limited. Acreage for these activities is becoming very limited because of excessive use and increased urbanization (U.S. Department of Agriculture, 1978).

Mining

There is no significant mining activity in the study region. Therefore, a discussion of state and/or national data for this sector is deemed unnecessary.

Construction

Construction employment within the region from 1970 to 1978 generally followed state and national trends. The region, state and nation displayed growth in this sector in raw numbers. However, construction employment declined in its share of total employment during this period in all three areas. In 1970, construction employment constituted 6.7 percent of total regional employment and 4.8 percent of national employment. By 1978, construction employment's share of total regional employment had declined to 5.5 percent while declining to 4.7 percent of national employment. It should be pointed out that the above data compare only two years (1970 and 1978). Construction employment is tied quite closely to economic conditions of the time. Therefore, employment in this sector tends to fluctuate from year to year depending on the economic climate in a particular area.

Manufacturing

Although Florida and the study region are comparatively weak in manufacturing, this sector is one of the more dominant employment sectors within the region. In 1970, the employment level in this sector accounted for 14.8 percent of the region's employment. By 1978, manufacturing's share of regional employment had declined to 12.7 percent although the actual employment base increased. This trend held true for the state and nation as well during this period. The national level for manufacturing employment in 1970 was about 26 percent of total employment. By 1978, this sector's share of total national employment had declined to 22.8 percent. Manufacturing employment's share of state employment dropped from 13.9 percent to 12.6 percent during the 1970-1978 period.

Manufacturing in the study region is primarily concentrated in four industries (Jacksonville Area Planning Board, 1980a). Food and kindred products dominate manufacturing employment, accounting for approximately 20 percent of the total. This is followed by fabricated metals (12 percent),

paper and allied products (11 percent), and printing and publishing (10 percent). Several of the larger employers in the manufacturing sector are St. Regis, Swisher and Son, Florida Publishing, Maxwell House, Anheuser-Busch, and Alton Box Board.

Although manufacturing is one of the larger employment bases in the study region, comparative data indicate this sector serves a less significant role within the region than it does on a national level.

Transportation, Communications and Public Utilities

The regional, state and national employment trends for the Transportation, Communication and Public Utilities (TCPU) sector for 1970 to 1978 are similar to those previously discussed in the construction sector description. From 1970 to 1978, the region expanded its employment level in the TCPU sector from approximately 15,700 to about 17,370. However, this sector's share of total regional employment decreased from 7.1 to 6.4 percent. National and state TCPU employment followed this same trend during the period. TCPU employment decreased from 6.1 percent to 5.4 percent for the nation and from 6.7 to 5.9 percent for the state.

Wholesale and Retail Trade

The wholesale and retail trade sector is the most dominant employment sector in the region. In 1970, employment in this sector accounted for 27.1 percent of total regional employment. Although wholesale and retail trade had a slight decrease of 1 percent in the sector's share of total regional employment from 1970-1978, it was well above the national level of 21.7 percent. During 1978, wholesale and retail employment in Duval County comprised approximately 85 percent of the total employment in this sector, indicating that Jacksonville/Duval County is the hub of wholesale and retail activity within the region.

Finance, Insurance and Real Estate

The Finance, Insurance and Real Estate (FIRE) sector for the region experienced an employment expansion slightly above the national level during the years 1970 to 1978. In 1970, regional FIRE employment was about 20,090 and by 1978, it had reached approximately 27,020. The FIRE sector accounted for 9.9 percent of total regional employment in 1978, well above the national level of 5.2 percent. This indicates the FIRE sector is somewhat more important to the economy of the region than it is to that of the nation as a whole.

Services

During the period 1970 to 1978, regional employment in the service sector followed the national trend quite closely. In 1970, the region's service sector accounted for 16 percent of total regional employment. By 1978, this sector's share of total regional employment increased to 17 percent. During the same period, national service sector employment increased its share of total employment from 15.5 percent to 17.9 percent.

Government

The regional government sector displayed a modest increase in its employment base from 1970 to 1978. In 1970, regional government sector employment accounted for 18.9 percent of total regional employment. By 1978, this sector accounted for 20.9 percent of total regional employment. National employment levels in this sector also showed modest increases over the period.

H.1.3 Income Characteristics

Table H-12 presents data for total personal income for the seven county study region for 1970-1985. In 1970, the region had a total personal income level of approximately $1.9 billion. By 1978, total

personal income had reached an estimated level of $3.7 billion. During the period 1970-1978, Baker County had the highest increase in personal income with a positive change of 209 percent (Table H-13). However, this substantial increase still gave Baker County less than 1 percent (0.95) of total regional personal income in 1978. In 1970, Duval County accounted for approximately 86.7 percent (Table H-13) of the personal income earned in the region. This proportion remained relatively stable (86.2 percent) from 1970-1978, displaying an increase of 97 percent. The primary contributing sectors to this income level in Duval County were government, wholesale and retail trade; and services, in that order. These three sectors accounted for 67.3 percent of total personal income in Duval County in 1970 and 61.1 percent in 1978. This distribution of income in Duval County is representative of the region as a whole, although, the construction; finance, insurance and real estate; and service sectors have displayed consistent increases in their contribution to total personal income in the region over the past several years. As can be seen from the regional data in Table H-12, this trend is expected to continue into 1985. By 1985, government, wholesale and retail trade; and services are expected to constitute approximately 60.6 percent of total regional personal income. Although the manufacturing sector has been declining in its contribution to regional personal income since 1970, it is expected to remain the fourth largest contributor into 1985 with approximately 11.6 percent of total regional personal income (Northeast Florida Regional Planning Council, 1979).

Table H-14 presents per capita income data for the region, state and nation. In 1970, every county in the region had a per capita income below the national and state average. Baker County had the lowest 1970 per capita income while Duval and Clay Counties had the highest. By 1978, national per capita income had increased 101 percent over the 1970 level. Although every county in the region remained below the national average in 1978, each county displayed a higher rate of increase from 1970 to 1978 than the nation. Flagler County showed the highest rate of increase (174 percent) in the region during the period. As in 1970, Duval County had the

highest per capita income in the region in 1978, exhibiting a 130 percent increase over the 1970 level. The geographical distribution of per capita income in the study region is expected to remain about constant through 1985. As the data in Table H-14 indicate, Duval County is projected to remain the region's leader, followed by Flagler and St. Johns Counties (Northeast Florida Regional Planning Council, 1979).

H.1.4 Public Services, Housing and Infrastructure Profile

Public Service

This section examines the current (1980) levels and capacities of specific public services within Jacksonville/Duval County. Since results of the Ebasco/Enviropshere Construction Worker Model determined any major population increases caused by the proposed plant would be in Jacksonville/Duval County, only the public services provided by Jacksonville/Duval County are considered in this analysis.

The current status (1980) of the identified service functions are presented in Chapter 7, Tables 7.2-5 through 7.2-16. The model used to determine the present status of the various public services assesses the current excess or deficient capacities of identified public services, based on current demand and desirable local service standards for that service. Table H-15 illustrates the service functions examined, the governmental jurisdiction of each service function and the desired service standard for each.

The city's general administration service function has two major components, financial administration and general control. This service function relates to the judicial, legislative, and government-wide financial management activities. Based on U.S. Department of Commerce standards (Table H-15) for cities with populations between 500,000 and 999,999, Jacksonville/Duval County should maintain a staff of approximately 1135 in this service function. According to these standards the

City/County needs an additional 122 employees to sufficiently meet the current (1980) demand for these services (current service level was extracted from the 1979-80 City of Jacksonville Budget).

The police component of the public safety service function currently (1980) has adequate capacity and personnel to meet public demand. Based on U.S. Department of Commerce standards (Table H-15), a city of Jacksonville's population would require a police department staff of approximately 1,325 officers and supportive personnel. The current staff of the Jacksonville police service function is about 1,485 personnel (1979-80 City of Jacksonville Budget), which actually allows the police department of Jacksonville/Duval County an existing excess of approximately 160 full time personnel. Full time personnel estimates are based on all activities concerned with the enforcement of law and order, including medical examiner, police training academies, investigation bureaus, dispatchers, and all operational and supportive personnel.

The fire protection component of the public safety service function is currently (1980) operating well within standards for a city the size of Jacksonville (Insurance Service Office, 1974 and American Insurance Association, 1975). Fire service function standards are based on first due response time and pumping capacity. The present status of the Jacksonville/Duval County Fire Department allows for a first due response radius of 2 miles or less for engine companies and 3 miles or less for ladder companies, with each having a pumping capacity of 500-1,500 gallons per minute (Duval County Fire Department, 1980).

The Jacksonville/Duval County public works service function is comprised of three components - sewage, water and sanitation. At present (1980), all three are operating with excess capacity. The sewage component has a current service level capacity of approximately 71.7 million gallons per day, while the current demand on the service is about 50.7 million gallons per day. This results in a current excess of approximately 21 million gallons per day. The water component has a current service level

capacity of about 178.3 million gallons per day. The current resident demand on the water system is approximately 57.1 million gallons per day allowing for an excess of over 121 million gallons per day. The current service level capacity of the sanitation component is 1,112,800 total pounds per day. Resident demand for this public service function is about 863,920 total pounds per day, resulting in an excess capacity of approximately 248,880 total pounds per day (Duval County Public Works Department, 1979).

Based on U.S. Department of Commerce standards, a city with a population as large as Jacksonville's should maintain a public health staff of approximately 750 personnel. At present, the public health service function of Jacksonville/Duval County has a staff of 165 (1979-80 City of Jacksonville Budget), resulting in a deficiency of approximately 590 personnel. However, there is an abundance of non-public health facilities in the Jacksonville area.

The recreation service function implies many various activities to each individual. Recreation may be an indoor or outdoor activity and participation may be active or passive. This analysis deals primarily with outdoor facilities such as local parks and beach areas.

As with most metropolitan areas, desirable and much needed open space for recreation is being lost daily to urban expansion. Jacksonville presently administers approximately 355 neighborhood, community and metropolitan parks. Population estimates for 1980 indicate the need for approximately 4000 acres of additional open space to adequately meet the recreational needs of Jacksonville/Duval County (Jacksonville Area Planning Board, 1980b).

The library service function of Jacksonville/Duval County also serves Nassau County. The system is currently (1980) operating at a deficit as far as total book holdings are concerned. It should be noted this deficit is based on a service level required to meet the demand created by the

population of Duval and Nassau Counties. Based on the demand level created by these combined populations, the library system has a current deficiency of 484,255 total book holdings. Current holdings of other items such as audio visual aids, records and periodicals are adequate to meet current demand (current level from Jacksonville Public Library System, 1980).

The public school system of Jacksonville/Duval County currently (1980) has the physical capacity to accommodate the school age children of the area. The projected total enrollment in Duval County for school year 1980-81 is approximately 102,600. The current physical capacity of the school system, in pupil stations, is a little more than 107,000, resulting in an excess of approximately 4,400 pupil stations (Duval County Public School System, 1980).

There are also approximately 60 private and parochial schools located throughout Duval County. These schools range from teaching only 3 grades to teaching 13 grades (K-12) and include two special education centers (Jacksonville Area Planning Board, 1979).

The Jacksonville area also provides several colleges and universities, and trade/technical schools which are listed below:

Colleges and/or Universities

Florida Junior College
University of North Florida
Jacksonville University
Edward Waters College
Jones College

Trade and/or Technical Schools

College of Medical Arts and Business
Jacksonville Business College
Florida College of Medical and Dental Assistants
Stenotype Institute of Jacksonville

Private Services and Facilities

This section examines the current (1980) status of two non-public services, hospitals and housing, in Jacksonville/Duval County.

As mentioned earlier in this section, the public health service function in Jacksonville/Duval County has a large deficit in personnel. One explanation could be the abundance of non-public health facilities (hospitals) in the city. The various private hospitals in Jacksonville/Duval County are currently (1980) maintaining a service level of approximately 1,065,000 patient days. With a current resident demand of about 779,200, this equates to a current excess of approximately 286,000 patient days or a capacity level of 73 percent. The capacity benchmark utilized by a majority of the hospitals in the area is 80 percent. When resident demand (utilization) reaches the 80 percent benchmark, enough beds are added to reduce the utilization percentage to 70 percent (Health Systems Agency of Northeast Florida, 1980).

At present (1980), there are approximately 223,000 total available housing units in Jacksonville/Duval County. The types of housing units considered in this analysis were single family homes (owned or rented), apartments, and mobile homes - motel rooms were not included. Based on current estimates, the resident demand for housing in Jacksonville/Duval County is approximately 211,800, which results in a current housing surplus of over 11,000 units (Jacksonville Area Planning Board, 1978). Although data regarding the quality and type (single family home, multi-family, mobile home) of available housing in Duval County are outdated (1976), reasonable assumptions about these factors can be made.

Based on a 1976 "windshield" survey by the Jacksonville Area Planning Board, the predominant type of residence in Duval County was single-family units, comprising 64.3 percent of the total housing stock. Mobile homes accounted for 6.7 percent of the total stock while multi-family dwellings made up the remaining 29 percent. Of the 211,506 units surveyed in 1976,

94.4 percent were determined to be in standard condition, 3.9 percent were substandard but suitable for rehabilitation, and the remaining 1.7 percent were substandard beyond repair.

During the period 1970 to 1974, despite several years of tight mortgage money and escalating interest rates, the number of year round dwelling units in Duval County increased substantially. The largest numeric increase during this period was in multi-family units. This apartment boom of the early seventies created a larger supply of multi-family units than demand could support, resulting in a high vacancy rate. This rate has lessened somewhat over the past few years, but is still quite high compared to single family units. Data available for October, 1979 showed a vacancy rate of 1.9 percent for single family homes, while multi-family units exhibited a vacancy rate of 5.7 percent (Jacksonville Area Planning Board, 1980a).

H.1.5 Traffic Circulation Service

Another segment of the infrastructure of Duval County to be considered is the local road and highway network. Neither current state or local highway department traffic counts are available for roads which are expected to provide access to the site. For this reason, traffic counts were conducted as a part of this study. Traffic counts were performed for Heckscher Drive, New Berlin Road, Eastport Road, and Main Street. Manual turning movement counts were also performed at the intersections of Main Street - Heckscher Drive, Heckscher Drive - Eastport Road, and Eastport Road - Main Street. From this information, average daily traffic and peak hour traffic were calculated for those points and compared to the existing capacity.

Figure H-2 indicates locations at which the traffic counts were taken. Several machine counts were made at various locations. These counts ranged from several hours to several days in order to validate the turning movement counts and also to give a good estimate of the average

daily traffic on these facilities. Four hour manual counts were made at the intersections to determine the turning movements during the peak hours. A sample classification count was also made at these locations to determine the percent of autos, single unit trucks, and tractor trailers that were passing through these intersections. Table H-16 shows an hourly tabulation of the average daily traffic for the four streets that were included in this project. This table indicates that the present traffic on Heckscher Drive is approximately 10,300 vehicles per day, New Berlin Road is approximately 1,600 vehicles per day, Eastport Road is approximately 7,600 vehicles per day, and Main Street is approximately 16,500 vehicles per day. These average daily traffic volumes are specific points along the roadway and could increase or decrease depending on the particular section of roadway. The volumes in Table H-16 are considered as average in the site area and are used as such.

Figures H-3, H-4, H-5 and H-6 indicate the peak hour traffic for both the a.m. and p.m. periods and the existing capacity of the approaches. As shown in these figures, the capacity of the approaches is much greater than the existing peak hour volumes (Harland Bartholomew and Associates, Inc., 1980). Presently the intersections of Heckscher Drive - Main Street and Eastport Road - Main Street are signalized. The intersection of Heckscher Drive and Eastport Road is stop controlled. The intersection of Heckscher Drive and the spur to I-95 and the intersection of Heckscher Drive and Main Street are locations noted to be creating delays at the existing traffic level. The Heckscher Drive and Main Street intersection is presently operating under stop control.

Additional transportation systems of importance to Jacksonville are airports and port facilities. Major airports include Jacksonville International Airport, Craig Airport, Herlong Airport, and the Mayport Naval Air Field. The locations of these airports are illustrated in Figure H-7.

Jacksonville International Airport is a major asset to the region. This airport provides commercial service directly to Atlanta and other southeastern cities as well as to certain other major airports. In addition, this airport provides general aviation facilities. It is the only civil airport in the region that is capable of accommodating higher performance, more sophisticated general aviation aircraft. Recently, improvements have been made to the facility and its growth is expected to continue.

Craig Airport serves as a general aviation facility. This airport has experienced increased traffic. Current plans call for runway and instrumentation improvements to accommodate traffic growth.

Herlong Airport, unlike Craig, is not projected to experience increased traffic. Two existing runways are to be closed. This would increase availability of land for future aircraft related facilities. Mayport Naval Air Field serves air support needs of the Mayport Naval Base. Levels of use of this facility are dependent upon military scheduling and requirements.

Jacksonville functions as a major port facility serving the southeastern United States. Port facilities include Blount Island and the Talleyrand Docks and Terminals. Many Jacksonville industries are dependent upon barge and oceangoing vessels for transportation of raw materials and finished products. Port facilities serve as an asset in attracting new industries to the city. Growth of the local economy requires the maintenance and expansion of port facilities. Direct and indirect improvements required include expansion of terminal facilities, improvements of the deep-water harbor, and improvements to the port's accessibility. Expansion of port facilities is constrained largely by the encroachment of other urban land uses, and the presence of sensitive wetlands (Jacksonville Area Planning Board, 1979). Current short range port improvement plans include a 1,150 foot extension to the marginal wharf at Blount Island (Jacksonville Port Authority, 1980).

H.2 REGIONAL POPULATION PROJECTIONS

At the present time, a wide range of different population projections are in use by different agencies throughout Florida. The University of Florida publishes a set of projections which are updated each year. The projections are presented as high, medium, and low scenarios. While the state of Florida makes use of these annual updates, the projections by the Jacksonville Area Planning Board (JAPB), which are utilized in this analysis, are based solely on the projections prepared by the University of Florida's Bureau of Economic and Business Research and published in their Bulletin No. 48, with the exception of Duval County projections. The population projections for Duval County are based on studies conducted by the JAPB staff during 1974 and 1975 (Northeast Florida Regional Planning Council, 1979).

Projections utilized in this study differ from the University of Florida figures produced in 1978 (Bulletin No. 44), and those produced in 1977 (Bulletin No. 41). In general, the difference between the figures used in this analysis and those utilized by the JAPB in earlier years is that the current figures are based on the University of Florida high scenario. The high series projections were chosen because they appeared to conform more closely to recent population trends than the projections previously used (Northeast Florida Regional Planning Council, 1979).

Most statistics for analyzing the socioeconomic impacts on the study region of this analysis are based on projections by the JAPB. Local units of government in the northeast Florida region rely on JAPB data for formulating local plans and forecasting required capital improvements. JAPB in turn relies on the projections prepared by the University of Florida's Bureau of Economic and Business Research. Since the scope of this study is regional, utilization of JAPB figures was deemed appropriate in assuring conformity with local and regional planning policies.

The following discussion details the actual method in which the JAPB population projections were utilized in the socioeconomic analysis of the proposed plant.

In order to assess the fiscal and demographic effects of the proposed plant, the Envirosphere Fiscal Impact (FIM) and Construction Worker Models were utilized. Before either model can be used, a projection of the resident populations of the area during the study period, which in this case is 1980-2027, must be made.

H.2.1 Resident Population

Resident population levels were derived for the following counties:

Duval
Baker
Clay
Flagler
Nassau
Putnam
St. Johns

The Duval County/City of Jacksonville resident population estimates, which were based on projections by the JAPB staff rather than the University of Florida, were utilized in computing the resident demand for public service functions, when applicable. The population estimates of the JAPB/University of Florida for all the counties mentioned above, with the exception of Putnam, were utilized in computing the resident demand (patient days) for the hospital (non-public) service function. Putnam County was excluded because it is not in the service area of Jacksonville area hospitals.

The method used to compute the Duval County/City of Jacksonville population level was a combination of the step-up and interpolation methods. For the years 1980, 1985, 1990, 1995 and 2000, the population levels are based upon estimates provided by the JAPB. For intervening years, such as 1982, interpolation was utilized, as illustrated by the example below:

Interpolation for Intervening Years:

$$Pop_{t+} = (Pop_{t+5} - Pop_t) \frac{T}{S} + Pop_t \qquad (H.2\text{-}1)$$

where:

Pop_{t+} - Population level at intervening year t+

Pop_{t+5} - Population level at 5 years above the base year t

Pop_t - Population level at base year t

T - Intervening year

S - Appropriate interval

Example: For Year 1982

$$Pop_{1982} = (Pop_{1985} - Pop_{1980}) \frac{2}{5} + Pop_{1980}$$

$$650,360 = (680,000-630,600)\ (.40) + 630,600$$

For the years 2000 to 2027, a step-up method was utilized to compute the Duval County population levels. The method incorporated population projections from both the University of Florida and the JAPB, as shown in Table H-17. From these two sets of projections, ratios were computed for the University of Florida to JAPB figures, resulting in the series of ratios listed in Table H-17. Examination of these ratios more closely indicates a decrease in the ratios from 1985 to 2000. The average decrease for the time period is 26.4 percent per 5 year period. Therefore, assuming this average decrease per five year period (26.4 percent), ratios for the years 2010 and 2020 can be computed, from which appropriate population levels can be estimated for the years 2010 and 2020. The example below illustrates the computational procedure for the year 2010.

Computation for Population Ratio:

$$PR_{t+10} = (PR_t - 1)(1-.264)(1-.264) + 1 \qquad \text{(H.2-2)}$$

where:

PR_{t+10} = Population ratio (multiplier) at 10 years above base

PR_t - Population ratio at base year t

Example: For Year 2010

$$PR_{2010} = (PR_{2000} - 1)\ (1-.264)(1-.264) + 1$$

$$1.0256 = (1.0473-1)\ (1-.264)(1-.264) + 1$$

Adjustment of University of Florida Projections:

$$Pop_t = Pop_f\ (PR_t) \qquad \text{(H.2-3)}$$

where:

Pop_t - Adjusted population level in year t

Pop_f - University of Florida population level in year t

PR_t - Population ratio, computed from previous step

Example: For Year 2010

$$Pop_{2010} = Pop_f\ (PR_{2010})$$

$$897,500 = 875,100\ (1.0256)$$

For any intervening years between 2000 to 2010 and 2010 to 2020, interpolation was utilized to derive the Duval County population levels in the same manner as previously discussed, except the interval is ten years instead of five. For the intervening years from 2020 to 2027, the annual increment computed by interpolation for the years 2010 to 2020 was used.

The population levels for each of the six other counties (Baker, Clay, Flagler, Nassau, Putnam, and St. Johns) were derived from the JAPB estimates for the years 1980, 1985, 1990, 1995 and 2000. All intervening years within the 1980 to 2000 time period were determined through interpolation of the five year intervals. The projection for each county for each of the years 2000-2027 is based on the average annual increment for the years 1980-2000.

H.2.2 Immigrant Population

The immigrant worker population that will move into Duval County/City of Jacksonville during the construction and operational phases of the proposed plant are utilized in computing the immigrant demand for public services. The term immigrant worker population refers to the level of immigrant workers and their dependents or induced population that will be attracted into an area due to the construction or operation of a proposed plant.

The Envirosphere Construction Worker Model determines and allocates (by county) the level of immigrant construction workers for each year of the construction phase. Table H-18 illustrates the level of immigrant construction workers that will reside in Duval County/City of Jacksonville, as a result of the proposed plant.

The level of immigrant operational workers are based upon the assumption that 15 percent of all operational workers will be immigrants and that all will reside in Duval County/City of Jacksonville. Table H-18 indicates the level of immigrant operational workers that will be induced by the proposed plant.

Table H-19 illustrates both construction and operational workers' household and school-age children multipliers that were utilized in determining the total immigrant population, and the level of immigrant school-age children by grades. The multipliers were derived from a June, 1979 survey conducted by Envirosphere of construction and operational workers at Louisiana Power and Light's Waterford 3 nuclear power plant. Listed below is the computational procedure utilized in determining both total population and level of school-age children for a given year.

For Total Immigrant Population:

$$IP_t = IC_t(HS_c) + IO_t(HS_o) \qquad \text{(H.2-4)}$$

where:

IP_t = Total immigrant population in year t.

IC_t = Total immigrant construction workers in year t.

HS_c - Immigrant construction worker household size multiplier.

IO_t - Level of immigrant operational worker in year t.

HS_o - Immigrant operational worker household size multiplier.

Example: For Year 1984

$$IP_{1984} = IC_{1984}\ (2.27) + IO_{1984}\ (2.88)$$

$$692 = 292(2.27) + 10\ (2.88)$$

For School Age Children

$$SC_{at} = IC_t\ (CSC_{at}) = IO_t\ (OSC_{at}) \qquad \text{(H.2-5)}$$

where:

SC_{at} - Total school children in age group a in year t.

IC_t - Level of immigrant construction workers in year t.

CSC_{at} - Construction school children multipler for age group a in year t.

IO_t - Level of immigrant operational workers in year t.

OSC_{at} - Operational school children multiplier for age group a in year t.

Example: For Year 1984 - Age Group 9 to 11

$$SC_{9/11_{1984}} = IC_{1984} (.12) + IO_{1984} (.19)$$

$$37 = 292 (.12) + 10(.19)$$

Based upon the above example, in 1984, there will be a total immigrant population of 692 people residing in Duval County/City of Jacksonville, which will generate 37 school children in the age group of 9 to 11 years old.

H.3 REGIONAL ECONOMIC IMPACTS

This discussion presents the specific parameters that were utilized in computing the regional economic impacts that would occur from the proposed plant. The term regional economic impacts is defined as the effect the proposed plant will have upon the basic and non-basic employment sectors in terms of additional employment opportunities and income.

H.3.1 Employment Impacts

Total basic employment requirements for the proposed energy facility during the construction and operational phases must first be determined. Table H-20 illustrates the construction and operational employment that would be generated by the proposed plant. However, the basic (construction and operational) employment requirements are only a portion of the total employment impacts which will occur within the study region (Duval, Nassau, Baker, Clay, Flagler, Putnam and St. Johns Counties) as a consequence of the proposed plant, since each annual increment in basic (or direct) jobs will stimulate annual increases in secondary employment within the non-basic sectors. The total employment and the non-basic or secondary, employment impacts of the proposed plant are computed by the use of an employment multiplier.

The assumption behind the employment multiplier is that any increase in the region's basic employment sector will generate indirect and income-induced (secondary) employment effects in the non-basic sectors.

For this study, two total employment multipliers are developed: 1) a 2.761 total employment multiplier for the construction sector, which means for every new job created in the construction (basic) sector, 1.761 jobs will be generated in the non-basic sectors and 2) a 2.879 total employment multiplier for the electric companies sector (operational workers), which means for every new job created in the electric companies (basic) sector,

1.879 jobs will be created in the non-basic sectors. The reason the construction multiplier is lower than the operational worker multiplier is due to a "leakage rate" wich will be discussed later. The procedure used to determine the total employment multiplier (2.879) is as follows:

$$M_r = \frac{E_r}{X_r} \qquad \text{(H.3-1)}$$

where:

M_r - Employment multiplier for region r.

E_r - Total employment in region r.

X_r - Total export activity employment in region r.

To determine the total export activity employment (X_r) in a study region, location quotients were computed by utilizing employment levels on a four digit Standard Industrial Classification (SIC) level for all industrial sectors within the region. The employment levels were derived from a special computer run of the U.S. Bureau of the Census, 1972 County Business Patterns (U.S. Army Corps of Engineers, 1980). The location quotient for an industry (LQi) is computed by determining the ratio of an industry's (i) share of the total economic activity to the industry's share of the national economy. The location quotient (LQ) is expressed as:

$$LQ_i = \frac{E_{ir}}{E_r} \Big/ \frac{E_{in}}{E_n}$$

where:

E_{ir} - Total employment of industry i for region r.

E_r - Total employment in region r.

E_{in} - Total employment of industry i in the nation n.

E_n - Total employment in the nation n.

If the location quotient for an industry is greater than one, it is assumed the region exports the products of that industry and the industry can therefore be described as a basic industry. To ascertain the level of export activity (X_{ir}) in the regional employment of an industry (E_{ir}), the following calculation is employed:

$$X_{ir} = 1 - (1/LQ_i)\ E_{ir} \qquad \text{(H.3-2)}$$

where:

X_{ir} - Total export activity employment of industry i in region r.

LQ_i - Location quotient of industry i.

E_{ir} - Total employment of industry i in region r.

No location quotients were computed for federal employment, hotels, motels, and tourist courts because they are termed exogenous, or created by external sources. These service oriented sectors are not classified as export in the traditional sense, but have income generating properties similar to exports. The total employment levels within those service sections are, therefore, classified as export activity employment. By

summing all total employment in export activities (X_{ir}) along with the employment in the identified service sectors, the total local export employment (X_r) can be ascertained and utilized in Eq. H.3-1. By evaluating changes in basic employment, the multiplier can be used to determine secondary (indirect and income-induced) employment changes during the construction and operational phases.

Development of Leakage Rate

A "leakage rate" is used because some construction workers do not reside within the study region. As a result of having residence outside the study region, a worker's income will "leak" from that region since he or she will spend their income outside the region. This "leakage rate" will affect the employment multiplier in that it will reduce the level of income-induced employment generated by the construction sector in the study region. The "leakage rate" for this analysis is 6.7 percent and is based upon the following:

Construction workers living outside the region (Envirosphere Construction Worker Model $C_{1/D}1.5$)	3.2 percent
Construction workers living within the region during week, but with household outside region (Envirosphere Construction Worker Survey - Waterford 3; June, 1979)	3.5 percent
Total Leakage Rate	6.7 percent

The application of the "leakage rate" to the total employment multiplier to yield the construction worker multiplier is as follows:

$$M_{cr} = (M_r - 1)(K-1) + 1 \qquad (H.3-3)$$

where:

M_{cr} - Construction employment multiplier for region r.

M_r - Total employment multiplier for region r.

K - Leakage rate.

There was no leakage rate applied to the operational worker multiplier since it was assumed that all operational workers would live within the region.

Determination of Non-Basic/Secondary Employment

Once the multipliers have been developed, it is possible to compute the changes that will occur in the non-basic employment sectors. The increment in both construction and operational employment for each time period must first be calculated, as illustrated in Table H-20. Then by incorporating the appropriate multiplier (construction or operational), the changes that will occur in the non-basic sector from both the increases (or decreases) in construction and operational employment can be computed as demonstrated in Table H-21. The multiplier used in this step is the total multiplier M minus 1 (M-1), which yields the non-basic or secondary multiplier.

Once the changes in the non-basic employment sectors have been determined, the user can then determine the preliminary total employment impact (new jobs) that will be created during each time period by the proposed plant, which is also illustrated in Table H-21.

Development of Adjustment Coefficients

One of the major shortcomings in a muliplier analysis is the inability of the multiplier to reveal the period-by-period increments in total regional employment given the exogenous increase in basic employment. The multiplier describes only the total increase in service or non-basic/secondary employment after the direct, indirect and income-induced efforts have worked themselves out. Thus, an employment multiplier of 1.879 merely indicates that after all effects have been experienced, the final increase in non-basic/secondary employment will be 1.879 times greater than the exogenous increase in basic employment. The multiplier is not capable of directly revealing the period-by-period increments in non-basic/secondary employment or how long it will take for local non-basic/secondary employment to arrive at the new equilibrium level. If it is not believed that the non-basic/secondary employment will materialize in a single year, a lag model may be used. By utilizing adjustment coefficients, equilibrium will require a much longer period of time, indicating that the non-basic/secondary employment effects within the regional economy will take place over a longer time frame.

To determine the adjustment coefficients, a factor [B/B+1], representing the proportion of employment that is basic, has been applied. Computations will serve to make this clearer. Assume that B is equal to 1.879 (multiplier used in analysis), and a change in basic employment is 100. Thus, in the first time period, illustrated by Table H-22, basic employment has increased by 100; therefore, total regional employment is instantly increased by that amount. In the second period, the basic employees have departed, but the stimulus they provided causes secondary employment to grow to 65.

In period three, the multiplier continues to operate on the total employment increment of 65 causing secondary employment to fall to 42. This iterative process continues until the change in non-basic/secondary employment attains 188.

Having described the increment nature of the multiplier, the actual amount of time it takes for each increment to be realized must now be identified. According to Moore and Peterson (Moore and Peterson, 1955), an increase in basic employment means an increase in income, hence an increase in consumer demand, which leads in turn to further adjustment in output and employment levels. In attempting to introduce time in the adjustment process, Moore and Peterson observed that each iteration must conform roughly to the amount of time required for income to complete a cycle within the economy. Since the annual velocity (turnover) of money is about three (in non-inflationary times), Moore and Peterson concluded that, on an average, it would take approximately one year for three iterations to work themselves out. Therefore, the annual changes in total and secondary employment can be computed as a percent of the total change by adding the increments of the first, second, third, fourth and fifth 3-period sets and dividing by the total sum of changes. In the previous example, (Table H-22) 100+65+42/288, the first 3-period over the total sum of changes is 72 percent. Therefore, 72 percent of the changes in total employment caused by the multiplier will occur within the first year. For purposes of estimating the lags in the equilibrium adjustments of secondary employment, the following percentages, by year, are used:

Year 1 - 72%
Year 2 - 20
Year 3 - 6
Year 4 - 1
Year 5 - 1

The use of the adjustment coefficients are shown in Table H-23, which indicates that it will take 10 years (1982 to 1992) for the regional economy to arrive at its equilibrium. Therefore, incorporating these adjustments in Table H-24, the total impact that the proposed plant will have upon regional employment for the entire analysis period can be determined.

H.3.2 Income Effects

The purpose of the income analysis is to determine the magnitude of construction, operational and secondary worker income that will accrue to the region during the construction and operation of the proposed plant. The construction phase for this analysis begins in 1982 and ends in 1987, while the operational phase, which actually overlaps with the construction phase during 1984-1987, begins in 1988 and ends in 2027. Commercial operation for Unit 1 is expected to be 1985 and commercial operation for Unit 2 is expected to be 1987. All monetary values are expressed in 1980 constant dollars. The steps required to determine the income effects are as follows:

Determine the Annual Gross Salary for a Construction Worker (AGS_c)

This step determines the annual gross salary paid to the construction workers during the construction phase. The annual gross salary is computed in the following manner:

$$AGS_{ct} = BR_{ct} \ (52) \qquad \text{(H.3-4)}$$

where:

AGS_{ct} - Annual Gross Salary, Construction worker in year t.

BR_{ct} - Weekly Base Rate, Construction worker in year t.

52 - 52 work weeks per year, assumed.

The assumed weekly base rate is $500.
(Ebasco Construction, 1980)

Determine the Annual Gross Salary for an Operational Worker (AGS_o)

This step determines the annual gross salary paid to the operational workers for each year beginning in 1985 and ending in 2027. The annual gross salary is computed in the following manner:

$$AGS_{ot} = AGS_t \ (12) \qquad \text{(H.3-5)}$$

where:

AGS_{ot} - Annual Gross Salary, operational worker in year t.

AGS - Monthly Gross Salary, operational worker in year t.

The base monthly gross salary is $1,420 (JEA union rates).

Determine the Annual Gross Salary for Secondary (Non-Basic) Workers (AGS_s)

This step determines the annual gross salary paid a secondary worker for the time period between 1982 to 2027 and is computed in the following manner:

$$AGS_{st} = W_{st} \ (52) \qquad \text{(H.3-6)}$$

where:

AGS_{st} - Annual Gross Salary, secondary worker in year t.

W_{st} - Weighted Weekly Earnings, secondary worker in year t.

Secondary employment is comprised of the following service-oriented industrial sectors: transportation, communication and public utilities; wholesale and retail; finance, insurance and real estate and services.

Therefore, the W_{st} variable is a weighted average of the weekly earnings for the above mentioned sectors, which is $196.61 per week (U.S. Department of Labor, 1980).

Determine the Applicable Federal Tax Rates (T)

The application of federal tax rates to the AGS_c, AGS_o, and AGS_s determines the level of income that will actually acrue or be generated within the region, since federal tax dollars leave the region for a governmental authority. In this analysis, three federal tax rates were developed, for construction, operational workers and secondary workers.

These rates are based upon 1978 federal (income and social security) taxes paid upon average gross salaries according to marital status and dependents (U.S. Department of Commerce, 1979). The average gross salaries that are utilized are as follows:

Construction - $26,000
Operational - 17,040
Secondary - 10,225

The marital status is married and each worker claims four (4) dependents.

The results are the following tax rates which remain constant through the analysis period:

Construction - 23.59%
Operational - 20.93
Secondary - 16.83

Application of Computed Variables to Determine Total Income Generated

For the Years 1982 to 1983:

$$I_t = E_{ct}(1-K_c)(AGS_{ct})(1-T_c) + E_{st}\ (AGS_{st})(1-T_s) \qquad (H.3\text{-}7)$$

where:

I_t - Total income accrued to the region in year t.

E_{ct} - Total construction employment at the proposed plant in year t.

K_c - The leakage rate for construction employment (discussed in Section II).

AGS_{ct} - Annual gross salary for a construction worker in year t.

T_c - Federal tax rate applied to AGS_{st}.

E_{st} - Total secondary employment induced by the proposed plant in year t.

AGS_{st} - Average gross salary for a secondary worker in year t.

T_s - Federal tax rate applied to AGS_{st}.

The total income (I) as previously stated is presented in 1980 constant dollars.

For 1984 to 1987:

During this time period, operational workers will begin to permanently work at the site. As a result of this action, the Eq. H.3-7 is modified to include operational worker variables and is expressed in the following manner:

$$I_t = E_c(1-K_c)(AGS_{ct})(1-T_c) + E_{oc}(AGS_{ot})(1-t_o) + E_{st}(AGS_{st})(1-T_s) \qquad (H.3\text{-}8)$$

and the operational worker variables are:

E_{ot} - Total operational employment at the proposed plant in year t.

AGS_{ot} - Annual gross salary for an operational worker year t.

T_o - Federal tax rate applied to AGS_{ot}.

As a result of these modifications, E_{st} will include levels generated by both construction and operational workers.

For year 1988 to 2027:

During this period, the proposed plant will be in full operation and all construction workers will have been removed from the site. Therefore, Eq. H.3-8 is modified to remove the construction worker variables and is explained as follows:

$$I_t = E_{ot}(AGS_{ot})(1-T_o) + E_{st}(AGS_{st})(1-T_s) \qquad (H.3\text{-}9)$$

Determine the Total Income for the Construction and Operational Phase

For the Construction Phase (1982 to 1987)

$$I_c = \sum_{t=1982}^{n=6} I_t$$

Total income for the construction phase (I_c) is the sum of total yearly income (I_t) for 1982 to 1987.

For the Operational Phase (1988 to 2027)

$$I_o = \sum_{t=1988}^{n=39} I_t$$

Total income for the operational phase (I_o) is the sum of total yearly income (I_t) for 1988 to 2027.

H.4 ENVIROSPHERE CONSTRUCTION WORKER MODEL

Estimates of the number of construction workers who would have to be relocated were made by utilizing multiple regression equations developed by Envirosphere. The first equation estimates the division of the construction force into local (i.e., those who are recruited from the region and will not be relocated) and immigrant workers (i.e., those who are recruited from outside the region and will have to relocate). The second equation estimates the county of residence of all immigrant construction workers.

The first equation was developed from data contained in 26 construction surveys carried out by the Old West Regional Commission and the Tennessee Valley Authority. The equation recognizes that the percentage of the local construction work force will vary directly as a function of labor force size and inversely as a function of the distance of the labor force from the project.

The study area for this equation was limited to counties within two hours driving time of the project site. The regression equation is given as follows:

$$Y_i = 25.96 + 25.42 \text{ LOG} \sum_{i=1}^{n} \frac{Ci}{D_i^{1.5}} \qquad \text{(H.4-1)}$$

Correlation coefficient (r_2) = .8444

r = .7131

where: Y_i = Local construction worker percentages.

D_i = The distance of the population locus of county "i" in minutes from site.

C_i = A function of the projected 1984 construction employment (labor force) for county "i".

The labor function (C_i) is calculated for each county by taking the projected 1984 (peak year) construction employment for each county within the study area and allocating this number between the plant and other construction projects competing for labor within the same counties. The allocation of construction workers is performed using the following equation:

$$Y_A = X_{1A} \frac{1}{X_{2A}}$$

where: Y_A = the allocation factor for construction project "A".

X_{1A} = the ratio of the number of workers on construction project "A" to the competing construction project with the smallest number of workers.

X_{2A} = the ratio of the distance of construction project "A" from the locus of the county or area population, to the smallest distance of any project from the locus.

The allocation factors for all the construction projects competing for labor within a county are added and then taken as a percentage of the total. Percentages are then multiplied by the projected 1984 construction employment to determine what portion of the construction worker force within each county will be allocated to each project.

The data used to compute the allocation factors, the labor function and the percentage of local construction workers are given in Table H-25. The data presented is for the peak construction year of the proposed plant and includes competing projects for that time period. The local construction worker percentage that is derived for the peak construction year is used for each year of the construction phase.

The second regression equation allocates the migrant construction workers among all counties within 90 minutes of the site. The 90 minutes limit is used in this case because construction worker surveys (Old West

Regional Commission, 1976 and Tennessee Valley Authority, 1971-1975) demonstrate that immigrant workers will be considerably less dispersed than local workers. TVA surveys indicated that only 5.3 percent of the immigrant construction workers lived more than 90 minutes from the site.

The second equation indicates that immigrant construction workers will locate in large numbers within the county nearest to the project. This inverse relationship with distance is by far the most important one. Other variables considered include county population, project size (immigrant construction workers only), county area, (square miles), and construction employment in the county. The regression equation is given as follows:

$$Y_i = -100.37 + 3512.2 \frac{1}{X_i} + .001\ (X_2) \qquad \text{(H.4-2)}$$

$$+ 0.6\ (X_3) + .002\ (X_4) + 3.67\ (\ln X_5)$$

Multiple Correlation Coefficient (r) = .7866

r^2 = .6187

where: Y_i = the number of immigrant construction workers in county "i".

X_1 = the distance (driving time, in minutes) of the locus of population of county "i" from the project.

X_2 = 1984 population of county "i".

X_3 = project size (immigrant construction workers only).

X_4 = county "i" areas (square miles).

X_5 = projected allocated construction employment in county "i" in 1984.

The use of Eq. H.4-2 results in a factor for each county in the study area. These factors are totalled and each county's factor is taken as a percentage of this total. The percentages for each county are then applied to the total immigrant construction workers, yielding the number of workers projected to reside in each county. These results are used to determine the projected population influx and subsequent socioeconomic impacts during the proposed plant's construction phase.

The total manpower requirements for the proposed plant were determined according to manhour estimates for individual items of equipment and unit manpower rates for commodity quantities developed for such categories as piping, insulation, instrumentation, electrical, structural steel, foundations, etc. In-house (Ebasco Services Incorporated) historical data were utilized to determine the appropriate craft mix for each major category of work. Then a monthly construction schedule was prepared by category in conjunction with the engineering and procurement schedule for the entire project. The time phasing indicated by the construction schedule was utilized to resource load the individual craft man hour estimates based on a 40-hour work week. Then by summing the total manhours by craft for each month, it was possible to determine the peak manpower requirements for each month of the construction phase.

The data used to determine the immigrant construction location patterns during the construction phase (1982 to 1987) are displayed in Tables H-26 and H-27. Table H-26 contains all the variables for the peak construction year of 1984. For the years 1982, 1983, 1985, 1986, and 1987 variables X_1 and X_4 remain constant and adjustments are made to variables X_2, X_3 and X_5 according to the year. Table H-27 gives the adjusted X_2, X_3 and X_5 variables for the years 1982, 1983 and 1984.

H.5 ENVIROSPHERE FISCAL IMPACT MODEL

This discussion presents specific parameters (required data inputs, stated assumptions and computational procedures) that are incorporated into the Envirosphere Fiscal Impact Model (FIM) to quantify the public service costs and revenue system impacts that will be generated by the proposed plant.

Model Description

The two models utilized in the fiscal analysis are illustrated in Figures H-8 and H-9 and Figures H-10 and H-11. The Residential Model is composed of two submodels. The first submodel (Figure H-8) identifies and computes all city and county operational and capital public service costs that are attributed to a proposed plant's immigrant construction and operational worker's population on a per period basis. This is done by first determining the level of population induced by the immigrant worker (the immigrant worker levels are computed via the Envirosphere Construction Worker Model), which then determines the immigrant worker population's service demand for specific city and county public services. Next, the submodel determines the excess or deficient capacities that exist within various public service functions that will be affected by the immigrant worker population. The excess or deficient capacities are based upon the current resident demand for a specific public service utilizing service demand standards in relation to the current maximum service level or capacity of that public service function. Then, based upon the ability or inability of a public service function to absorb the immigrant worker population's induced demand (excess or deficient demand), additional operating and capital costs will be assigned to the immigrant population. The submodel also determines whether an increase in operational service will require any additional capital outlays. The second submodel (Figure H-9) identifies and computes the effect the immigrant worker population will have upon a city's and county's revenue systems (e.g., property tax

revenue, revenue sharing) on a per period basis during the construction and operational phases. The methods used to compute the new public revenues are based upon federal and state allocation formulas and local computational procedures.

The Nonresidential Model, like the Residential Model, is comprised of two submodels. The first submodel (Figure H-10) isolates and computes city and county public service costs, on a per period basis, that are attributed to the proposed plant during the construction and operational phases. This is done by identifying specific operational and capital responses requested by the proposed plant. Based upon specific service responses, operational and capital costs are then assigned to the proposed plant. The submodel will also determine whether an increase in operational service will require any additional capital outlays. The second submodel (Figure H-11) ascertains the effect the proposed plant will have upon a city's and county's revenue systems during the construction and operational phases. Like the Residential Model's public revenue submodel, all new public revenues will be determined by federal and state allocation formulas and local computational procedures.

The term operational cost is defined as that cost which occurs when an immigrant population or proposed plant will require a service function to respond to its demand with public manpower, such as a new policeman or maintenance of highways or inspection of a facility. The term capital cost is defined as that cost which occurs when an immigrant population or proposed plant will require a service function to purchase a piece of equipment (e.g., patrol car) or construct a new facility (e.g., fire station).

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Table H-1

REGIONAL POPULATION ESTIMATES AND PROJECTIONS, 1970-2020

County	1970	1978	1980	1985	1990	1995	2000	2010	2020
Baker	9,242	13,045	14,200	16,800	19,100	21,100	23,200	27,700	32,200
Clay	32,059	54,339	61,100	76,600	87,000	96,200	105,300	127,400	149,500
Duval	528,865	584,252	630,600	680,000	726,000	772,600	817,000	897,500	978,400
Flagler	4,454	8,405	9,600	12,400	14,000	15,500	17,000	20,700	24,400
Nassau	20,626	31,686	35,000	42,700	48,500	53,700	58,800	69,500	81,000
Putnam	36,424	45,045	47,700	53,700	60,900	67,400	73,800	86,850	99,900
St. Johns	31,035	44,550	48,700	58,100	65,900	72,900	79,800	95,350	110,900
Total	662,705	781,322	846,900	940,300	1,021,400	1,099,400	1,174,900	1,325,000	1,476,300

Source: Northeast Florida Regional Planning Council, 1979; Ebasco/Envirosphere Company

Table H-2
MEDIAN AGE OF REGIONAL POPULATION, 1970-2000

Year	Baker	Clay	Duval	County Flagler	Nassau	Putnam	St. Johns
1970	26.5	25.2	26.0	33.4	25.4	28.3	31.8
1978	28.5	25.2	27.5	38.5	25.8	31.7	34.7
1980	24.0	29.8	27.0	35.5	35.5	32.2	32.9
1985	25.5	32.0	28.0	36.6	36.6	33.6	34.2
1990	26.4	34.2	30.0	37.5	37.6	35.5	36.1
1995	27.0	36.4	32.0	37.9	37.9	37.6	38.0
2000	26.2	38.4	32.0	38.3	38.3	39.9	40.1

Source: Northeast Florida Regional Planning Council, 1979

Table H-3

POPULATION ESTIMATES AND PROJECTIONS
WITHIN A 5-MILE RADIUS OF PROPOSED PLANT, 1980-2005

1980	1985	1990	1995	2000	2005
20,800	23,300	26,270	29,480	33,120	37,255

Source: Jacksonville Area Planning Board, 1979; Ebasco/Envirosphere Company

Table H-4

REGIONAL EMPLOYMENT BY MAJOR SECTOR, 1970

Sector	County							Total
	Baker	Clay	Duval	Flagler	Nassau	Putnam	St. Johns	
Agriculture	49	14	592	I	54	33	I	742 (.003)
Mining	-	-	-	-	-	-	-	-
Construction	I	153	13,219	16	683	282	378	14,731 (.067)
Manufacturing	138	625	25,036	124	2,273	3,231	1,148	32,575 (.148)
TCPU	37	I	15,008	I	78	309	267	15,699 (.071)
W/R Trade	337	830	54,369	108	997	1,625	1,710	59,976 (.271)
FIRE	I	172	19,402	22	68	198	232	20,094 (.091)
Services	28	672	31,575	149	308	679	1,980	35,391 (.160)
Government	1,120	1,360	34,200	200	1,440	1,700	1,700	41,720 (.189)
Total	1,709 (.008)	3,826 (.017)	193,401 (.875)	619 (.003)	5,901 (.027)	8,057 (.036)	7,415 (.034)	220,928 (1.000)

Notes: 1. Numbers in parenthesis represent proportions of the total and may not total 1.000 due to rounding.

2. Definitions - TCPU is for Transportation, Communication and Public Utilities
- W/R Trade is for Wholesale and Retail Trade
- FIRE is for Finance, Insurance and Real Estate
- "I" signifies no data available

Source: Northeast Florida Regional Planning Council, 1979

Table H-5

REGIONAL EMPLOYMENT BY MAJOR SECTOR, 1978

Sector	County							Total
	Baker	Clay	Duval	Flagler	Nassau	Putnam	St. Johns	
Agriculture	182	I	1,890	I	194	273	288	2,827 (.010)
Mining	-	-	-	-	-	-	-	-
Construction	34	610	12,607	96	224	969	515	15,055 (.055)
Manufacturing	174	696	26,260	164	2,505	3,234	1,893	34,926 (.127)
TCPU	50	534	16,087	90	123	277	205	17,366 (.064)
W/R Trade	330	3,226	60,541	271	1,310	2,310	3,262	71,250 (.261)
FIRE	56	524	25,222	131	319	321	445	27,018 (.099)
Services	70	1,985	40,374	502	515	1,178	3,272	47,896 (.175)
Government	1,780	2,676	44,136	464	2,321	2,978	2,743	57,098 (.209)
Total	2,676 (.010)	10,251 (.037)	227,117 (.831)	1,718 (.006)	7,511 (.028)	11,540 (.042)	12,623 (.046)	273,436 (1.000)

Notes: 1. Numbers in parenthesis represent proportions of the total and may not total 1.000 due to rounding.

2. Definitions - TCPU is for Transportation, Communication and Public Utilities
- W/R Trade is for Wholesale and Retail Trade
- FIRE is for Finance, Insurance and Real Estate
- "I" signifies no data available

Source: Northeast Florida Regional Planning Council, 1979

Table H-6

NATIONAL AND STATE EMPLOYMENT BY MAJOR SECTOR, 1970

	U.S. (in 000)	Florida (in 000)
Agriculture	3,566.0	160.4
	(.048)	(.069)
Mining	623.0	8.3
	(.008)	(.004)
Construction	3,588.0	175.7
	(.048)	(.076)
Manufacturing	19,367.0	322.6
	(.260)	(.139)
TCPU	4,515.0	154.5
	(.061)	(.067)
W/R Trade	15,040.0	545.8
	(.202)	(.236)
FIRE	3,645.0	131.3
	(.049)	(.057)
Services	11,548.0	416.2
	(.155)	(.180)
Government	12,554.0	397.8
	(.169)	(.172)
Total	74,446.0	2,312.6
	(1.000)	(1.000)

Notes: 1. Numbers in parenthesis represent proportions of the total and may not total 1.000 due to rounding.
2. Definitions - TCPU is for Transportation, Communication and Public Utilities
- W/R Trade is for Wholesale and Retail Trade
- FIRE is for Finance, Insurance and Real Estate
- "I" signifies no data available

Source: U.S. Department of Labor, 1980

Table H-7

NATIONAL AND STATE EMPLOYMENT BY MAJOR SECTOR, 1978

(000)

	U.S. (in 000)	Florida (in 000)
Agriculture	3,501.0	114.7
	(.039)	(.035)
Mining	837.0	9.5
	(.009)	(.003)
Construction	4,212.0	209.5
	(.047)	(.064)
Manufacturing	20,332.0	415.5
	(.228)	(.126)
TCPU	4,859.0	194.2
	(.054)	(.059)
W/R Trade	19,394.0	836.9
	(.217)	(.254)
FIRE	4,676.0	219.3
	(.052)	(.067)
Services	15,979.0	693.9
	(.179)	(.211)
Government	15,476.0	601.8
	(.173)	(.183)
Total	89,266.0	3,295.3
	(1.000)	(1.000)

Notes: 1. Numbers in parenthesis represent proportions of the total and may not total 1.000 due to rounding.

2. Definitions - TCPU is for Transportation, Communication and Public Utilities
   - W/R Trade is for Wholesale and Retail Trade
   - FIRE is for Finance, Insurance and Real Estate
   - "I" signifies no data available

Source: U.S. Department of Labor, 1980

Table H-8

REGIONAL, STATE AND NATIONAL RATES OF CHANGE IN EMPLOYMENT BY SECTOR, 1970 TO 1978

Sector	Regional	State	National
Agriculture	3.810	.715	.982
Mining	-	1.145	1.344
Construction	1.022	1.192	1.174
Manufacturing	1.072	1.288	1.050
TCPU	1.106	1.257	1.076
W/R Trade	1.188	1.533	1.290
FIRE	1.345	1.670	1.283
Services	1.353	1.667	1.384
Government	1.369	1.513	1.233
Total Employment	1.238	1.425	1.199

Note: Definitions - TCPU is for Transportation, Communication and Public Utilities
- W/R Trade is for Wholesale and Retail Trade
- FIRE is for Finance, Insurance and Real Estate

"Rate of change" is a ratio measure of 1978 employment levels to 1970 employment levels, which allows the analyst to gauge the magnitude of change occurring during that specific time period for a specific industrial sector. The interpretation of "rate of change" is as follows: greater than 1.000, a growing sector; equal to 1.000, a stable sector; less than 1.000, a declining sector.

Source: Ebasco/Envirosphere Company, U.S. Department of Labor

Table H-9

REGIONAL CIVILIAN LABOR FORCE: BY PLACE OF RESIDENCE, 1970-2005

Year	County							
	Baker	Clay	Duval	Flagler	Nassau	Putnam	St. Johns	Total
1970	3,092	9,531	220,070	1,470	7,143	13,091	11,058	265,455
1978	5,220	21,540	232,630	3,450	12,500	16,590	15,620	307,550
1980	5,950	25,520	254,060	4,290	14,050	17,260	18,120	339,250
1985	7,590	34,030	275,910	6,020	17,640	19,930	22,450	383,570
1990	9,050	39,700	296,250	7,010	20,550	23,130	26,390	422,080
1995	10,300	44,750	316,880	7,910	22,770	25,955	29,310	457,875
2000	11,630	49,740	336,530	8,840	25,150	28,820	32,490	493,200
2005	12,660	53,850	356,753	9,580	27,090	31,210	35,120	526,263

Source: Northeast Florida Regional Planning Council, 1979.

Table H-10

REGIONAL, STATE AND NATIONAL UNEMPLOYMENT TRENDS, 1973-1979

(Percent)

Area	1973	1974	1975	1976	1977	1978	1979
National	4.9	5.6	8.5	7.7	7.0	6.0	5.8
Florida	4.3	6.2	10.7	9.0	8.2	6.6	6.0
Region - 7 Counties	4.8	5.1	6.7	6.3	6.8	6.1	5.7
Baker	3.0	3.9	6.3	5.7	5.4	5.1	3.7
Clay	3.7	3.6	5.1	4.4	4.2	4.7	4.3
Duval	4.9	5.0	6.6	6.4	6.9	6.1	5.6
Flagler	2.0	5.9	8.8	9.1	7.9	5.8	5.5
Nassau	3.9	3.6	5.9	5.4	6.0	5.6	5.3
Putnam	3.3	6.2	8.1	6.7	8.4	7.1	7.6
St. Johns	6.9	8.1	9.6	7.0	8.8	7.7	7.4

Source: U.S. Department of Labor, 1980

Table H-11

JACKSONVILLE SMSA, STATE AND NATIONAL AVERAGE

WEEKLY EARNINGS, 1970 AND 1978

Area	1970	1978	% Change
Jacksonville SMSA	$122.36	$243.36	98.9
Florida	$118.78	$207.36	74.6
National	$119.83	$203.70	58.8

Notes: 1. Definition - Jacksonville SMSA is the Jacksonville Standard Metropolitan Statistical Area - includes Baker, Clay, Duval, Nassau and St. Johns Counties.
2. Earnings are for production and/or nonsupervisory workers.

Source: U.S. Department of Labor, 1980

Table H-12

TOTAL ESTIMATED AND PROJECTED PERSONAL INCOME ($000) EARNED BY INDUSTRY - REGIONAL, 1970-1985

(Constant Dollars)

Year	Industry								
	Manufac-turing	Construc-tion	W/R Trade	FIRE	TCPU	Services	Agricul-ture	Govern-ment	Total
1970	264,480 (.141)	16,647[b] (.009)	398,773 (.213)	170,485[a] (.091)	174,940 (.093)	276,219 (.147)	21,750 (.012)	553,433 (.295)	1,876,727 (1.000)
1978	451,500 (.122)	291,200 (.078)	711,100 (.192)	349,200 (.094)	331,700 (.089)	602,700 (.162)	54,600 (.015)	920,300 (.248)	3,712,300 (1.000)
1980	493,400 (.120)	325,100 (.079)	781,300 (.190)	388,300 (.094)	366,200 (.089)	674,400 (.164)	60,800 (.015)	1,032,500 (.250)	4,122,000 (1.000)
1985	598,000 (.116)	409,600 (.080)	952,900 (.185)	486,300 (.095)	452,300 (.088)	853,600 (.166)	76,400 (.015)	1,313,300 (.255)	5,142,400 (1.000)

a signifies no data were disclosed for this sector in Duval County.
b signifies no data were disclosed for this sector in Clay County.

Notes: 1. Numbers in parenthesis represent proportions of the total and may not total 1.000 due to rounding.
2. Definitions - TCPU is for Transportation, Communication and Public Utilities
- W/R Trade is for Wholesale and Retail Trade
- FIRE is for Finance, Insurance and Real Estate

Source: Northeast Florida Regional Planning Council, 1979

Table H-13

TOTAL PERSONAL INCOME - COUNTY, 1970-1978

(Constant Dollars)

County	Total Personal Income 1970 ($000)	% Total	Total Personal Income 1978 ($000)	% Total	% Change 1970-1978
Baker	$ 11,410	.61	$ 35,300	.95	+209
Clay	40,022	2.31	92,300	2.49	+130
Duval	1,626,849	86.69	3,199,300	86.18	+ 97
Flagler	7,685	.41	20,100	.54	+162
Nassau	56,615	3.02	108,600	2.93	+ 92
Putnam	71,035	3.79	122,900	3.31	+ 73
St. Johns	63,111	3.36	133,800	3.60	+112

Source: Northeast Florida Regional Planning Council, 1979

Table H-14

PER CAPITA INCOME - ESTIMATES AND PROJECTIONS, 1970, 1978, and 1985

			County						
	U.S.	Fla.	Baker	Clay	Duval	Flagler	Nassau	Putnam	St. Johns
1970	$3,893	$3,698	$1,886	$2,620	$2,853	$2,156	$2,308	$2,303	$2,473
1978	7,840	7,478	3,802	5,354	6,560	5,897	4,704	4,674	5,684
1985	I	I	5,087	7,086	8,962	8,414	6,271	6,523	7,686

Note: "I" signifies no data available

Source: U.S. Department of Labor, 1980; Northeast Florida Regional Planning Council, 1979

Table H-15
SERVICE STANDARDS UTILIZED TO DETERMINE THE ADEQUACY OF PUBLIC SERVICES IN JACKSONVILLE/DUVAL COUNTY

Service Function	Jurisdiction	Standard Utilized	Source
General Administration			
Financial Administration	City/County	.0005 Full Time Employees/Person	U.S. Dept. of Commerce, 1978
General Control	City/County	.0013 Full Time Employees/Person	U.S. Dept. of Commerce, 1979
Public Safety			
Police	City/County	.0021 Full Time Employees/Person	U.S. Dept. of Commerce, 1978
Fire	City/County	1 Engine - 2 Mile Service Radius 1 Ladder - 4 Mile Service Radius 500-1500 gpm Pumping Capacity	Insurance Service Office, 1974 American Insurance Association, 1975
Public Works			
Sewage	City/County	Resident Demand - 80.44 Gallons/Person/Day Includes Residential, Commercial and Industrial Usage	Jacksonville/Duval County Dept. of Public Works, 1979
		Immigrant Demand - 1975-1984; 23.91 Gallons/Person/Day 1985-1999; 24.96 Gallons/Person/Day 2000+; 26.02 Gallons/Person/Day Includes Residential Usage Only	Water Resources Council, 1978
Water	City/County	Resident Demand - 90.62 Gallons/Person/Day Includes Residential, Commercial and Industrial Usage	Jacksonville/Duval County Dept. of Public Works, 1979
		Immigrant Demand - 1975-1984; 33.63 Gallons/Person/Day 1985-1999; 35.11 Gallons/Person/Day 2000+; 36.59 Gallons/Person/Day Includes Residential Usage Only	Water Resources Council, 1978

Table H-15 (Continued)
SERVICE STANDARDS UTILIZED TO DETERMINE THE ADEQUACY OF PUBLIC SERVICES IN JACKSONVILLE/DUVAL COUNTY

Service Function	Jurisdiction	Standard Utilized	Source
Sanitation	City/County	Resident Demand - 1.37 Pounds/Person/Day	Jacksonville/Duval County Dept. of Public Works, 1979
		Immigrant Demand - 2.44 Pounds/Person/Day	Environmental Protection Agency, 1980
Health and Welfare			
Public Health	City/County	.0012 Health Personnel/Person	U.S. Dept. of Commerce, 1978
Recreation/Library			
Parks	City/County	2.5 Acre/1,000 Population	Jacksonville Area Planning Board, 1979
Library	City/County	2.5 Books/Person 1 Film/1,000 Population 1 Record/50 Population 1 Periodical/250 Population under 250,000 and 1 Periodical/500 Population over 250,000	Florida Library Association, 1974
Education			
Elementary (Grades K-6)	City/County	22.4:1 Student/Teacher Ratio	Jacksonville/Duval County School Board, 1980
Middle (Grades 7-9)	City/County	24.1:1 Student/Teacher Ratio	
High (Grades 10-12)	City/County	18.4:1 Student/Teacher Ratio	

Table H-16

AVERAGE DAILY TRAFFIC, 1980

	Heckscher Drive	New Berlin Road	Eastport Road	Main Street
6-7 a.m.	602	61	615	1,041
7-8	825	119	567	1,386
8-9	544	63	405	839
9-10	591	85	403	813
10-11	665	127	369	856
11-12	642	112	412	827
12-1 p.m.	633	91	394	909
1-2	626	100	416	950
2-3	791	102	495	1,059
3-4	741	120	528	1,261
4-5	810	159	565	1,292
5-6	708	130	515	1,228
6-7	451	89	400	868
7-8	271	69	282	696
8-9	267	51	266	542
9-10	243	47	216	519
10-11	278	38	228	244
11-12	168	15	136	318
12-1 a.m.	120	16	115	234
1-2	60	4	63	99
2-3	44	7	36	98
3-4	55	6	41	59
4-5	46	10	47	81
5-6	84	15	77	227
TOTAL (ADT)	10,265	1,636	7,591	16,446

Source: Harland Bartholomew and Associates, Inc., 1980, Contract Traffic Study

Table H-17

DATA INPUTS FOR POPULATION PROJECTIONS

Year	U of Fla	JAPB	Ratio
1980	584,100	630,600	1.0796
1985	607,600	680,000	1.1192
1990	670,900	726,000	1.0821
1995	725,500	772,000	1.0641
2000	780,100	817,000	1.0473
2010	875,100	897,500	1.0256
2020	965,000	978,400	1.0139

Sources: University of Florida, Jacksonville Area Planning Board and Envirosphere Company

Table H-18

LEVEL OF IMMIGRANT CONSTRUCTION AND OPERATIONAL WORKERS
DUVAL COUNTY/CITY OF JACKSONVILLE

Year	Construction Worker	Operational Workers
1982	43	
1983	204	
1984	292	10
1985	290	42
1986	167	42
1987	99	56
1988	0	56
-		
1992		56
-		
1997		56
-		
2022		56
-		
2025		56
2026		42
2027		42

Source: Envirosphere Company

Table H-19

IMMIGRANT HOUSEHOLD SIZE AND SCHOOL-AGE CHILDREN MULTIPLIERS

Construction and Operational Workers

Category	Construction	Operational
Household Size	2.27	2.88
School-Age Chidren (Ages)		
4 and under	.12	.56
5 to 8	.19	.31
9 to 11	.12	.19
12 to 15	.13	.09
16 to 18	.08	.06

Source: Envirosphere Company

Table H-20

CONSTRUCTION AND OPERATIONAL EMPLOYMENT LEVELS
(Basic Sectors)

Year	Construction	Operational	Δ Construction	Δ Operational
1982	254	0	+254	0
1983	1,366	0	+1,112	0
1984	2,316	68	+950	+68
1985	2,294	281	-22	+213
1986	1,089	281	-1205	0
1987	614	375	-475	+94
1988	0	375	-614	0
1989	0	375	0	0
-				
-				
2025	0	375	0	0
2026	0	281	0	-94
2027	0	281	0	0

Source: Envirosphere Company

Table H-21

BASIC AND SECONDARY EFFECTS FROM CONSTRUCTION AND OPERATIONAL EMPLOYMENT

(without lags)

Year	Construction Employment		Operational Employment			Total
	Δ Basic	Δ Secondary	Δ Basic	Δ Secondary	ΔTotal	New Jobs
1982	+254	+445	0	0	+699	699
1983	+1,112	+1,949	0	0	+3,061	3,760
1984	+950	+1,665	+68	+128	+2,811	6,571
1985	-22	-39	+213	+400	+552	7,123
1986	-1,205	-2,112	0	0	-3,317	3,806
1987	-475	-833	+94	+177	-1,037	2,769
1988	-614	-1,076	0	0	-1,690	1,079
1989	0	0	0	0	0	1,079
-						
-						
2025	0		0	0	0	1,079
2026	0		-94	-177	-271	808
2027	0		0	0	0	808

Note: Construction non-basic/secondary multiplier is 1.761 and the operational non-basic/secondary multiplier is 1.879.

Source: Envirosphere Company

Table H-22

REGIONAL EMPLOYMENT CHANGES
7-COUNTY REGION
(Example)

Time Period (Quarter)	Basic	Secondary	Total
1	100		100
2	0	65	65
3	0	42	42
4	0	28	28
5	0	18	18
6	0	12	12
7	0	8	8
8	0	5	5
9	0	3	3
10	0	2	2
11	0	1	1
12	0	1	1
13	0	1	1
14	0	1	1
15	0	1	1
New Equilibrium	0	0	0
Sum of Changes	100	188	288

Source: Envirosphere Company, based on Moore and Peterson

Table H-23

INCORPORATION OF ADJUSTMENT COEFFICIENTS - BASIC AND SECONDARY EMPLOYMENT

CHANGES WITH "LAGS" IN IMPACT CONSIDERED

	Changes in Secondary (Table 2)										
Year	82 +445	84 +1,949	84 +1,793	85 +361	86 -2,112	87 -656	88 -1,076	Annual Changes	Total Secondary Employment	Total Basic Employment	Total Employment
1982	(.72) 321							321	321	254	575
1983	(.20) 89	(.72) 1,404						1,493	1,814	1,366	3,180
1984	(.06) 27	(.20) 390	(.72) 1290					1,707	3,521	2,384	5,905
1985	(.01) 4	(.06) 117	(.20) 359	(.72) 260				740	4,261	2,575	6,836
1986	(.01) 4	(.01) 19	(.06) 108	(.20) 71	(.72) -1521			-1,319	2,942	1,370	4,312
1987	(.00) 0	(.01) 19	(.01) 18	(.06) 22	(.20) -422	(.72) -472		-835	2,107	989	3,096
1988		(.00) 0	(.01) 18	(.01) 4	(.06) -127	(.20) -131	(.72) -775	-1,011	1,096	375	1,471
1989			(.00) 0	(.00) 4	(.01) -21	(.06) -39	(.20) -214	-270	826	375	1,201
1990				(.00) 0	(.01) -21	(.01) -7	(.06) -65	-93	733	375	1,108
1991					(.00) 0	(.01) -7	(.01) -11	-18	715	375	1,090
1992						(.00) 0	(.01) -10	-11	704	375	1,079
1993							(.00) 0	0	704	375	1,079
1994									704	375	1,079

Source: Envirosphere Company, 1980

Table H-24

REGIONAL EMPLOYMENT
7-COUNTY REGION
(with lag effects)

Year	Basic		Non-Basic/ Secondary	Total
	Construction	Operational		
1982	254		321	575
1983	1,366		1,814	3,180
1981	2,316	68	3,521	5,905
1985	2,294	281	4,261	6,836
1986	1,089	281	2,942	4,312
1987	614	375	2,107	3,096
1988		375	1,096	1,471
1989		375	826	1,201
1990		375	733	1,108
1991		375	715	1,090
1992 -		375	704	1,079
1997 -		375	704	1,079
2002 -		375	704	1,079

Table H-25

DATA INPUTS USED FOR ESTIMATING THE LOCAL CONSTRUCTION WORKER PERCENTAGE

COUNTY AND POPULATION LOCUS	DISTANCE FROM SITE IN MINUTES (D)	1984 CONST. EMPLOYMENT	ALLOCIATION FACTOR	ALLOCATED 1984 CONST. EMP. JEA (C_i)	$C_i/D1.5$	JEA 2316 X_{1A} = 2.79			KINGSBAY 1200 X_{1A}=1.44			SEMINOLE 831 X_{1A}=1.00		
						D	X_{2A}	Y_A	D	X_{2A}	Y_A	D	X_{2A}	Y_A
Florida														
Baker-Macclenny	61	590	.62	366	.77	61	1.00	2.79	85	1.39	1.04	90	1.48	.68
Bradford-Starke	82	489	.54	264	.36	82	1.26	2.21	106	1.63	.88	65	1.00	1.00
Clay-Orange Park	40	1424	.62	883	3.49	40	1.00	2.79	71	1.78	.81	44	1.10	.91
Columbia-Lake City	101	929	1.00	929	.96	101	1.00	2.79	127	-	-	130	-	-
Duval-Jacksonville	25	16021	.74	11856	94.85	25	1.00	2.79	59	2.36	.61	71	2.84	.35
Flagler-Bunnell	108	256	.57	146	.13	108	2.08	1.34	139	-	-	52	1.00	1.00
Nassau-Fernandina Beach	44	1310	.61	799	2.74	44	1.00	2.79	46	1.05	1.37	112	2.55	.39
Putnam-Palatka	97	850	.21	179	.19	97	10.78	.26	133	-	-	9	1.00	1.00
St. Johns-St. Augustine	66	1380	.58	800	1.49	66	1.16	2.41	109	1.91	.75	57	1.00	1.00
Union-Lake Butler	95	213	.57	121	.13	95	1.00	2.79	120	1.26	1.14	96	1.01	.99
Georgia														
Brantley-Nahunta	107	393	.62	237	.21	107	1.20	2.33	89	1.00	1.44	157	-	-
Camden-St. Marys	61	321	.06	19	.04	61	30.50	.09	2	1.00	1.44	111	55.50	.02
Charlton-Folkston	67	96	.52	50	.09	67	1.43	1.95	47	1.00	1.44	118	2.51	.40
Glynn-Brunswick	88	1381	.58	801	.97	88	1.40	1.99	63	1.00	1.44	145	-	-
Ware-Waycross	115	656	.62	407	.33	115	1.20	2.33	96	1.00	1.44	167	-	-

Y_1 = 25.96 25.42 (Log 103.62)

TOTAL $C_i/D1.5$ 106.71

Y_1 = 77.19% Local Construction Workers

NOTES: Kingsbay is a large military construction project in Camden County, Georgia.
Seminole is another power plant construction project in Putnam County, Florida.

SOURCE: EBASCO/ENVIROSPHERE COMPANY

Table H-26

DATA INPUTS FOR DETERMINING THE IMMIGRANT CONSTRUCTION WORKER LOCATION PATTERNS,
PEAK CONSTRUCTION YEAR - 1984

COUNTY AND POPULATION LOCUS	DISTANCE FROM SITE IN MINUTES (X_1)	1984 POPULATION (X_2)	TOTAL IMMIGRANT COST WORKERS (X_3)	AREA IN SQ. MILES (X_4)	1984 ALLOCATED CONST. EMP. (X_5)	RESULTANT FACTOR (Y_1)	PERCENT OF TOTAL	IMMIGRANT CONST. WORKERS
Florida								
Baker-Macclenny	61	15500	493	585	366	11.17	4.0	20
Bradford-Starke	82	19020	493	294	264	5.01	0.0	--
Clay-Orange Park	40	68660	493	593	883	49.98	17.9	88
Duval-Jacksonville	25	602900	493	766	11856	165.95	59.3	292
Nassau-Fernadina Beach	44	38760	493	650	799	38.74	13.9	69
St. Johns-St. Augustine	66	53200	493	605	800	13.49	4.8	24
Georgia								493
Camden-St. Marys	61	14682	493	653	19	.38	.1	--
Charlton-Folkston	67	7110	493	796	50	-1.71	0.0	--
Glynn-Brunswick	88	54298	493	412	801	- .09	0.0	--
					TOTAL	279.71		

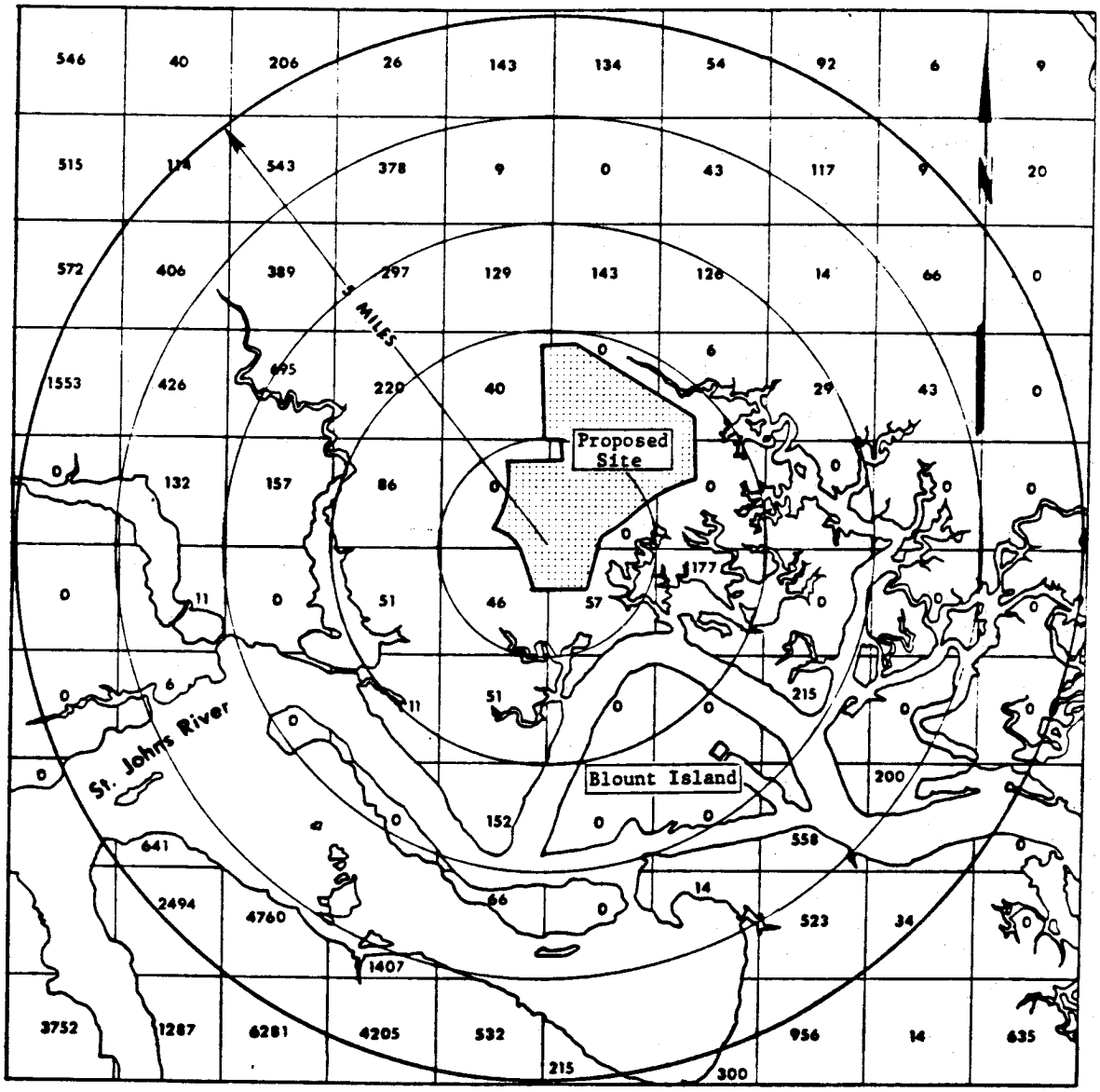
SOURCE: EBASCO/ENVIROSPHERE COMPANY

Table H-27

INPUTS FOR DETERMINING IMMIGRANT CONSTRUCTION WORKER LOCATION PATTERNS FOR THE YEARS 1982-1987 (EXCLUDING PEAK YEAR 1984)

	Counties and Population Locus				
	Baker-Macclenny	Clay-Orange	Duval-Jacksonville	Nassau-Fernandina Beach	St. Johns-St. Augustine
1982					
Population (X_2)	14700	63980	593500	36480	50400
Tot. Immi. Const. Workers (X_3)	54	54	54	54	54
Allocated Const. Emp. (X_5)	347	821	11639	752	756
1983					
Population (X_2)	15100	66320	598200	37620	51800
Tot. Immi. Const. Workers (X_3)	291	291	291	291	291
Allocated Const. Emp. (X_5)	357	851	11731	776	778
1985					
Population (X_2)	15900	71000	607600	39900	54600
Tot. Immi. Const. Workers (X_3)	489	489	489	489	489
Allocated Const. Emp. (X_5)	376	911	11915	823	820
1986					
Population (X_2)	16300	73340	612300	41040	56000
Tot. Immi. Const. Workers (X_3)	232	232	232	232	232
Allocated Const. Emp. (X_5)	385	941	12007	846	841
1987					
Population (X_2)	16700	75680	617000	42180	57400
Tot. Immi. Const. Workers (X_3)	131	131	131	131	131
Allocated Const. Emp. (X_5)	394	971	12099	870	862

Source: Ebasco/Envirosphere Company



NOTE: 5-Mile radius centered on proposed plant stack location

SOURCE: Aerial Photography 1980
Jacksonville Area Planning Board, 1978

Figure H-1 Estimated Population Density Within 5 Miles of the Proposed Site

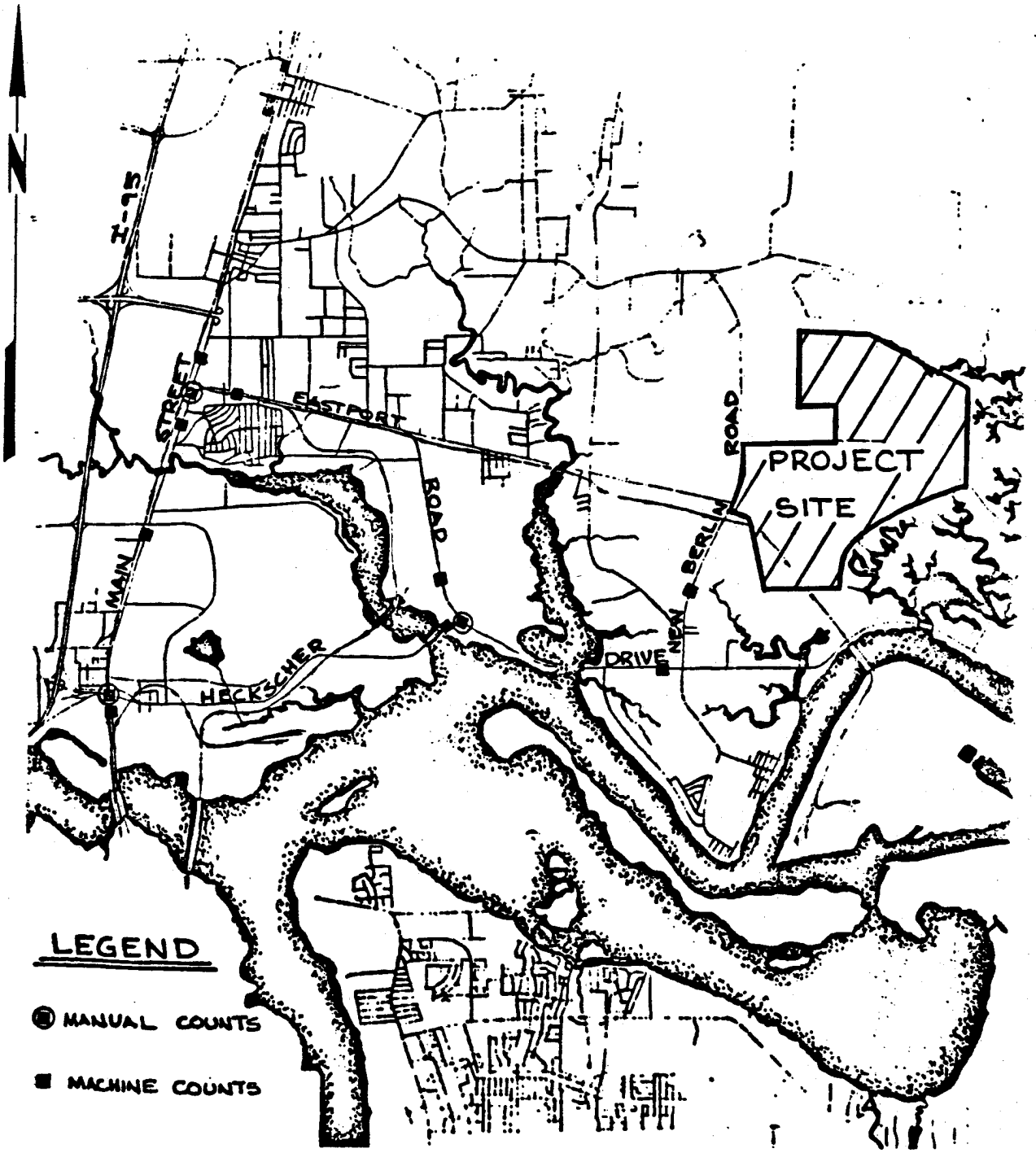


Figure H-2 Location Map - August 6, 1980

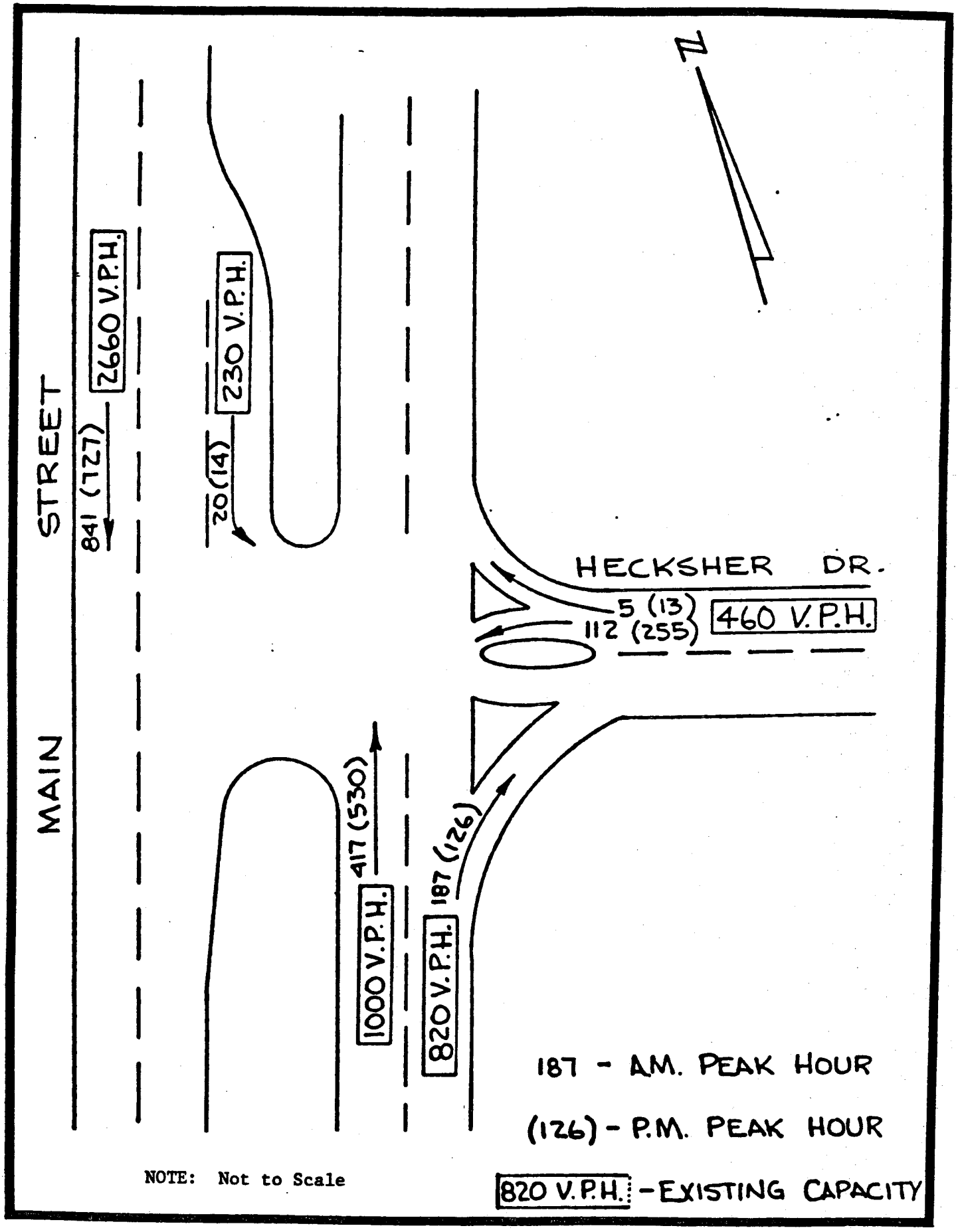


Figure H-3 Peak Hour Traffic - Heckscher Drive - Main Street

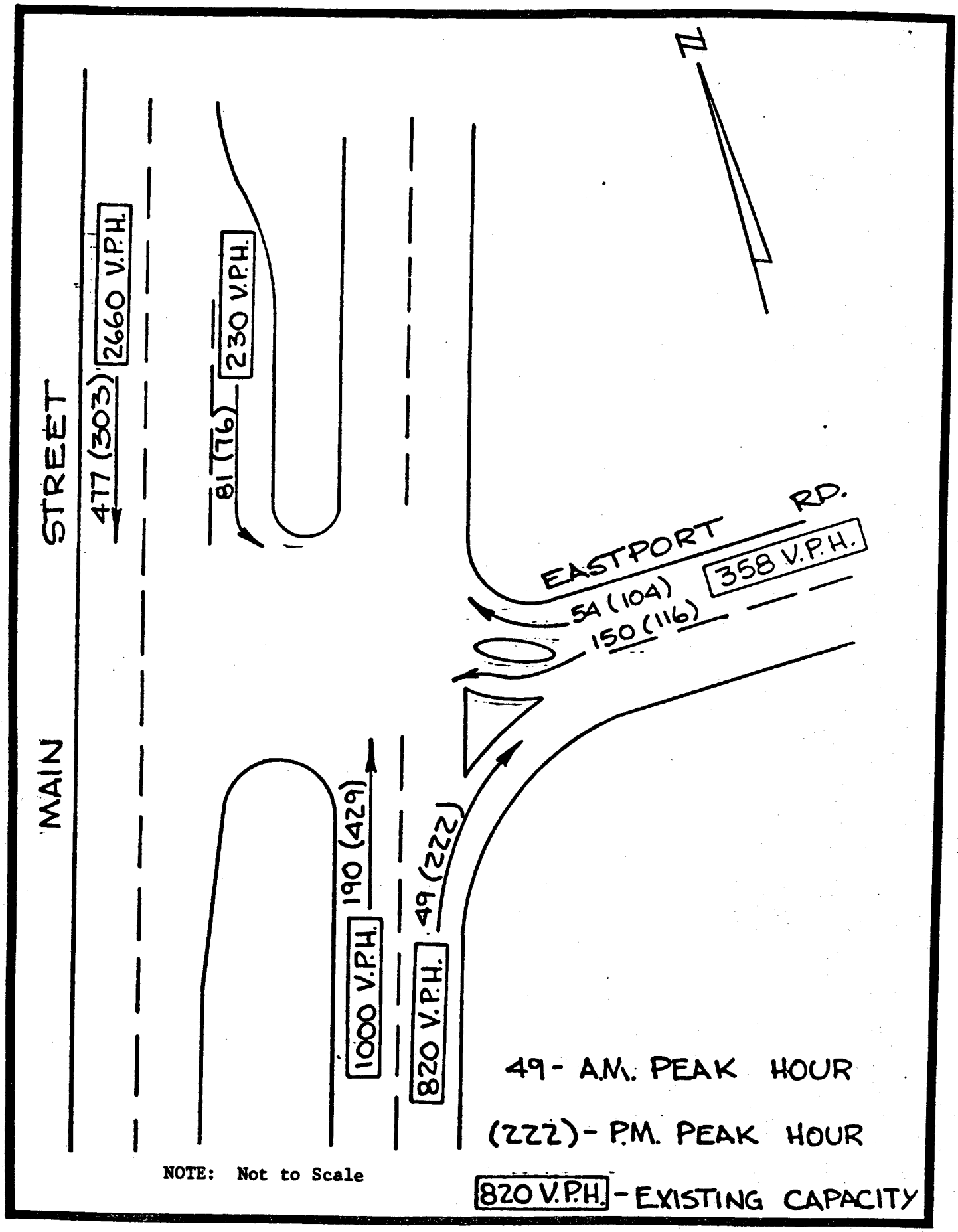


Figure H-4 Peak Hour Traffic - Eastport Road - Main Street

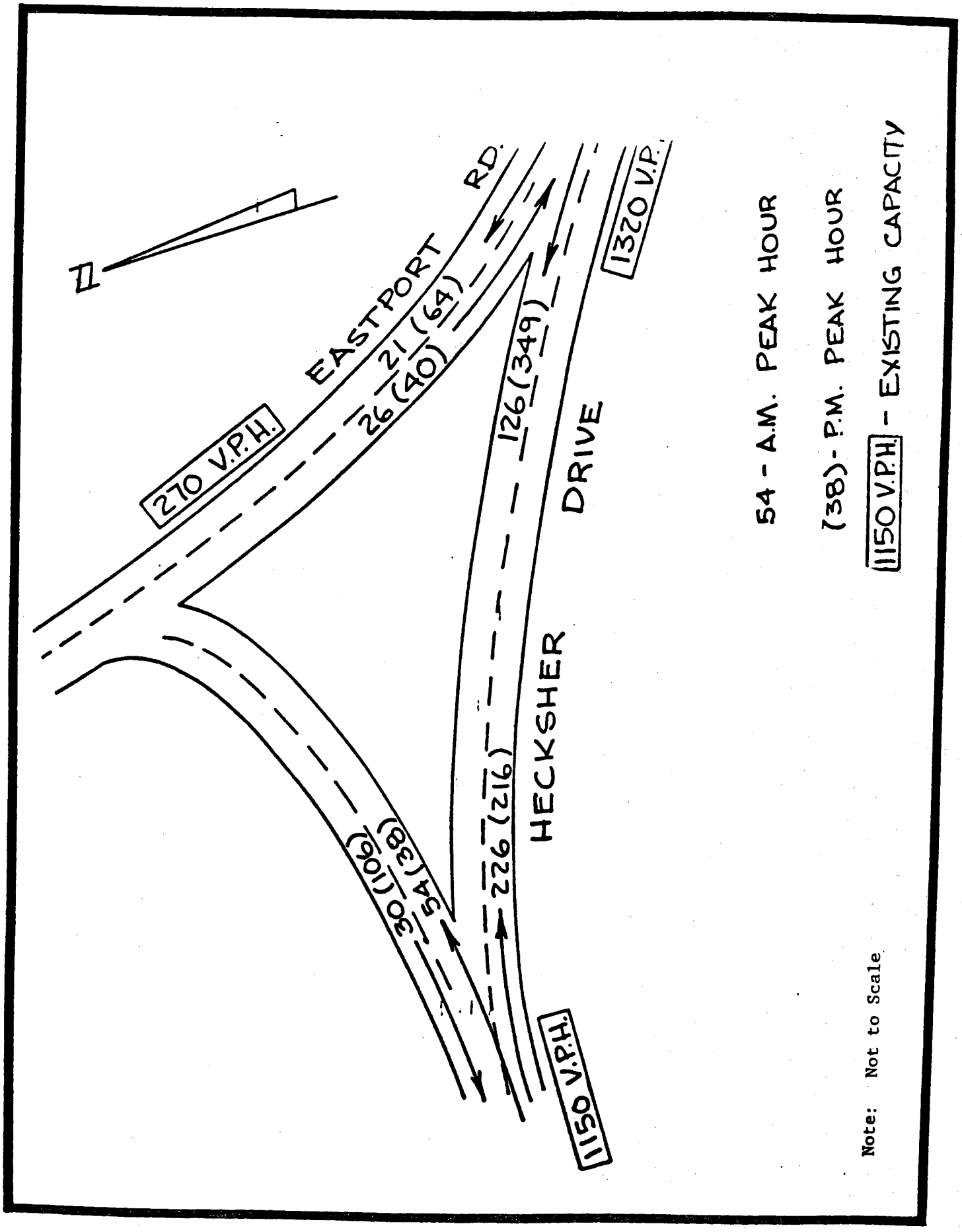


Figure H-5 Peak Hour Traffic - Eastport Road - Heckscher Drive

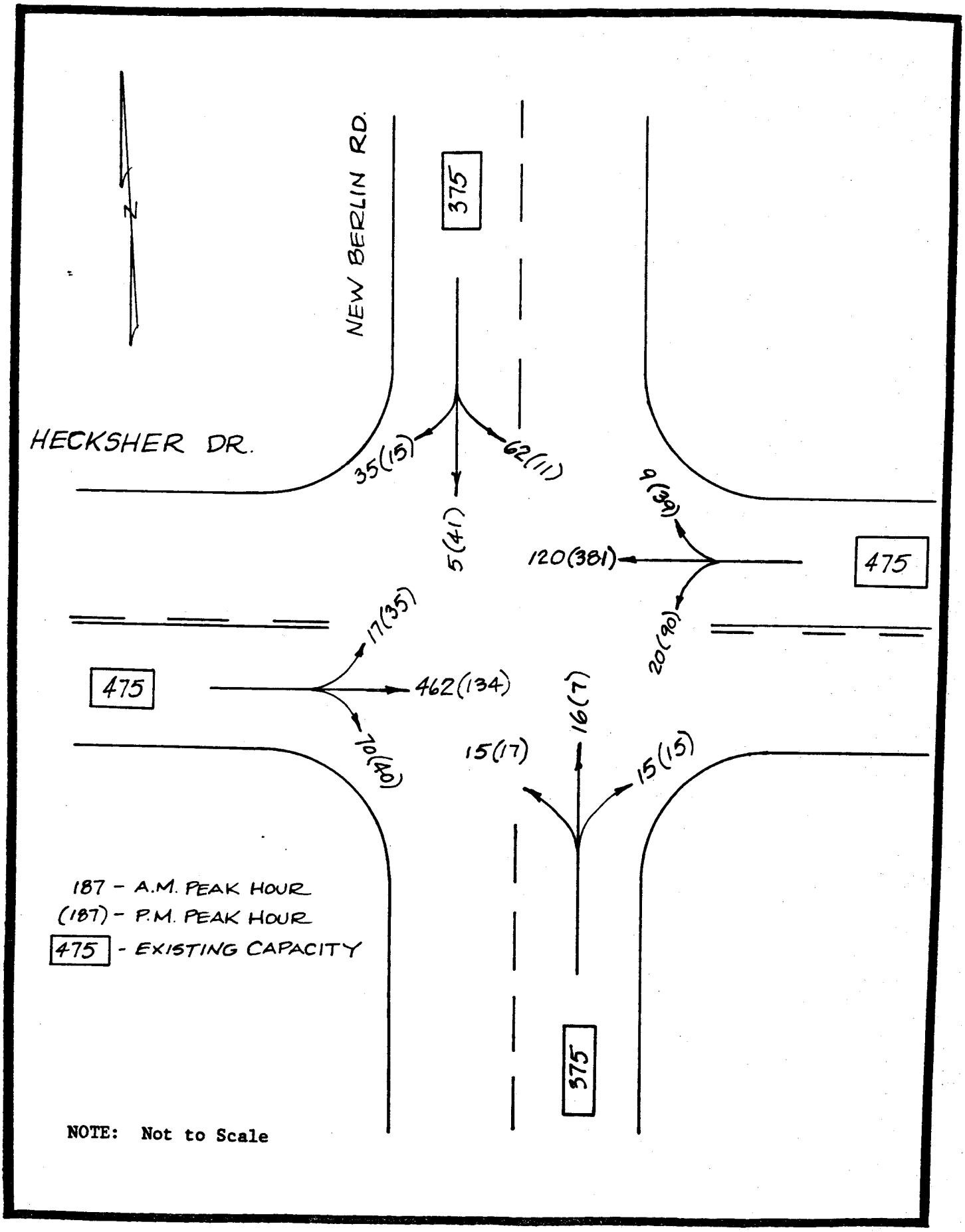
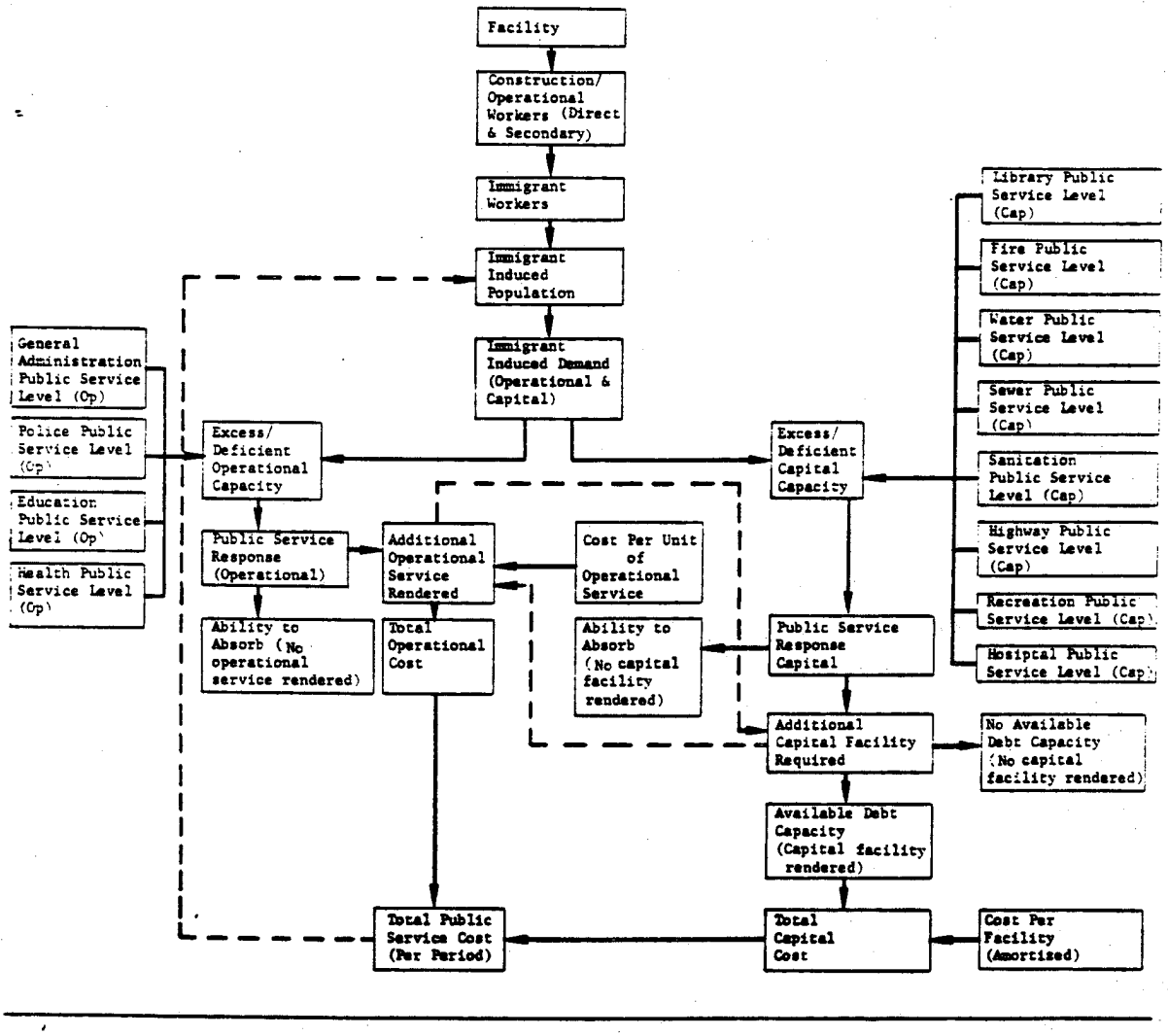


Figure H-6 Peak Hour Traffic - New Berlin Road - Heckscher Drive

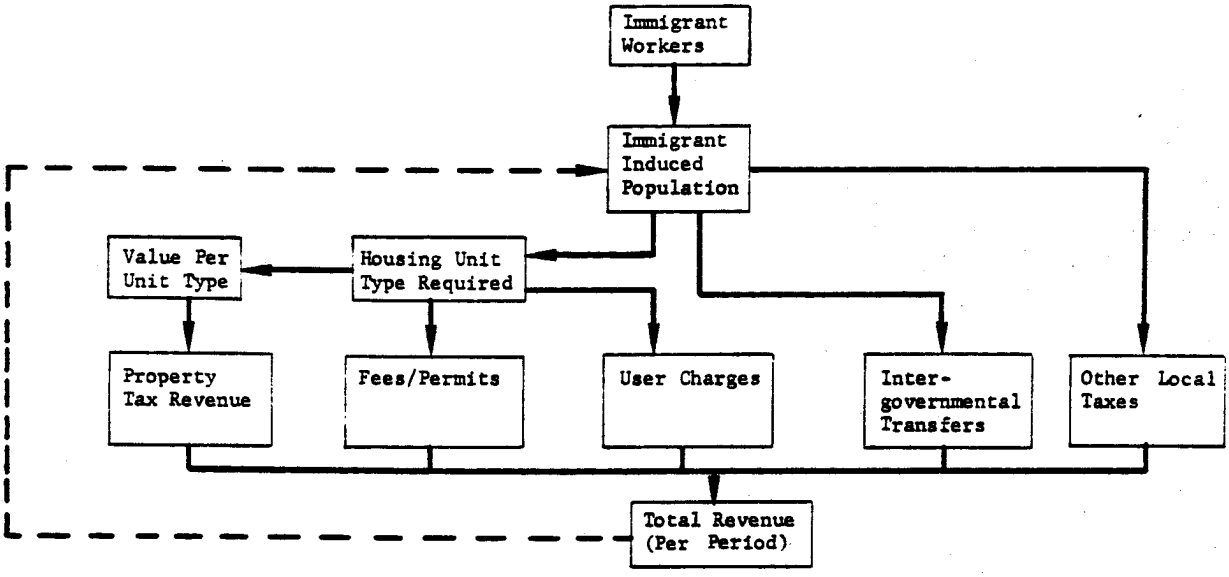
Figure H-7 Airports and Airways in Vicinity of Proposed Site

SCALE 1:250,000
VORTAC
Victor Airways
Roads
Non-Directional Radiobeacon
Tower Controlled Airport
DAYTON CT - 118.9 1028 L 70
Special Airport Traffic Areas
OBSTRUCTIONS
1000 ft and higher AGL
below 1000 ft AGL
Group Obstruction
Obstruction with hi-intensity lights
1520 (1210) UC
Elevation of the top above mean sea level
Height above ground
Under Construction or reported; position and elevation unverified
CAUTION: Guy wires may extend outward from structures.
SITE
VORTAC
JACKSONVILLE INTL CT - 118.3 ATIS 125.85 30 L 80 122.95
JACKSONVILLE 114.5 CH 92 JAX
122.7R 122.55
MAYPORT CT - 118.75 19 L 80
NAS JACKSONVILLE CT - 124.0 22 L 80 120.15
VFR Advsy
NAS CECIL - 128.1 ATIS 278.2 80 L 125
OLF WHITEHOUSE (NAVY) CT 126.2* 99 L 80
HERLONG 87 L 40 122.9
HERLONG 122 HEG
DINNS 344 JAX
JACKSONVILLE NAVY AIRPORT TRAFFIC AREA
SPECIAL NOTICE
Floor 1200 ft. above surface
Floor 700 ft. above surface
JAX BCH ISLAND
FERNANDINA BEACH 15 - 53 122.8
Amelia City
American Beach
Atlantic Beach
Jacksonville Beach
Pablo Beach
Ponte Vedra Beach
Mayport
Naval Station
Naval Air Station
Whitehouse
Bryceville
Yulee
Callahan
Hilliard
Nassau River
Pecan Park
Duval
Tallyrand
Hodges
Normandy
Murphy Gold Mine
Trailer Park
Golf course
Transformer station
Beach Blvd
Donner
Fess
Craig CT - 119.1 41 L 40 122.95
Impression Flight Watch
Caution
Caution Tower
Caution Antenna
Caution Crane
Caution Houses
Caution Water Tower
Caution Water Tanks
Caution Water Plant
Caution Bridges
Caution Vehicle Test Tracks
Caution Glider Operating Area
Caution Hospital
Caution Hospital
Caution Water
Caution Water
Caution Water



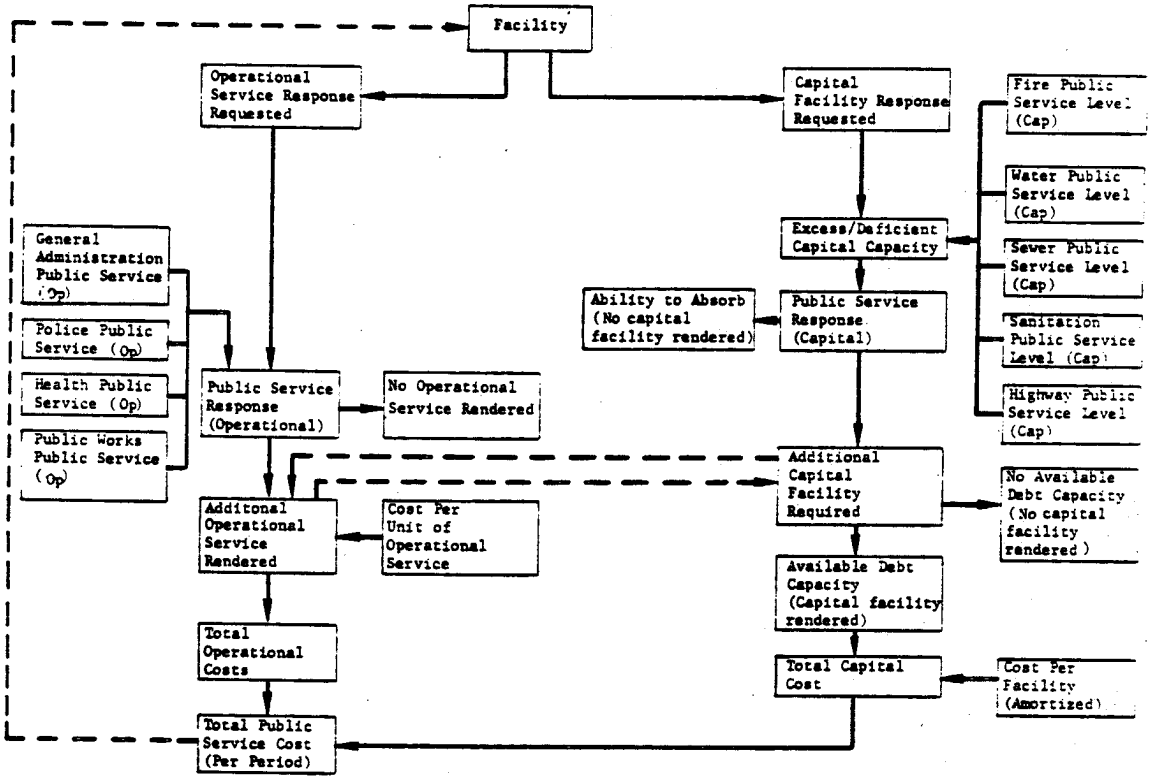
Note: The above submodel is for one time period (year) for both city and county governments.

Figure H-8 **Envirosphere Residential Model - Operational and Capital Public Service Cost Submodel**



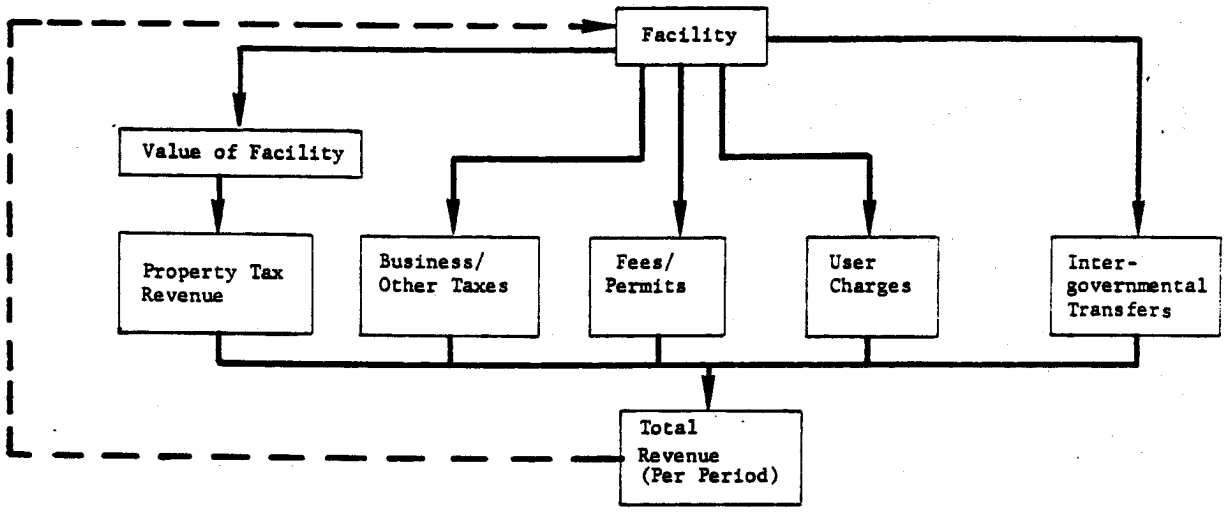
Note: The above submodel is for one time period (year) for both city and county governments.

Figure H-9 Envirosphere Residential Model - Public Revenue Submodel



Note: The above submodel is for one time period (year) for both city and county governments.

Figure H-10 **Envirosphere Nonresidential Model - Operational and Capital Public Service Cost Submodel**



Note: The above submodel is for one time period (one year) for both city and county governments.

Figure H-11 Envirosphere Nonresidential Model - Public Revenue Submodel

J

ARCHEOLOGY

APPENDIX J

ARCHEOLOGY

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ARCHEOLOGY

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APPENDIX J

ARCHEOLOGY

J.1 INTRODUCTION

Southeastern Wildlife Service, Inc. (SWS) has conducted a two stage cultural resources study at the site of the proposed plant. The site covers a 1,656 acre (670 ha) tract in northeast Duval County on the north side of the St. Johns River between Dunn and Browns Creeks. It is approximately 16 km west of the mouth of the St. Johns River (Figure J-1). Although it is contained in the northern St. Johns Archeological Areas as defined by Goggins (1952), the region between the mouth of the St. Johns and St. Marys Rivers has been referred to as a transition zone between two cultural areas (Deagan, 1978).

The first stage of the study was designed to locate historical, architectural, and archeological resources on the plant site, and all architectural resources in excess of 50 years of age within one mile (1.6 km) of the project boundaries. In addition, the horizontal extent of all sites which were located were to be recorded. Forty man-days of fieldwork were associated with the first stage of the study which was carried out between June 30 and July 9, 1980. A total of 401 shovel tests were excavated. One previously recorded site (8Du634) was relocated and an additional ten sites were found.

The second stage of the study was a more detailed investigation of the eleven archeological sites located during the first stage. The purpose of this additional work was to gather information necessary to support a request for determinations of National Register eligibility for each of the sites. The second stage fieldwork involved a 62 man-day effort between August 22 and September 5, 1980. A total of 29 1x2 m test excavations were made at the eleven sites.

This appendix contains a discussion of the local environment, a brief summary of the cultural history of the area, a description of the methodologies employed by the study, and a discussion of the results. All field notes and artifacts material recovered will be stored at the Florida Division of Archives, History and Records Management, Tallahassee.

J.2 ENVIRONMENTAL SETTING

The proposed site area is located on the St. Johns River in northeast Duval County, Florida. The St. Johns River flows north, beginning at Melbourne, Florida, and ends at the Atlantic Ocean within 16 km of the project area. The upper St. Johns River is a series of connecting lakes with extensive marshes and swamps along the shore. North of Palatka, Florida, 80 km from the project area, the river widens and the banks are elevated and dry. The area is formed by late Pleistocene sand deposits (Goggin, 1952).

The climate is distinguished by warm, humid summers and mild winters. Rainfall is evenly distributed from fall through spring, but 65 percent of all rainfall occurs during the summer. Temperatures during the winter rarely drop below freezing (Stem et al., 1978).

The present vegetation, with the exception of the recently cleared pine areas, has been stable since 3000 B.C. According to Watts (1971), at that time the vegetation in southern Georgia and central Florida shifted from a dry oak forest to the familiar pine forest with hammock, bayhead, and cypress swamp vegetation. This shift in vegetation resulted in the movement of prehistoric populations from the interior forest to the riverine environment.

Sea level fluctuations have also affected the environment. Goggin (1864) suggests a rise in sea level around 500 B.C. that increased the brackish marshes and provided a larger area for the growth of saltwater shellfish. Work on the Georgia coast (DePratter, 1977) has demonstrated several fluctuations in sea level during the last 5000 years. At 2500 B.C., the sea level was very high, but it began to drop at 1100 B.C. and reached a low at 700 B.C.. This drop had a direct impact on prehistoric populations by reducing shellfish, a major contribution to the diet. Around 400 B.C. the sea level began to rise again, creating the present conditions.

The present vegetation affected the survey in two ways: visibility and access. Visibility over the project area is generally poor. The soil surface is apparent only in disturbed areas such as roads, firebreaks, bulldozer cuts, and tree falls. The ground cover consists of humus, 5-10 cm deep, and grasses. Access was generally good everywhere within the project area. The cleared interior is covered with grasses, but was easily traveled. At the time of the survey, no rain had fallen for at least a week. This lack of rain made the testing of certain swamps much easier; in fact, tests were made along swamp edges that would have been in standing water after a rain storm.

Land use and clearing have affected not only the vegetation but also have impacted archeological sites. Land use in the pine flatwoods section of the project area has been centered primarily on lumbering and the turpentine industry. Fragments of turpentine pots were found scattered along Pelotes Road and adjacent trails. These low fired, clay pots were used in the turpentine industry from 1915 to 1950, although the most extensive use was in the 1930s (Wright, 1979). Fragments of turpentine pots are a common site throughout the pine forests of south Georgia and north Florida. Although no evidence for current use of the area for turpentining was available, it appears from the vegetation that some of the pine flatwood area has been logged within the last five years. As such, some site disturbance should be expected, but the area of clearing occurs in the least desirable location for archeological sites. In addition, the area has been used as a depository for modern garbage and appliances. A great deal of disturbance has occurred at the previously located archeological site, 8Du634 (Figure J-4). This site has been partially destroyed by the excavation of a borrow pit and additionally disturbed by erosion along the edge of the pit.

J.3 HISTORICAL OVERVIEW

J.3.1 Introduction

The project area falls within the Northern St. Johns Archeological Area as defind by Goggin (1952). This region extends from the Georgia border to Mosquito Inlet, midway down the Atlantic coast of Florida. More specifically, the project area is included in the northern coastal subarea located from the St. Marys River to St. Augustine. Here the St. Johns River is distinguished by the lack of extensive lagoons and marshes which are present farther south. Although the northern St. Johns area refers primarily to prehistoric periods, the discussion of European and American history will be confined to this culture area also.

For organizational purposes, the history and prehistory of the area will be divided into aboriginal and European/American Sections. The interactions of these two groups will be discussed in the proper places.

J.3.2 Aboriginal Culture History

Information on this section was derived from Goggin (1952) and a Florida Division of Archives, History and Records Management report on Duval County archeology (FDAHRM, 1980).

Paleo-Indian Period (?-8000 B.C.)

This period is generally distinguished by fluted projectile points and a hunting, fishing, and gathering subsistence. Although sites from this period are found in Florida, no Paleo-Indian sites are known in Duval County (FDAHRM, 1980).

Archaic Period (8000-2000 B.C.)

The Archaic period in northeast Florida is represented by two subperiods--early Archaic (8000-3500 B.C.) and Mt. Taylor (3500-2000 B.C.)--both which have distinctive settlement and subsistence patterns (FDAHRM, 1980). Artifacts from this period include large triangular projectile points, steatite vessels, and busycon gouges.

During the early Archaic subperiod, settlement was centered on the interior oak forest, with small foraging camps along the St. Johns River. The Mt. Taylor subperiod began during a rise in sea level that caused a change in vegetation from oaks to pines in the interior forests. The settlement pattern shifted from forest habitation to an occupation along the St. Johns River and coastal lagoons. Most Archaic sites are found south of Palatka (FDAHRM, 1980).

Orange Period (2000-1000 B.C.)

Throughout most of this period, settlements were concentrated on the St. Johns River with occasional occupation on the coast. The major location for Orange period freshwater shell middens is south of Palatka, although some Orange sites are found on the bluffs and islands of the St. Johns River in Duval County (Goggin, 1952). At the end of the Orange period, there was a trend toward the utilization of saltwater shellfish. Possible reasons for an increase in oyster exploitation were a depletion of freshwater shell populations and an increase in oyster populations caused by an expansion of coastal lagoons (FDAHRM, 1980). The Orange period is distinguished by plain and incised fiber tempered ceramics (Goggin, 1952).

Florida Transition Period (100-500 B.C.)

Sites from this period have plain or simple stamped sand and fiber tempered ceramics and typically chalky St. Johns ceramics in the same context. Some sites identified as transition period may actually have separate Orange and St. Johns period occupations (FDAHRM, 1980).

St. Johns I Period (500 B.C.-800 A.D.)

This period is characterized by plain, chalky ceramics, shell middens and sand burial mounds. Although few changes occurred in artifact styles, two subperiods (St. Johns Ia and Ib) have been established based on trade wares from the Florida Gulf Coast (Deptford, Swift Creek, Weeden Island). At this time, there was a general shift in the location of sites from the upper St. Johns to the lower St. Johns River (Goggin,1952). One possible reason for the shift may have been a rise in sea level, which increased the oyster habitat, creating a more favorable area to settle (Goggin, 1964). The tendency toward exploitation of saltwater rather than freshwater shellfish, begun at the end of the Archaic, continued.

Excavations at the Mayport mound (8Du96), near the mouth of the St. Johns River, indicated a St. Johns Ib occupation. Of all ceramics found at the burial mound, 42 percent was sand tempered plain, 34 percent St. Johns plain and Dunns Creek red, and 2 percent Swift Creek complicated stamped (Wilson, 1965).

St. Johns II Period (800-1650 A.D.)

The production of check stamped, chalky ceramics marks the beginning of this period. As in St. Johns I, subperiods (St. Johns IIa, b, c) are determined from the presence of trade wares from the Florida Gulf Coast (Weeden Island and Fort Walton). In addition to St. Johns ceramics, cordmarked (Prairie cordmarked or Savannah fine cordmarked) and clay tempered ceramics are found on sites between the mouths of the St. Johns and St. Marys Rivers (Goggin, 1952). The latest subperiod, St. Johns IIc, also contains Spanish olive jar and majolica ceramics. St. Johns II period shell middens are prevalent in Duval County (FDAHRM, 1980).

St. Augustine Period (1650-1704)

In 1650, British raids on the Guale Indians of coastal Georgia forced them south into the Timucuan area in northeast Florida (Deagan, 1978). The aboriginal sites from this period have San Marcos ceramics, a grit tempered, complicated stamped ware, and may have Spanish olive jar and majolica ceramics as well (Goggin, 1952). By 1704, the Guale Indians were almost totally destroyed by British raids and disease. They were removed to St. Augustine by the Spanish where they eventually died of disease (Deagan, 1978).

Seminole Period (1750-1840)

The Seminole Indians moved from Georgia into northern Florida in 1750. By the 1840s they had either been driven into south Florida or removed to Oklahoma. Seminole period sites have coarse, grit tempered ceramics with deep striations on the surface (Goggins, 1952).

J.3.3 Archeology of the Lower St. Johns and the Georgia Coast

According to Deagan (1978), the area from Camden County, Georgia to the mouth of the St. Johns River is a transition zone between the Willington/Savannah complex and the St. Johns tradition. From 700-1650, the area has both St. Johns material and cordmarked or sherd tempered ceramics similar to coastal Georgia material.

In the ethnohistorical record of the area, the zone corresponds to the boundary of the Saturiwa, a tribe of the Timucua (Deagan, 1978). Their subsistence was based on horticulture, shellfish collecting, hunting, and gathering (Deagan, 1978). They are represented in the archeological record by St. Johns check stamped ceramics and occasional Spanish trade goods. By 1650, with the decimation of the indigenous Indian population, the Guale, moved into the St. Johns region ending the St. Johns tradition.

Excavations by Hemmings and Deagan (1973) on Amelia Island demonstrated the combination of Georgia and Florida traits found within the transition zone. Two sites excavated on the island were the Harrison Homestead site and the Walker Point mound and village site.

The Harrison Homestead site (8Na41) is a St. Augustine period shell midden with Orange and Savannah period occupations. Ceramics from the St. Augustine period include San Marcos stamped and sand tempered plain and Spanish olive jar and majolica. Both Savannah fine cordmarked and check stamped ceramics and St. Johns ceramics are present as minor occupations before the St. Augustine period. Also present are cordmarked ceramics, which may be similar to the Alachua ceramics of north-central Florida. A clay tempered ware, produced in small amounts from 700-1700 A.D. on the Georgia and Florida coasts, was found at the site as well.

The Walker Point village (8Na28) was inhabited during St. Johns I and II periods, about 700-1200 A.D., although the neighboring burial mound was used only from 1000-1200 A.D. The village is located along a ridge adjacent to the saltwater marsh. The subsistence pattern consisted of a heavy dependence on estuarine fish and shellfish and on a lesser exploitation of birds, turtles, and assorted mammals. The ceramics include sand tempered plain (43 percent), St. Johns plain and check stamped (26 percent), and Colorinda (8 percent), a ware tempered with crushed St. Johns ceramics.

As is evident from these two sites, the ceramics are a mixture of traditional north Florida and south Georgia types. Later the Amelia Island material will be compared to artifacts found in the project area.

Sears' (1957) excavations at several sites on St. Johns Bluff indicated a connection between the cultural material on the Georgia coast and the area north of the mouth of the St. Johns River. These sites contained Deptford, Savannah fine cordmarked, and St. Johns plain and check stamped ceramics. A layer of sand tempered plain ceramics was found overlaying a Deptford layer at 8Du61.

J.3.4 European and American History

The St. Johns River was originally discovered and settled by the French in 1562. Fort Caroline was established at St. Johns Bluff in 1564, but the inhabitants were massacred by the Spanish in the following year (Gold, 1929).

During the first Spanish occupation (1565-1763), the major European settlement was concentrated at St. Augustine, although Franciscan missions were scattered on the coast and bluff edge of the St. Johns River (Deagan, 1978).

In 1763, the Spanish traded Florida to the British in exchange for Cuba. The British occupation lasted until 1784 and much of the lower St. Johns River area was colonized. British plantations produced indigo, cotton, lumber and turpentine (Gold, 1929). In 1783, the British exchanged Florida for the Bahamas, beginning the second Spanish occupation of the peninsula.

In order to settle the plantations vacated by the British, the Royal Order of 1790 was issued by the Spanish governor. Foreigners were able to receive land grants by improving property within 10 years (Gold, 1929).

The town of Jacksonville, formerly Cowford, was established in 1823 (Gold, 1929). The production of naval stores and the port facilities made Jacksonville an important trading center (Stem et al., 1978). During the Civil War, it was captured and abandoned several times by Union forces. Confederate fortifications were constructed at St. Johns Bluff and Yellow Bluff, but were abandoned in 1862 when the Union Army occupied Jacksonville (Craig, 1954). After the Civil War, Jacksonville became famous as a health resort. Railroads and shipping expanded the reputation of the city as a regional trading center (Stem et al., 1978).

The community of New Berlin, 1.6 km from the project area, was founded at Yellow Bluff prior to the Civil War by Dr. Henry von Balsan, a German immigrant. After the war, a shad fishing and shipbuilding industry was established (Brinton 1869), but it declined at the turn of the century (Craig, 1954). A minor tourist industry was also present at the height of New Berlin's prosperity. Tourists from Jacksonville came to attend local dances and stayed at the Gray Hotel (Craig, 1954). This structure is still standing although it is now a private residence.

J.4 LITERATURE REVIEW AND ARCHIVAL RESEARCH

Prior to fieldwork, an extensive literature and document search was conducted in Tallahassee and Jacksonville. Records consulted in Tallahassee include the Bureau of Land Records, Department of Natural Resources; the Map Files of Florida State University; the Florida Master Site File; the library of archeological survey and testing reports curated with the Florida Division of Archives, History and Records Management; and the Southeast Archeological Center, National Park Service. In Jacksonville, the Florida collections at Jacksonville University were consulted.

J.4.1 Master Site File

The Florida Master Site File revealed that two sites, 8Du92 and 8DU634, are present within the project boundaries and that nine additional sites have been located within 1.6 km of the project area. Unfortunately basic information such as site location and cultural affinity is sketchy or nonexistent on many of the site forms.

Site 8Du634 is called the JEA Borrow Pit Site and is recorded as being previously mostly destroyed by this pit. No cultural affiliation has been assigned to the site and its only description is that of a shell midden, approximately 4 ha in size and containing sherds. The condition of the site is recorded as deteriorated and the integrity as altered. The present survey relocated this site and by subsurface testing determined that it is much larger than recorded (approximately 12.5 ha).

The site form for 8Du92 states that its location was plotted per vague verbal description. The coordinates given and the location shown on the State Site File map placed the site on a peninsula of the mainland, but the instructions for locating the site placed it at San Carlos Plantation on the north end of Brown's Island. The only descriptive information supplied

on the site form is that 8Du92 is a refuse area. The present survey located three sites in the general area of 8Du92. Because it was impossible to determine whether any of these were 8Du92, they were assigned field site numbers 3, 9, and 12. If 8Du92 is in fact located on the mainland and not on Brown's Island, it is probably field site 3, since this is a prominent site with obvious surface artifacts.

Of the nine sites within 1.6 km of the project area, only one, 8Du10, has been investigated to any appreciable extent (Moore, 1896). The site form refers to this as Johnson Mound and describes it as a burial mound site with a St. Johns Ib cultural affiliation. Artifacts recovered include complicated stamped ceramics, a celt, grinding stones, worked shell, and sheet copper fragments and ornaments.

Of the remaining eight nearby sites, two are historic and six are prehistoric. For the most part, they are considered destroyed or in the process of being destroyed by urban activity. One seemingly well preserved site, however, is 9Du645, which is described as a military fortification in excellent condition. The cultural classification of the site is uncertain, but it is speculated to be associated with Yellow Bluff Fort, a Civil War fortification in the same general area. The other historic site, 8Du99, is recorded and described as containing nineteenth century ceramics and ballast stone.

Three of the six aboriginal sites contained diagnostic artifacts. Two sites contained Orange period fiber tempered ceramics and one site contained a single check stamped (chalky paste) fine sand tempered rim which is assumed to be a St. Johns II sherd.

J.4.2 Florida State University

The map files in the main library of Florida State University contain a wide variety of maps pertaining to various aspects of the project area. One of the earliest maps showing the project area is a British map of the

"His Majesty's Flourishing Province of South Carolina Showing Settlements of y English, French and Indian Nation" which includes the Florida coast south to St. Augustine (Herbert, 1925). The map shows no settlements in the project area but does show the Spanish named settlement of St. Paulo on the south side of the St. Johns River.

Another British map (Popple, 1733) shows the "....British Empire in America" and includes adjacent French and Spanish settlements. In addition to St. Paulo, this map shows an unnamed Spanish lookout at the mouth of the St. Johns River and labels the project area "Full of Swamps". A third British map (Jefferys, 1775) shows a settlement labeled St. Matheo in the same area St. Paulo was earlier shown. None of these maps show any activity or settlements immediately north of the St. Johns River.

Other maps at Florida State University that contain pertinent information include:

1. A privately produced map of Duval County (The Associated Map Co, 1926) that shows the otherwise unrecorded community of Eulalia, which is adjacent to New Berlin.

2. Three U.S. Coast and Geodetic Survey maps (Nassau River, 1934; Mill Cover, 1934; and Dunn Creek, 1939) that each show roads and generalized land use and vegetation patterns for portions of the project area. Several roads, firebreaks, and trails are shown crossing the project area but no structures or other cultural features are indicated.

3. Two general highway maps of Duval County (1936a and 1936b) that show roads, structures and other cultural features. More recent county highway maps do not show the detail of the earlier maps and were not very useful.

J.4.3 Bureau of Land Records

The Bureau of Land Records, Department of Natural Resources, in Tallahassee, contains documents and maps showing land grants and property boundaries for the first half of the nineteenth century, a period poorly represented by other maps. In order to incorporate the newly acquired province of Florida into the United States, a careful recording of land grants and property ownership was undertaken in the early 1880s. An 1849 map (Bureau of Land Records, 1849) shows the majority of the project area belonging to two individuals, John Christopher and John F. Brown. Spicer (or Spencer) Christopher was awarded land within the project area in 1809. At his death, it was inherited by his son John (Bureau of Land Records, 1828). When Florida was transferred to the United States, this claim was confirmed by the Congress, as was the claim of John F. Brown. These claims are Sections 40, 41, and 43 in the project area. As proof of his claim, Brown submitted a sketch map (Figure J-2) showing the location of his house (Bureau of Land Records, 1828). This map shows the area between Dunn and Clapboard Creeks. It records much of the area as belonging to Brown but does not show Christopher as the landowner. The map labels Brown's residence but it is difficult to precisely locate the house site on a modern map. It is probably located on what is today Pelotes Island. The documents concerning Brown's and Christopher's land grants contain little other useful information.

J.4.4 Florida Division of Archives, History and Records Management

Another source of background information was the collection of survey and testing reports at the Florida Division of Archives, History and Records Management (FDAHRM) in Tallahassee. At least four such surveys in Duval County have been reported by FDAHRM in the past six years (Daniel and Fryman, 1978; Jones, 1975; Miller, 1976; Nelson, 1975).

One of these (Nelson, 1975) was conducted 5 km from the project area. Approximately 308 ha near Dames Point were surveyed using surface reconnaissance and subsurface testing. One site, 8Du101, which is a

largely destroyed shell midden site of unknown affiliation, was located. Another survey (Miller, 1976) of wastewater pipeline corridors in the north Jacksonville area discovered no sites.

J.4.5 National Park Service

The Southeast Archeological Center, National Park Service, Tallahassee, was consulted in person concerning their knowledge of the archeological history of the Duval County area. They provided no additional information.

J.4.6 Jacksonville University

The Florida collection at the library of Jacksonville University was consulted after initiation of field work. Sources inspected include county maps, local publications including the Papers of the Jacksonville Historical Society and photographs. A 1949 highway map of Duval County found at the library shows a structure in the project area, on the lower part of Pelotes Road.

J.5 SITE RECONNAISSANCE FIELD METHODS

J.5.1 Archeology

The three major goals of the field portion of this reconnaissance survey were to relocate previously recorded sites in the project area, locate all other sites, and determine the horizontal limits of all sites. The field methods employed to meet these goals consisted of searching all exposed ground surface, systematic subsurface testing of designated high probability areas, and systematic subsurface testing along transects through low probability areas. This field work was accomplished by four people from June 30 through July 9, 1980.

J.5.1.1 Site Location

The major feature of the research design formulated for this survey was the delineation of low and high probability areas and the subsequent testing programs for each. High probability areas are those considered likely to contain sites because of their elevated topography, well drained soil types, and proximity to water. SWS determined these areas from its experience with similar tracts on the Georgia coast. L. Ross Morrell, State Historic Preservation Officer for Florida, and Louis Tesar, Historic Sites Specialist for Florida, also determined high probability areas. The composite of the three was marked on the USGS Quadrangle map (Figure J-3). The remainder of the project area, the interior portion containing little relief and poorly drained soil types, was considered a low probability area.

The research design to locate sites in low probability areas consisted of intensive surface searching and systematic subsurface testing. The subsurface testing was accomplished by means of four east-west transects containing shovel tests every 50 m (Figure J-4). In two instances, the transects had to be shifted to avoid swamps. The transects were aligned with a compass and the intervals paced.

The term shovel test actually refers to a test excavated with either a shovel or a post hole digger. Tests excavated by shovel were 30 cm in diameter and those excavated by post hole digger were 15 cm. All tests were excavated to water table or a depth of approximately 70 cm or more below surface. The soil from the majority of tests was screened through 1/4-inch hardware cloth. Tests in poorly drained soil types containing much wet clay were screened with 1/2-inch hardware cloth. The stratigraphy of each test was noted and recorded. The vertical locations of artifacts and shell deposits were determined as precisely as possible, but with the given mode of excavation, the precision was generally limited to a 10-20 cm range.

The testing program to locate sites in high probability areas consisted of intensive surface searching of roads and bulldozer cuts and lines of subsurface shovel tests at 50 m intervals. No available maps of the project area accurately showed all the existing roads, thus, plotting unrecorded roads was the first task undertaken in the field. With the exception of Island Drive, all roads in the project area are single lane, unimproved dirt roads. Island Drive is a wide, partly paved, partly graded road. In addition to the roads, numerous bulldozed spurs have been cut throughout the project area to provide access for a large, truck-mounted drilling rig. The surface visibility resulting from these cuts varied with vegetation and soil types but generally was very good. Additional surface exposure consisted of:

1. The banks of a fairly recent borrow pit on the southern border of the project area.

2. Several acres of bulldozed cleared land that houses the Jacksonville Sand Drag track located at Island Drive and New Berlin Road.

3. A small, cleared and leveled tract immediately south of the drag strip.

4. The banks of a wide railroad cut through the southwest corner of the project area.

Whenever cultural material was found (shell and/or artifacts), subsurface tests were placed beyond the surface exposure to determine whether the material was modern surface scatter (road fill) or was indicative of buried cultural deposits.

The subsurface testing of the high probability areas consisted of the judgemental placement of lines of shovel tests. The tests were at 50 m intervals and were placed on ridge tops, along marsh edges, along bluffs adjacent to small interior streams, and through other areas of elevated, well drained soils. Distances between tests were paced. All available maps that showed structures in the project area were consulted to locate historic sites. The series of county road maps from 1936 through the 1950s was the best source for this information. Only one structure was shown in the project area and that was on the 1949 county road map. The structure was not shown on two 1936 county maps. This site was later located in the field and was determied to be a mid-twentieth century site by the presence of ketchup bottles, pickle jars, and other modern artifacts.

J.5.1.2 Site Delineation

The testing of located sites was designed to determine quickly the horizontal limits and cultural affinity of each site and was not designed to determine vertical limits, presence of subsurface features, or distributional patterns of artifacts. The testing was accomplished by placing a series of additional shovel tests away from an initial find. Since site sizes differed greatly (0.01-12.5 ha), the spacing of these additional tests varied. Based on size and testing procedures, two types of sites were found:

1. Large (greater than 1.0 ha) ridge top sites that were tested using 25 and 50 m intervals, and

2. Small non-ridge top sites that were tested using 10 m intervals.

Field site 3 is unique in that it was the first site encountered and was subjected to various testing methods and intervals to determine the most expeditious methods of site testing.

The four large sites tested with 25 and 50 m intervals are 8DU634 and field sites 2, 7, and 8. Six sites, 4, 5, 9, 10, 11, and 12, were anticipated to be small and were tested using 10 m intervals. The patterns of tests for these sites are recorded on the individual site maps.

Based on surface distribution of shell and historic material, field site 3 was initially thought to be 40-50 m long and 20-30 m wide. A base line was established on the road that runs along the ridge top on which the site is situated. This line was oriented north northeast-south southwest but was considered north-south for the gridding of shovel tests. Shovel tests were initiated at 5 m intervals along and outward from this line. The first tests indicated that the site consisted of a subsurface aboriginal shell midden overlain by near surface historic shell and artifacts. Since subsurface shell consistantly appeared in the tests without screening, the remaining tests were not screened and the presence or absence of shell was noted. After 40 tests on a 5 m grid, it became apparent that the site was much larger than anticipated and that a greater interval would be more practical. Tests were continued at 10 and 20 m intervals as shown on the site map (Figure J-4). Artifacts were recovered from several of these tests and their depths below surface were noted. The tests in field site 3 were labeled and identified using grid coordinates and were not incorporated into the consecutive numbering system.

J.5.2 Architecture

The purpose of the architectural reconnaissance was to locate and identify all structures and architectural units within 1.6 km of the project, which are in excess of 50 years of age. An architectural

historian accomplished this objective by consulting various maps of the area and then inspecting all structures. The area of survey was expanded slightly to include New Berlin. Photographs were taken and state historic site inventory forms were completed. The architectural historian also conversed with several local inhabitants concerning the recent history of the area.

J.6 SITE RECONNAISSANCE RESULTS

J.6.1 Archeology

J.6.1.1 Laboratory Analysis

All cultural material was cleaned, sorted, and identified at Southeastern Wildlife Service's laboratory in Athens, Georgia. Identification of ceramics consisted of a placement within the cultural historical sequence of the area. The artifacts and notes will be curated with the Florida Division of Archives, History and Records Management, Tallahassee, Florida. The results of the analysis and a comparison between the artifacts found in the project area and those found in the nearby area follows.

Sand Tempered Plain

One third of the ceramics found in the project area belongs in this category. The surface finish varies from uneven, partially smoothed to smooth and even. Because of the lack of surface decoration, it is not possible to assign ceramics of this type to a definite time period. However, a large percentage of sand tempered plain ceramics occurs at the Walker Point village and at one of the sites excavated by Sears (1957) on St. Johns Bluff. Both of these sites date from 700-1200 A.D.

Clay Tempered Plain

These ceramics contain a mixture of clay (grog) and sand tempering or clay tempering alone. They were present in limited amounts on four of the sites. The clay tempering is not composed of crushed St. Johns ceramics and does not correspond to the Colorinda type established by Sears (1957). It is similar to a second clay tempered series mentioned by Hemmings and Deagan (1973) which they date to 1000 A.D. and later.

Sand Tempered Cordmarked

Cordmarking is present in small amounts at many of the sites in the surrounding areas. These are usually trade wares from the Georgia coast or north-central Florida. Possible types of cordmarked ceramics found on the St. Johns River include Savannah fine cordmarked and Prairie cordmarked. Goggin (1952) mentions the presence of both Savannah fine and Prairie cordmarked on St. Johns II period sites.

Savannah fine cordmarked ceramics found at Amelia Island are thin (4-9mm), fine-grained, and have the surface decoration applied at an angle to the rim (Hemmings and Deagan, 1973). These ceramics were produced on the Georgia coast from 1100-1300 A.D. Prairie cordmarked ceramics are described as medium sized, grit tempered ceramics with a rough surface texture and small to large cord impressions on the exterior. Prairie cordmarked ceramics were produced in north-central Florida from 700-1100 A.D. (Milanich, 1971).

The cordmarked ceramics, which compose 37 percent of all ceramics found in this survey, were divided into two groups based on either a smooth or rough surface texture. The smooth sherds had a mean thickness of 4.4 mm and a cord size of less than 1 mm. Sherds with a rough surface texture had a mean thickness of 5.5 mm and a cord size of 1-2 mm. Both of these categories were found at the same sites. The two groups may correspond to the above ceramic types.

Fiber Tempered

Three fiber tempered sherds were found during the reconnaissance. One of the sherds had a irregular incision on the surface. These sherds correspond to the Orange phase ceramics in the St. Johns area (Goggin, 1952).

Sand Tempered Roughened

Several of the sherds in the project area were an unidentifiable, roughened type, which may be cordmarked ceramics similar to that found at Amelia Island (Hemmings and Deagan, 1973).

Miscellaneous Sand Tempered

A limited number of other sand tempered ceramics were found in the project area, including one incised sherd, two check stamped sherds, and two possible basket impressed sherds. The incised sherd is not of the bold incised type and does not resemble incised ceramics from Amelia Island. The check stamped ceramics may be Deptford check stamped, Savannah check stamped, or San Marcos (check) stamped ceramics. The sherds are very small and cannot be identified at this time. The two possible basket impressed sherds are not similar to anything found in the vicinity.

European/American Ceramics

All historic ceramics were analyzed using South's (1977) chronology. These ceramics were composed of various types of painted whiteware, saltglazed stoneware, and porcelain.

J.6.1.2 Low Probability Areas

Four transects containing 88 shovel tests were placed in areas of low site probability (Figure J-4). No cultural resources were located by these tests or by surface reconnaissance.

The transects were placed in the interior of the project area, an area characterized by a nearly level relief containing large and small swamps. The predominant non-swamp soil associations are Leon, Pottsburg, and Lynn Haven with isolated occurrences of Ortega. The entire low probability area, with the exception of the larger swamps, has been clean cut recently and left idle.

A very generalized description of the stratigraphy revealed by these shovel tests is a top zone of grey humus overlying either a lighter grey or tan sand zone, which in turn often overlies a dark brown sand zone. Many tests were excavated to the water table, which was usually encountered at approximately 40 cm below surface. Tests in slightly higher and drier portions of the transects revealed a top grey sand zone overlying a deep tan sand zone. Absent from the low probability tests was the yellow sand zone, which is prevalent on the ridges in the southern portion of the project area.

J.6.1.3 High Probability Areas

Subsurface testing and surface reconnaissance of the high site probability areas discovered 10 sites and relocated one previously recorded site (Figure J-4). With limited shovel testing, site boundaries were determined and for most sites a diagnostic artifact assembladge was obtained. The diagnostic aboriginal material consisted wholly of ceramics. The occupation of the area ranges from 3000 B.C. - mid-nineteenth century, with large gaps between 1000 B.C. and 700 A.D. and 1500 A.D. - 1850. Site data is summarized in Table J-1 and a summary of the artifacts for each site is presented in Table J-2.

Site Descriptions

8Du634 - This is a large, previously recorded site that was located and superficially tested by this survey. The site is situated around a borrow pit on the marsh edge. Shell and ceramics are presently eroding from the banks of this pit, especially from the north bank.

Three lines of shovel tests were placed out from the pit to determine site boundaries (Figure J-5). In all, 22 tests were excavated in the site and 13 of these produced cultural material (Table J-2). The site is 12.5 ha, much larger than the previously recorded size of 4 ha.

Tests throughout the site determined a uniform stratigraphy:

0-15 cm below surface - humus, grey sand

15-70 cm below surface - yellow sand

Cultural material consisted of shell and ceramics consistently located between 25 and 50 cm below surface. Sterile shovel tests excavated immediately beyond the site limits (288 and 256) revealed a much different stratigraphy consisting of several shades of grey sand overlying a dark brown compact sand zone. This suggests that the site limits are associated with soil types.

In addition to the subsurface material and the material eroding from the banks of the borrow pit, discontinuous light scatters of shell were noted along both roads. Tests adjacent to these scatters revealed subsurface shell, demonstrating that this was not simply road fill or surface scatter.

Approximately 50 m north of the borrow pit and 15 m from the marsh edge is what appears to be an old 1 x 2 m excavation unit. The pit itself was not investigated but placed a shovel test several meters away (Figure J-5) and found no shell or cultural material. The site form reports no testing at 8Du634.

Artifacts recovered from the site include sand tempered plain, cordmarked sand tempered, check stamped sand tempered, and plain clay tempered ceramics. The cordmarked ceramics place the occupation at least during 700-1300 A.D. The presence of a large percentage of plain sand tempered ceramics tends to support this date.

Field Site 2 (8Du669) - This is a large, aboriginal ridge top site located by surface reconnaissance and defined with subsurface tests. The site covers 8.8 ha and is situated on a sand ridge running parallel to a large bayhead swamp and down to a ridge overlooking the marsh edge (Figure J-6).

Originally, the site was defined as two sites (field site 2 and field site 6) because of a sterile test on a line of shovel tests to the road. In August, while testing sites found on the survey an additional six shovel tests were excavated on a ridge between ST 259 and ST 280. Cultural material was discovered in all of the additional shovel tests. Based on this information, the two sites were combined as field site 2.

The stratigraphy from all of the shovel tests is uniform and characteristic of the Ortega soil association on which the site is situated:

0-15 cm below surface - humus, grey sand
15-70 cm below surface - yellow sand

The yellowness of the second zone varies slightly, but is generally easy to distinguish from the tan zone associated with other soil types. Shovel test 7 was placed adjacent to the bayhead swamp and contained a different stratigraphy:

0-14 cm below surface - humus, grey sand
14-40 cm below surface - whitish grey sand mottled with brown sand

Twenty-seven shovel tests were placed throughout the site. Cultural material consisted of plain sand tempered, Orange fiber tempered, and sand tempered cordmarked ceramics. The tests also produced shell, bone, and chert debitage.

Almost all of the subsurface cultural material came from 20-50 cm below surface, which corresponds to the top 30 cm of the yellow sand zone. One exception to this was test 265. It contained a single, light grey sand zone with the shell and sherds occurring between 10 and 30 cm.

Test 269 revealed a dense shell midden at 20-30 cm below surface. This midden is in the yellow sand zone and contained cordmarked ceramics. In addition to this, ST 285 produced two Orange period fiber tempered

sherds at 60-70 cm below surface, although fiber tempered sherds were found at 40 cm below surface at ST 316. From this, at least two separate occupations are inferred for this site: 2000-1000 B.C. and 700-1300 A.D.

Field Site 3 (8Du670) - This is a large, ridge top site containing prehistoric and historic components (Figure J-7). The site is approximately 0.9 ha in size and is situated on an interior ridge of Kershaw fine sand. This ridge is the highest point in the project area.

Two roads that cross through the site intersect at the crest of the ridge. These roads, especially that part on the northwest slope of the ridge, contained a moderately dense scatter of shell and historic artifacts. One plain sand tempered aboriginal sherd was collected from the surface.

As was the case with the other ridge sites, the stratigraphy was uniform:

0-15 cm below surface - humus, grey sand
15-75 cm below surface - yellow sand

Unlike other sites, however, cultural material was recovered from both the grey and yellow sand zones. Because of the emphasis on defining horizontal rather than vertical limits, the stratigraphy of the cultural components is not clear. Shovel test 1000 N 995 E revealed a well defined shell midden containing two sand tempered aboriginal sherds at 35-55 cm below surface. In the test only 5 m south, however, a less distinct shell layer 25-40 cm below surface contained four pieces of glass. Three other tests south of the 1000N grid line produced historic material. Tests 980N 995E and 940N 985E contained brick, metal and glass in the grey sand zone (0-15 cm below surface), while test 980N 985E had metal in the yellow sand zone (20-40 cm below surface).

The aboriginal shell layer located in the yellow zone of test 1000N 995E was traced 70 m north to the edge of an unnamed creek. No subsurface shell was encountered south of grid 980N. The site boundaries were drawn to include test 14 which contained one plain sand tempered and three basket impressed sherds, and test 324 with a check stamped sherd. These tests were located at the edge and foot of the ridge. These shovel tests were included in site 3 because they contain similar material, are found on the same ridge, and are less than 50 m from other tests with cultural material. The operational definition of a site for this survey was at least a 50 m gap in cultural material and/or a discontinuous topography. Neither of these criteria apply in this case. Test 222 also was placed off the ridge and it revealed a dense shell midden at 20-30 cm below surface and contained three plain sand tempered aboriginal sherds. The aboriginal ceramics include sand tempered and clay tempered sherds and seem to date from 700-1500 A.D. The historic artifacts include transfer printed whiteware, hand painted whiteware, sponge printed whiteware, and North American saltglazed stoneware among others. These ceramics range from 1825-1905; therefore, the historic component appears to be mid to late nineteenth century.

Essentially, the site appears to contain a late nineteenth century historic component and an aboriginal component which overlap both horizontally and vertically. The historic material occurs either on or near the surface. The aboriginal material usually occurs at 30-50 cm below surface. Horizontally, the aboriginal material, including subsurface shell, occurs mostly in the northern half of the site and the historic material occurs in the southern half.

Field Site 4 (8Du671) - Site 4 is a small subsurface shell midden that contains sand tempered cordmarked sherds and probably dates from 700-1300 A.D. Six tests in the area demonstrated that the site is 15-20 cm in diameter (Figure J-8). The stratigraphy of the soil was generally uniform:

0-10 cm below surface - humus, grey sand
10-70 cm below surface - yellow sand

Test 130 revealed a 30 cm thick, mottled grey and tan sand zone between the grey sand and yellow sand zones. The shell and sherds were located between 10 and 30 cm below surface, which is the top 20 cm of the yellow sand zone. In spite of a great deal of surface disturbance and exposure, no material occurred on the surface.

Field Site 5 (8Du672) - Site 5 consists of two large, plain grit tempered sherds found on the surface in an area of bulldozer disturbance. Three shovel tests were placed 10 m from the sherds but no subsurface material was recovered (Figure J-9). This site is situated on nearly level Ortega fine sand exhibiting the following stratigraphy:

0-10 cm below surface - humus, grey sand
10-30 cm below surface - grey and tan mottled sand
30-70 cm below surface - yellow sand

Field Site 7 (8Du673) - This is a fairly large ridge top site adjacent to the marsh edge (Figure J-10), which contained several aboriginal components and an historic component.

Ten subsurface tests were placed to define the site and five of these produced cultural material. The stratigraphy of the tests revealed the characteristic grey and yellow sand zones:

0-10 cm below surface - humus, grey sand
10-70 cm below surface - yellow sand

Two tests, 271 and 299, contained tan rather than yellow sand beneath the grey top zone. The aboriginal sherds and shell were located in the top of the yellow sand zone, between 20 and 50 cm below surface.

The historic material occurred on or just below surface. Test 209 contained two pieces of glass at 10-20 cm below surface and shell at 30-40 cm. Test 200 contained brick, shell, glass, and nails in the grey sand zone and small amounts of shell and one roughened aboriginal sherd in the top of the yellow sand (15-40 cm below surface). A concentration of brick and shell occurred on the surface at the crest of the ridge.

At the foot of the ridge, adjacent to the marsh edge, are what appear to be three old excavation units. Two are approximately 1 x 2 m and one is approximately 2 x 2 m. There is no record of any test excavations at this site.

Aboriginal artifacts include cordmarked and roughened sand tempered ceramics, one plain clay tempered sherd, and an incised fiber tempered sherd. Possible dates of occupation include 2000-1000 B.C. and 700-1500 A.D.

Field Site 8 (8Du674) - This site is located on a broad, nearly level tongue of land between two unnamed creeks. Aboriginal ceramics and shell occurred in seven shovel tests in an area of 1.2 ha (Figure J-11). Several roads and bulldozer cuts cross the site, but no surface material was observed.

The stratigraphy revealed in the tests was uniformly the following:

0-10 cm below surface - humus, grey sand
10-70 cm below surface - yellow sand

The shell and sherds recovered came from the top of the yellow sand zone (20-50 cm below surface). Ceramics found at the site include cordmarked, plain, and roughened sand tempered.

Field Site 9 (8Du675) - Ths is a small, subsurface aboriginal site. Seven shovel tests in the area defined the site as being 100 m^2 (Figure J-12). The soil survey indicates that the site is located on Kershaw fine sand, but in fact, the site is situated on poorly drained soil with a complex stratigraphy generalized as follows:

0-10 cm below surface - humus, grey sand
10-30 cm below surface - tan sand
30-60 cm below surface - yellow sand

The cultural material was recovered from 30-50 cm below surface, again at the top of the yellow sand zone. Artifacts found at site 9 include clay tempered plain, sand tempered plain, cordmarked, and roughened sand tempered ceramics.

Field Site 10 (8Du676) - This site consists of a single artifact, a chert retouch flake, that was recovered from a shovel test. Three adjacent tests produced no cultural material (Figure J-13). The stratigraphy of the tests was generally as follows:

0-20 cm below surface - humus, grey sand
20-70 cm below surface - yellow sand

The flake was recovered from the yellow sand zone at approximately 50 cm below surface.

Field Site 11 (8DU677) - This site consists of a surface and subsurface scatter of shell in a 200 m^2 area. Eight shovel tests were placed around a small shell scatter occurring on Pelotes Road (Figure J-14). Two of these tests revealed a shell midden layer in the yellow sand zone approximately 25-40 cm below surface, although no artifacts were found. The six other tests produced no shell or artifacts. The stratigraphy was generally uniform:

0-15 cm below surface - humus, grey sand
15-60 cm below surface - yellow sand

Field Site 12 (8Du678) - This is a small, subsurface aboriginal site. Ten shovel tests were placed to define site limits (Figure J-15). Three of these tests produced artifacts that indicate a site size of approximately 300 m^2. The tests revealed a uniform stratigraphy:

0-15 cm below surface - humus, grey sand
15-70 cm below surface - yellow sand

The cultural material was recovered from the yellow sand zone at approximately 30 cm below surface. The site is 30 m from the bluff edge of a small creek. Aboriginal ceramics found at the site include roughened and plain sand tempered sherds.

J.6.2 Architecture

The architectural survey located a single structure older than 50 years within the visual impact zone of the proposed plant. This structure, the Gray Hotel, is an 1830s style, wood frame building located in New Berlin. During the 1830s, the hotel served as a residence for tourists. It has since become a private residence and has been expanded several times and moved back from the river's edge. Vegetation effectively screens views of the proposed plant site from the Gray Hotel.

J.7 DETAILED TESTING METHODS

In the cultural reconnaissance of the project area, eleven archeological sites were defined (Figure J-4). All are located near the marsh in well drained soils and fall into two size categories--large (greater than 1.0 ha) and small (less than 0.03 ha). All five of the large sites and two of the small sites contain shell. The most distinctive aspect of the results was the absence of traditional chalky St. Johns ceramics. Most of the sherds recovered were sand tempered, although a small number of clay tempered and fiber tempered sherds were found.

The major goals of the testing of these sites included the culture historical defintion of the occupations, a preliminary investigation of the settlement pattern, and the collection of information on site integrity and cultural significance.

J.7.1 Field Methods

In order to accomplish the above goals, 29 1x2 m test pits were excavated on the eleven sites. The intensity of testing at each site was based on site size and possible impact from the proposed plant. The construction of the proposed plant tentatively will impact 8Du634, 8DU669, 8Du671, and 8Du677. Eight test pits were excavated at 8Du634, seven at 8Du699, and two each at 8Du671 and 8Du677. The remainder of the large sites--8Du670, 8Du673, and 8Du674 had two test pits each, and one test pit was excavated at each of the smaller, unimpacted sites (8Du672, 8Du675, 8Du676 and 8Du678).

The location of test pits within the sites was based on a mixed strategy of random sampling and judgemental placement. A permanent datum was placed near the crossroads at 8Du634 with a grid line extending 350 m north and 50 m south of the datum marked at 50 m intervals. A random number was chosen which represented the distance in meters west of the datum line. Using this system, test pits were located systematically at 50

m intervals, but were placed randomly on the east-west axis. Five random test pits were excavated at 8Du634 and two random pits at 8Du699. The remainder of the test pits were located adjacent to previously excavated shovel tests that produced certain types of artifacts, bone, or shell concentrations.

The tests were 1x2 m units, and were excavated in 10 cm levels within natural strata. The presence of two culturally sterile levels was required before ending the test except in a few cases of obvious root disturbance. Completely sterile test pits were excavated to a minimum depth of 50 cm. All dirt was screened through 1/4-inch mesh, and a flotation sampling collected from a level in each test pit. In addition, flotation and pollen samples were collected from all features. Profiles were drawn of all test pits and features, and a daily log compiled. The test pits were located in relation to a permanent datum established at each site. Vertical measurements were taken from a temporary "datum" created for each test pit.

J.7.2 Laboratory Methods

All artifacts were washed and sorted at Southeastern Wildlife Services' laboratory in Athens, Georgia. Flotation samples were screened through 1/16-inch mesh and examined for small faunal and floral remains. Pollen samples were not analyzed. The artifacts, pollen samples, sorted flotation remains, and notes will be curated with the Florida Division of Archives, History and Records Management, Tallahassee.

Ceramics were classified according to temper, paste, and surface decoration. In addition to this, sherds at least 2 cm in size were placed in the cultural historical sequency of the area. This analysis was performed by a Florida archeologist using the collection and categories of the Florida State Museum and the Department of Anthropology, University of Florida.

Lithics were classified according to raw material and level of sequence of bifacial retouch flake, percussion flake, and tools of various levels of formation.

J.8 DETAILED TESTING RESULTS

The results of the testing program will be presented on a site-by-site basis. Emphasis is placed on the analysis of cultural stratigraphy and features. Because of the limited number and condition of the artifacts, a functional analysis was not performed. However, certain observations concerning possible site function will be made in the conclusion based on the location of the site and the material recovered.

8Du634 - This site was originally discovered in 1976 by Lynn Nidy during an archeological and architectural survey of Duval County. The site was severely disturbed by a borrow pit and no further work was recommended by Nidy. The collections from this site are not stored at the Florida Division of Archives, History, and Records Management and could not be found.

During the cultural reconnaissance by Southeastern Wildlife Services in June, 1980, 8Du634 was relocated. Shovel tests indicated the site was approximately three times the size originally reported. Cultural material recovered from the shovel tests included plain, check stamped, and cordmarked sand tempered ceramics as well as scattered shell fragments. Shell and ceramics were found eroding out of the edge of the borrow pit and on the roads.

Five randomly located test pits were excavated. Three additional test pits were placed so that all areas of the site were systematically tested (Figure J-16). The location of test pit 7 was based on the erosion of shell from the corner of the borrow pit.

The stratigraphy of the test pits was consistent. Test pits 1, 2, 4, 6, and 7 contained the following natural strata: humus and grey sand, mottled brown-yellow sand, and fine white sand (Figure J-17). These zones correspond to the natural soil horizons. Test pits 3, 5, and 8 were located in a lower, wetter area of the site. The stratigraphy consisted of

the following natural strata: humus and dark grey sand, light grey and white sand (Figure J-17). These zones also correspond to the natural soil horizons.

The artifacts were almost exclusively ceramics (Table J-3). One tan chert bifacial retouch flake was recovered from test pit 7. Overall, there was no apparent cultural stratigraphy in any of the test pits. Test pits 1 and 2 produced eroded fiber tempered sherds from the upper levels while Savannah fine cordmarked sherds were recovered in similar amounts thrugh all the levels. The proportions of any ceramic type changed very little in a 50 cm vertical span in all of the test pits. No artifacts were recovered from test pits 3, 5, and 8, although test pit 5 contained the only feature found at the site (Figure J-17).

Feature 1 was a small shell pit containing 1002 g of oyster shell (Crassostrea virginica), 107 g of clam shell (Rangia cuneata), and some unidentifiable charcoal. The charcoal was from partially burned and decayed roots found throughout the feature.

Overall, the ceramics consisted of Savannah fine cordmarked, unidentified cordmarked, plain and tempered, and plain grit tempered sherds. A few unidentified stamped sherds and eroded unidentifiable sherds were also found. Three fiber tempered sherds were recovered from the upper levels of test pits 1 and 2.

Other than oyster and clam shell, no faunal remains were found. Floral remains - small charcoal fragments - were actually burned or decayed tree roots.

Apparently the disturbance of the site is severe. It is possible that the site was once a large Savannah period shell midden which was destroyed by the borrow pit. This would explain the large site size (12.5 ha), although the ceramics were primarily from one time period. The remainder of the site is composed of a light scatter of ceramics and oyster shell

with very little context. The lack of cultural stratigraphy is probably a result of root disturbance and wind erosion. Large roots were a constant problem during excavations and extended 50-60 cm below surface.

8Du669. This site was discovered during the cultural reconnaissance and was originally designated as two sites (field site 2 and field site 6). After the excavation of additional shovel tests, the two sites were combined. The site contained cordmarked sand tempered and Orange fiber tempered ceramics. One shovel test on the eastern part of the site produced a dense shell layer at 20-30 cm below surface.

Seven test pits were excavated at 8Du669 (Figure J-18). Test pits 9 and 10 were randomly located on the western section of the site. Test pit 11 was placed near shovel test 279 because of its proximity to the bayhead swamp and its location in the central part of the site. Test pit 25 was located near test pit 11 because of the existence of a non-ceramic level in the latter test. The presence of Orange fiber tempered ceramics in shovel test 316 determined the location of test pit 12. Test pit 13 was placed near shovel test 259, on a ridge above the marsh. Test pit 14 was positioned near shovel test 269, which produced a distinct shell layer.

The stratigraphy fell into two categories. Test pits 10 and 12 followed a pattern similar to excavation units from 8Du634: humus and grey sand, yellow sand, and fine tan grading to white sand. The stratigraphy from test pits 9, 11, 13, 14, and 25 included the following: humus and grey sand, mottled brown, grey-brown, and tan grading to yellows and (Figure J-17). In addition to the natural soil horizons, test pit 13 contained a layer of dense shell 11 cm thick.

Four components were represented at the site: Savannah period, Deptford period, Orange period, and an unknown lithic occupation (Table J-4). Orange period ceramics were recovered from test pits 9, 10 and 12. Test pits 9 and 12 contained a mixture of cordmarked sand tempered and fiber tempered ceramics in the lower levels. In addition, test pit 12

produced Deptford simple stamped ceramics from one of the bottom levels. Although cordmarked ceramics were restricted to the upper levels in test pit 10, the lower levels had both fiber tempered and sand tempered ceramics.

Test pit 13 contained a dense shell layer with Wilmington and Savannah period ceramics. The sampled shell was primarily oyster (1081 g) but also included 17 g of clam. In addition, the level produced fish bone and scales. Test pit 14 did not contain any diagnostic artifacts, but it did produce two features. Feature 2 was a small pit with oyster shell, fish bone, and small charcoal fragments (Figure J-19). Feature 3 was also a small shell pit but was not excavated (Figure J-19).

Test pits 11 and 25 contained Savannah cordmarked ceramics in the upper levels and lithics in the bottom levels of test pit 11. Test pit 25 produced an unworked quartz river cobble in level 12. The appearance of the chert flakes and cobble coincided with the beginning of the yellow-tan sand layer.

The western portion of the site appears to be disturbed with a mixture of Savannah, Orange, Deptford period ceramics. The eastern portion of the site contains a shell deposit and shell features, while separate Savannah period and an unknown lithic strata are found in the central area.

8Du670. This site is a large ridge top site with historic and prehistoric components. The prehistoric component is centered primarily in the northern portion of the site and the late nineteenth century component in the southern half.

Two test pits were excavated; one was placed in the northern half, the other in the southern (Figure J-20). The stratigraphy of test pit 21 was as follows: humus and grey sand, yellow-brown mottled sand, yellow sand, and fine tan sand. Test pit 22 contained similar strata: humus and grey sand, yellow sand, tan-grey sand, and tan sand (Figure J-19).

Feature 6 was found in the upper levels of test pit 22. It was a small pit with oyster shell (211.2 g) and plain whiteware ceramics.

Both test pits contained historic and prehistoric artifacts in the four upper levels (Table J-5). Grit tempered ceramics were recovered from the lower levels. Although two types of Savannah period sherds were found in the lower levels, most of the Savannah period ceramics were removed from the upper levels. The historic ceramics were primarily whitewares, although two pearlware sherds were recovered.

Although the two components overlap to a great extent, this site produced an historic shell feature. It also produced a large number of historic ceramics and artifacts associated with domestic structures.

8Du671. This site was originally considered to be a small (0.02 ha) shell midden with cordmarked sherds. Two test pits were excavated (Figure J-21). The stratigraphy included humus and grey sand, yellow sand, and fine yellow-tan sand (Figure J-19). Test pit 26 contained mainly Deptford period ceramics (Table J-6). Test pit 27 produced Orange fiber tempered ceramics. The two test pits were located 10 m from each other. No shell was recovered from either excavation.

Apparently this site has two components that barely overlap over a very small area. Also, the preliminary designation of this site as a shell midden was incorrect.

8Du672. This site consisted of two large, grit tempered sherds in an area of bulldozer disturbance. One test pit was placed near the surface find (Figure J-22). The stratigraphy was humus and grey sand, tan and yellow mottled sand, and yellow sand (Figure J-19). No features were discovered. The test pit produced one plain grit tempered sherd, three unidentifiable sherds, and a very small amount of shell (Table J-6).

8Du673. This is a fairly large ridge top site adjacent to the marsh edge. It contained a brick and shell feature on the surface. Cordmarked and fiber tempered sherds were recovered from the shovel tests.

Two test pits were excavated: test pit 15 at the brick feature and test pit 16 near shovel test 270 (Figure J-23). Shovel test 270 produced cordmarked and roughened ceramics (Table J-7). The stratigraphy from test pit 15 followed the usual pattern of humus and grey sand, yellow sand, and fine tan sand (Figure J-24). Test pit 16 had a slightly different stratigraphy: humus and grey sand, yellow-brown sand, dark grey sand, and fine tan sand (Figure J-24). The dark grey sand was not a natural soil stratum but was considered a cultural deposit.

Test pit 15 was excavated to a depth of 10 cm and the surface bricks removed. The lower bricks were aligned in a northeasterly direction. It appears that the chimney was originally located southeast of the test pit and fell to the northwest. Historic artifacts came primarily from the first two levels, although mortar and brick fragments were found throughout the test pit (Table J-8). These artifacts consisted of whiteware, saltglazed stoneware, glass, and building materials. The prehistoric artifacts were mixed. Two-thirds of the ceramics were found in the first two levels. The lower levels contained plain and weathered grit tempered and weathered fiber tempered ceramics. Level eight produced an irregular dark stain (Feature 5) which contained 48.5 g of clam shell and Savannah cordmarked sherds.

Test pit 16 contained mainly Orange fiber tempered ceramics (Table J-7). The levels with the highest number of fiber tempered ceramics corresponded to the dark grey sand level in profile. A small number of Deptford sherds were present also. Feature 4 was an irregular dark stain which extended from the dark grey midden. It slanted downward into the north wall profile, appearing as an oval stain (Figure J-24). It produced Orange fiber tempered ceramics.

This site produced two separate components. One is a mid to late nineteenth century structure; the other is an Orange period occupation.

8Du674. This site was found on a broad, nearly level tongue of land between two unnamed creeks and yielded shell and sand tempered ceramics. Two test pits were excavated near shovel tests 218 and 307 (Figure J-25). These were chosen because of the presence of shell in test 218 and a cordmarked sherd in 307. The stratigraphy of both pits consisted of humus and grey sand, yellow-brown sand, and yellow and white sand.

Test pit 23 contained an irregular shell layer at 18-23 cm below surface that partially extended into the north wall profile (Figure J-24). A 2 liter sample of the shell contained 313 g clam and 102 g oyster shell. Savannah fine cordmarked and untyped cordmarked ceramics were recovered from the shell layer and below to a depth of 90 cm below surface (Table J-9).

Test pit 24 contained very little shell. Generally, Savannah period ceramics were found in the upper levels and Wilmington period ceramics in the lower levels (Table J-9). Two St. Johns check stamped sherds were recovered from the upper levels of test pit 24.

The site contains a Savannah period shell deposit of limited area and a potentially separate Wilmington period occupation. Other than the usual problem with root disturbance, the mixture of artifact levels does not appear to be severe.

8Du675. This site is a very small (100 m^2) non-shell site located near the marsh and a swamp. It produced clay tempered and cordmarked sand tempered ceramics. One test pit was excavated at the site (Figure J-26). The stratigraphy was humus and grey sand, yellow-tan sand, brown sand, and light grey sand (Figure J-27). The last two strata were very near the water table. Savannah fine cordmarked ceramics were recovered from the upper levels (Table J-10). Plain grit tempered ceramics were found

throughout the excavation. Three chert flakes were removed from the lower half of the square. A small amount of shell was recovered. This site appears to be a small Savannah period occupation. Other than the small amount of shell, no faunal or floral remains were obtained.

8Du676. This site is located next to the marsh and produced one chert retouch flake on the reconnaissance. One test pit was excavated (Figure J-28). The stratigraphy was humus and grey sand, tan sand, and brown sand - the natural soil horizon (Figure J-27). The site produced a limited number of undiagnostic sand tempered and grit tempered sherds and one chert biface fragment from 25-35 cm below surface (Table J-10). No shell was recovered.

8Du677. This site is a small (200 m^2) shell site. No artifacts were recovered from the reconnaissance. Two test pits were excavated: one on either side of the road (Figure J-29). The stratigraphy ranged from humus and grey sand to yellow-brown sand to yellow sand (Figure J-27). Dense oyster shell was encountered from 20-50 cm below surface. Artifacts were sparse. A total of seven undiagnostic grit tempered sherds were recovered from both test pits (Table J-11).

8Du678. This is a small (300 m^2) non-shell site located near the bluff edge of a small creek. It produced undiagnostic sand tempered ceramics from the reconnaissance. One test pit was placed in the middle of the artifact-producting shovel tests (Figure J-30). The stratigraphy was humus and grey sand, yellow sand, and mottled white and orange sand (Figure J-27). No shell or features were discovered. The ceramics were primarily cordmarked and undiagnostic grit tempered, although one Orange incised sherd was obtained from a meter below surface (Table J-12). One Savannah cordmarked and two Wilmington cordmarked sherds were recovered.

J.9 SUMMARY AND CONCLUSIONS

J.9.1 Site Reconnaissance

The site reconnaissance survey located ten archeological sites, relocated one site discovered previously, and recorded the presence of a mid-nineteenth century structure in New Berlin. The sizes of the sites ranged from 0.01-12.5 ha. All of the sites were located near the marsh in well drained soils, the region previously designated as a high probability site area.

The most distinctive aspect of the results was the absence of traditional chalky St. Johns ceramics. Most of the sherds recovered were sand tempered, although a small number of clay tempered sherds were found. A great deal of consistency exists between the types of ceramics found at all of the sites: two-thirds of the sites have plain sand tempered ceramics, half have cordmarked and tempered ceramics, and one-third have roughened sand tempered ceramics. In addition to the above ceramics, two sites contained an Orange phase component.

It is possible that the area has had three noncontinuous occupations. The first was during the Orange period, from 2000-1000 B.C. The second occupation probably was between 700-1500 A.D., the date marked by the production of cordmarked and clay tempered ceramics in the area. The third occupation was European/American in the mid-nineteenth century, although the area probably was used for lumbering from the early nineteenth century.

The absence of early and middle Archaic sites is not unexpected since most Archaic sites are located at least 50 miles south of the project area. Also, the location of Orange period sites along the marsh edge follows what is known about the settlement pattern of this period. The lack of St. Johns pottery, although found at other sites in the vicinity, also pointed out certain research questions, addressed in the detailed survey:

1. Is there actually a lack of St. Johns pottery or is it a function of small sample size?

2. Are the sand tempered pottery sites contemporaneous with the St. Johns II sites in the region, and, if so, what is the relationship between the two?

3. What is the relationship between shell sites and non-shell sites in the project area?

J.9.2 Detailed Survey

The goals of the detailed survey, as mentioned in the "Methods" section, were to examine the basic settlement pattern of the sites in the area, to investigate the lack of St. Johns period ceramics, and to collect information which could be used for a determination of each site's potential eligibility for the National Register of Historic Places.

The basic settlement pattern appears to be that of specialized fish and shellfish gathering camps during the prehistoric period. These would be short-term occupations based on the limited horizontal and vertical extent of the shell deposits. The non-shell sites could have been locations for the exploitation of marsh fauna, other than shellfish, or small nut collecting camps. The presence of several sites of the same period can be ascribed to repeated occupation.

Essentially, the area was occupied during two major prehistoric periods. The sand ridges adjacent to the marsh contain Orange period and Savannah period components. In addition, Savannah period occupations are found on the level ridges by a creek, 400 m from the marsh. The historic occupation centers on two small ridge tops overlooking the marsh.

From the testing of these sites one can conclude that the project area was not occupied by populations producing St. Johns type ceramics. Only two St. Johns period sherds were found, and these were associated with

contemporaneous Savannah period ceramics. Whether the presence of the Savannah period ceramics is a result of migration, diffusion, or acculturation is unknown.

Overall, the eleven archeological sites tested in the project area were disturbed to varying degrees. One large site, 8Du634, has been severely disturbed. The other large sites, 8Du669, 8Du670, 8Du673, and 8Du674, contain some mixture of cultural material but retain intact cultural levels and/or features. The small sites, 8Du671, 8Du672, 8Du675, 8Du676, 8Du677, and 8DU678, were primarily single component sites of limited horizontal and vertical extent.

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Table J-1

SUMMARY OF SITE DATA

Site	Size (ha)	Shell	Occupation	Vegetation	Soil Series
8Du634	12.5	yes	700-1500 A.D.	mixed hardwoods	Ortega
Field Site 2	8.8	yes	2000-1000 B.C. 700-1300 A.D.	mixed hardwoods	Ortega
Field Site 3	.94	yes	700-1500 A.D. mid-19th century	mixed hardwoods	Kershaw
Field Site 4	.02	yes	700-1300 A.D.	mixed hardwoods	Ortega
Field Site 5	unk.	no	unknown prehistoric	mixed hardwoods	Ortega
Field Site 7	1.3	yes	2000-1000 B.C. 700-1500 A.D. unknown prehistoric	mixed hardwoods	Kershaw
Field Site 8	1.2	yes	700-1300 A.D.	mixed hardwoods	Ortega
Field Site 9	.01	no	700-1500 A.D.	mixed hardwoods	Kershaw
Field Site 10	unk.	no	unknown prehistoric	mixed hardwoods	Ortega
Field Site 11	.02	yes	unknown	mixed hardwoods	Ortega
Field Site 12	.03	no	unknown prehistoric	mixed hardwoods	Kershaw

	Fiber tempered	Cord marked	Check stamped	Basket impressed	Incised	Roughened	Unidentified stamped	Clay tempered plain	Sand tempered plain	Weathered	Chert biface-broken	Chert retouch flake	Chert debitage	Plain whiteware (HW)	Transfer print HW	Handpainted polychrome HW	Sponge printed HW	Raised relief HW	Hand painted floral blue HW	Annular HW	Yellow ware	North American Salt glaze	Alkalin salt glaze	Porcelain	Glass	Nails	Misc. metal	Plastic	Bricks & Mortar	TOTAL
BDu634																														
Surface		4						1	9																					14
ST 252			1																											1
ST 253		1																												1
ST 290										1																				1
ST 292										1																				1
ST 296										1																				1
ST 297									1																					1
ST 322		1																												1
Total		6	1					1	10	3																				21
Field Site 2																														
Surface		1																												1
ST 259		3																												3
ST 262													1																	1
ST 263					1																									1
ST 264		2	1																											3
ST 265		2							1																					3
ST 266		2																												2
St 267									1	1																				2
ST 268		1																												1
ST 269		2																												2
ST 276		1																												1
ST 280		2																												2
ST 281									3																					3
ST 282		2							2																					4
ST 284									1																					1
ST 285	2																													2
ST 311									1																					1
ST 312							1		1				2																	4
ST 313							1																							1
ST 314							2																							2
ST 316	4																													4
ST 317											1																			1
Total	6	18	1		1		4		10	1	1		3																	45

Table J-2 Artifact Tabulations

	Fiber tempered	Cord marked	Check stamped	Basket impressed	Incised	Roughened	Unidentified stamped	Clay tempered plain	Sand tempered plain	Weathered	Chert biface-broken	Chert retouch flake	Chert debitage	Plain whiteware (HW)	Transfer print HW	Handpainted polychrome HW	Sponge printed HW	Relief relief HW	Hand painted floral blue HW	Annular HW	Yellow ware	North American Salt glaze	Alkalin salt glaze	Porcelain	Glass	Nails	Misc., metal	Plastic	Bricks & Mortar	TOTAL
Field Site 3																														
Surface									1					13	1	1	1		1	1	1	1	11	1	13	1	8	2	X	57
1035N 980E									1																					1
1005N 1010E																		1												1
1000N 995E									1	1																				2
995N 995E																									4					4
980N 995E																									1		1			2
940N 985E																													2	2
980N 985E																													2	2
ST 14				3					1																					4
ST 222								1	3																					4
ST 324			1																											1
Total			1	3				1	7	1				13	1	1	1	1	1	1	1	1	11	1	18	1	9	2	4	80
Field Site 4																														
ST 126									1																					1
ST 127		2																												2
Total		2							1																					3
Field Site 5																														
Surface									2																					2
Field Site 7																														
Surface	1																													1
ST 270		3				2																								5
ST 271						1																								1
ST 272								1																						1
ST 298																								2						2
ST 299																								6	1	2		1	10
Total	1	3				3		1																8	1	2		1	20
Field Site 8																														
ST 221									1																					1
ST 306						1																								1
ST 307		1																												1
ST 326		2					1			3																				6
ST 327		1																												1
ST 328		1							1																					2
Total		5				1	1		2	3																				12
Field Site 9																														
ST 41		1																												1
ST 44								1	1																					2
ST 45						1																								1
Total		1				1		1	1																					4
Field Site 10																														
ST 80											1																			1
Field Site 12																														
ST 23						1																								1
ST 27						1																								1
ST 29						1			1																					2
Total						3			1																					4
GRAND TOTAL	1	35	3	3	1	8	5	4	34	8	1	1	3	13	1	1	1	1	1	1	1	1	11	1	26	2	11	2	5	192

Table J-2 Artifact Tabulations (cont'd)

	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Surface Collection														5		2						5	1		3	16						2.6	
Test Pit 1																																	
Level 1														2												2							
2			1				2						1	4		8					4	5			4	29							18.1
3													3	1			1			1	6	3		1	3	19							29.4
4														1	1	2	1			3	1					9							25
5														1			2							4		7							5.3
6													1	1							3			2		7							.6
7													2	3				1			2	2		1		11							1.2
8																				1						1							7.2
TOTAL			1				2						7	18	1	12	4	1		5	16	15	1	8	10	101						2.6	87.0
Test Pit 2																																	
Level 1																						1		1		2							4.2
2																1					8			2	1	12							16.3
3			2											3							2	2				9							54.1
4													1	1			1		1						2	6							9.4
5							1														2			1	3	7							.6
6														1												1						3.9	2.4
7																1					1			1		3							9.6
8																					1				2	3							3.3
9													1				1									2							.2
10																																	.1
11														1							1					2						.4	.2
TOTAL			2				1						2	6		2	2		1		15	3		5	8	47						5.1	100.4

Table J-3. Artifact Tabulations: 8Du634

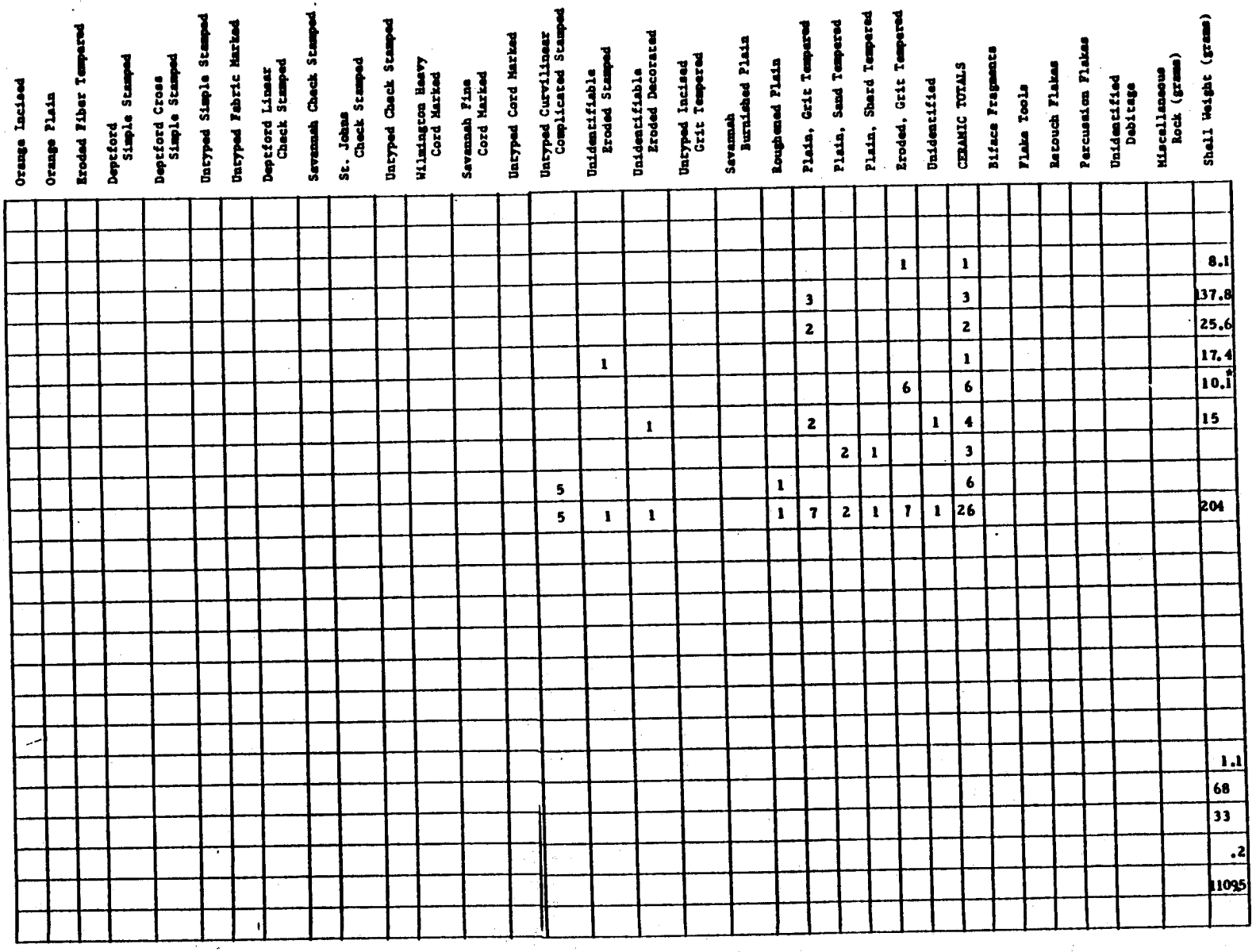
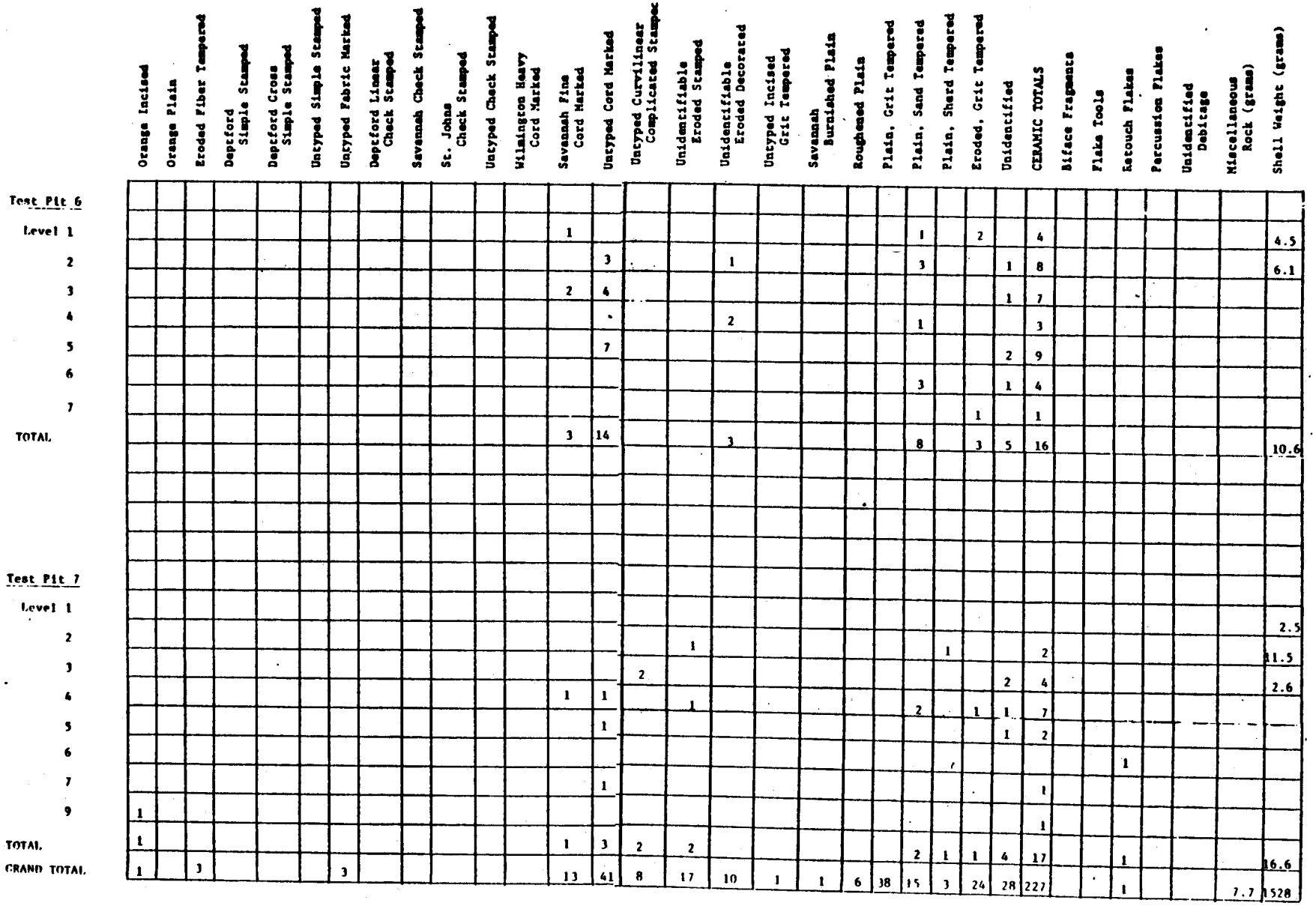


Table J-3. Artifact Tabulations: 8Du634 (cont.)



	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Test Pit 6																																	
Level 1													1									1		2		4							4.5
2														3			1					3			1	8							6.1
3													2	4											1	7							
4																	2					1				3							
5														7											2	9							
6																						3			1	4							
7																								1		1							
TOTAL													3	14			3					8		3	5	16							10.6
Test Pit 7																																	
Level 1																																	2.5
2																1							1			2							11.5
3															2										2	4							2.6
4													1	1		1						2		1	1	7							
5														1											1	2			1				
6																										1							
7														1												1							
9	1																									1							
TOTAL	1												1	3	2	2						2	1	1	4	17			1				16.6
GRAND TOTAL	1		3				3						13	41	8	17	10	1	1	6	38	15	3	24	28	227			1			7.7	1528

Table J-3. Artifact Tabulations: 8Du634 (cont.)

	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Test Pit 9																																	
Level 2																								1		1							
5																																	.1
7																					1					1							
8											1										1					2							5.2
9			1											1							1		1			4							.7
11													1	1												2							
TOTAL			1								1		1	2							3		1	1		10							6.0
Test Pit 10																																	
Level 1			2																							2							25
2		1												2							1			1	2	7							57.1
3													1	1							2				4	8							13.6
4	2																1		1		1					5							.7
5			2																1						1	4							4.4
6			2																		1					3							
7			3																							3							
8			2																					1		3							
9			5																			4		1		10							2.9
11	1																									1							
12																					1					1							
TOTAL	3	1	16								1		1	3			1		2		6	4		2	7	47							103.7

Table J-4 . Artifact Tabulations: 8Du669

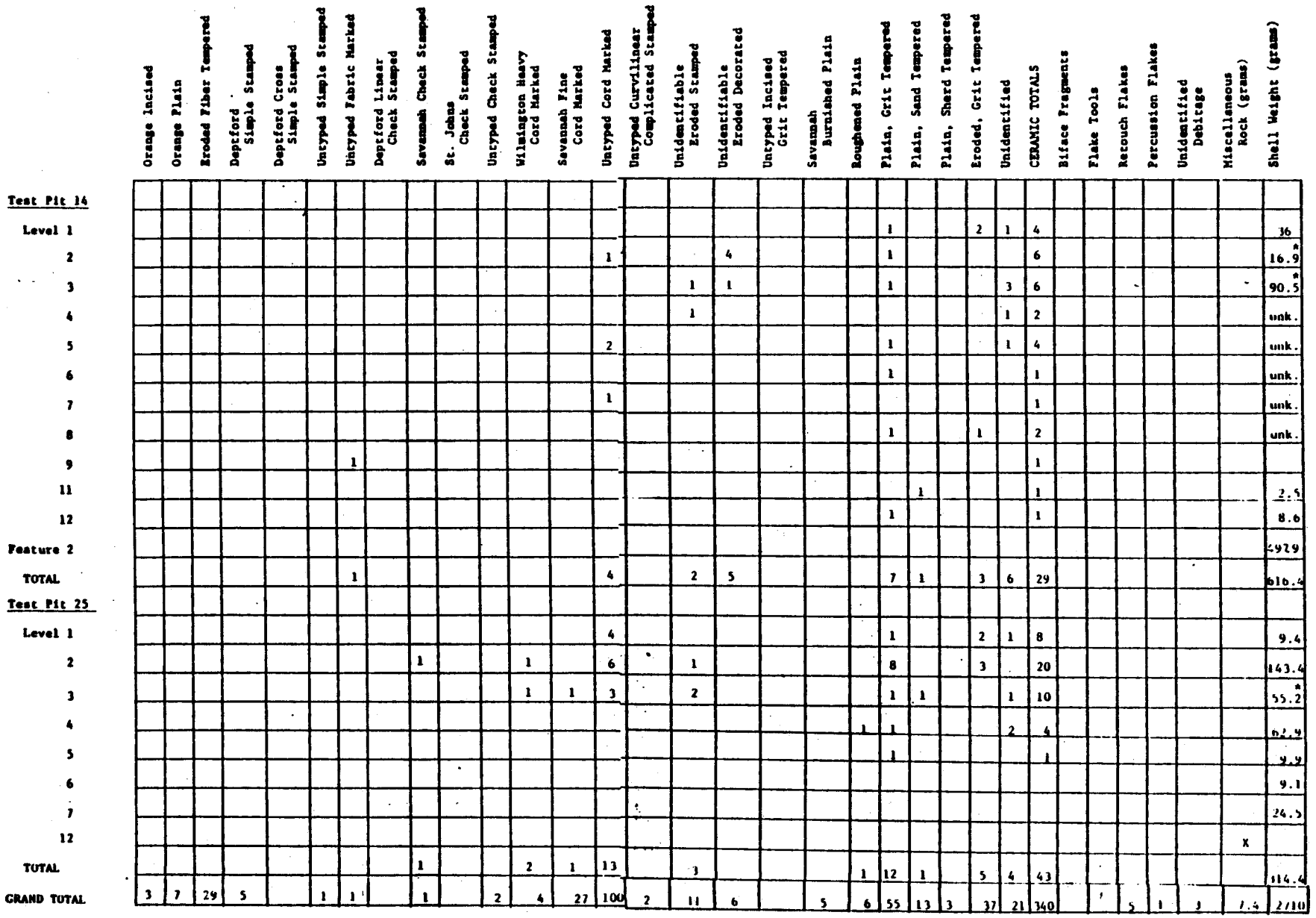
Test Pit 11	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Level 1														3												3							
2													2	15											1	18			1			6.1	
3													6	9		1					4			5		25							11.1
4													3	11							1			1		16							
5													4	4							2	2			1	13							
6													4	5										1		10							8.1
7													2	18		2			1		2					25							4.1
9													2	4							2		1	5		14							
10														1												1							
11																								1		1							
12																															1	.6	.7
13																														1			
14																																	.7
15																													2				
16																															2	.7	
17																													1				
TOTAL													23	70		3			1		11	2	1	13	2	126			4	1	3	7.4	24.7

Table J-4. Artifact Tabulations: 8Du669 (cont.)

	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Test Pit 12																																	
Level 2																								4		4							7.9
3		3	2																		3					8							18.4
4																						2				2							
5			2																					1		3							3.4
6																									1	1							.3
7																																	5.5
9		1																								1			1				3
10		1	3																							4							.2
12			1																		1					2							
13			2											1						1		1				5							
14		1		5		1								1							1				1	10							9.6
15			2								1					1					1	1				6							7
TOTAL		6	12	5		1					1			2		1				1	6	4		5	2	46			1				55.2
Test Pit 13																																	
Level 1																																	148.9
2															1	2								2		5							323.3*
3															1						9			3		13							1115*
4												2	1	5					2		1			3		14							.2
5														1												1							
7																							1			1							
8																				4						4							.2
9																						1				1							.6
TOTAL												2	1	6	2	2			2	4	10	1	1	8		39							1590

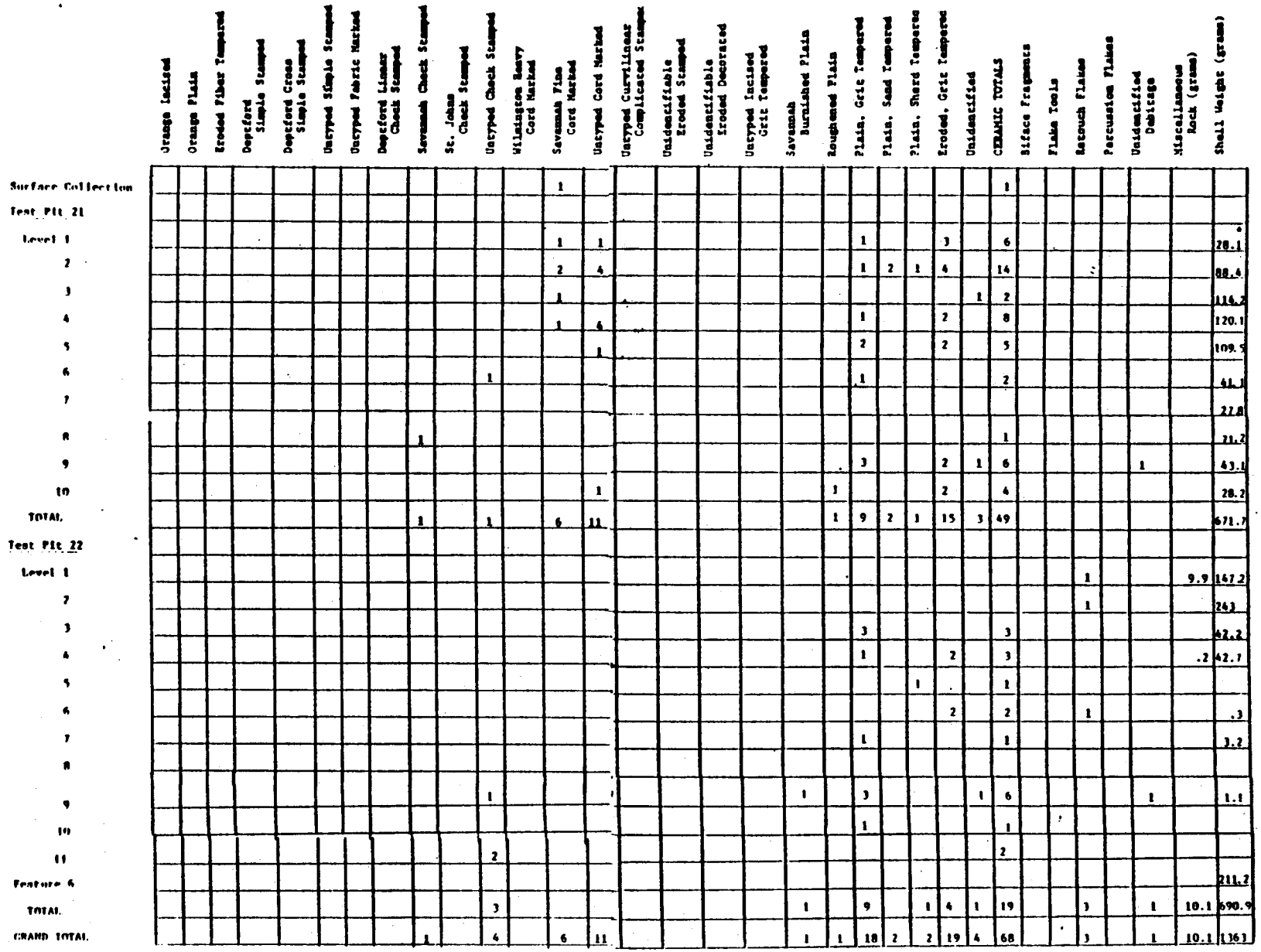
* sample

Table J-4. Artifact Tabulations: 8Du669 (cont.)



	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Test Pit 14																																	
Level 1																					1			2	1	4							36
2														1			4				1					6							16.9*
3																1	1				1				3	6							90.5*
4																1									1	2							unk.
5														2							1				1	4							unk.
6																					1					1							unk.
7														1												1							unk.
8																					1			1		2							unk.
9							1																			1							
11																						1				1							2.5
12																					1					1							8.6
Feature 2																																	4929
TOTAL							1							4		2	5				7	1		3	6	29							616.4
Test Pit 25																																	
Level 1														4							1			2	1	8							9.4
2									1			1		6		1					8			3		20							143.4
3												1	1	3		2					1	1			1	10							55.2*
4																				1	1				2	4							62.4
5																					1					1							9.9
6																																	9.1
7																																	24.5
12																																X	
TOTAL									1			2	1	13		3				1	12	1		5	4	43							114.4
GRAND TOTAL	3	7	29	5		1	1		1		2	4	27	100	2	11	6		5	6	55	13	3	37	21	340		1	5	1	3	1.4	2710

Table J-4. Artifact Tabulations: 8Du669 (cont.)



	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Unstyped Simple Stamped	Unstyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Unstyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Unstyped Cord Marked	Unstyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Unstyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Surface Collection													1													1							
Test Pit 21																																	
Level 1													1	1							1			3		6							28.1
2													2	4							1	2	1	4		14							88.4
3													1												1	2							114.2
4													1	4							1			2		8							120.1
5														1							2			2		5							109.5
6											1										1					2							41.1
7																																	27.8
8									1																	1							21.2
9																					3			2	1	6					1		43.1
10														1						1				2		4							28.2
TOTAL									1		1		6	11						1	9	2	1	15	3	49							671.7
Test Pit 22																																	
Level 1																													1			9.9	147.2
2																													1				24.3
3																					3					3							42.2
4																					1			2		3						.2	42.7
5																							1			1							
6																								2		2			1				.3
7																					1					1							3.2
8																																	
9											1								1		3				1	6					1		1.1
10																					1					1							
11											2															2							
Feature 6																																	211.2
TOTAL											3								1		9		1	4	1	19			3		1	10.1	690.9
GRAND TOTAL									1		4		6	11					1	1	18	2	2	19	4	68			3		1	10.1	1361

Table J-5. Prehistoric Artifact Tabulations: 8Du670

* sample

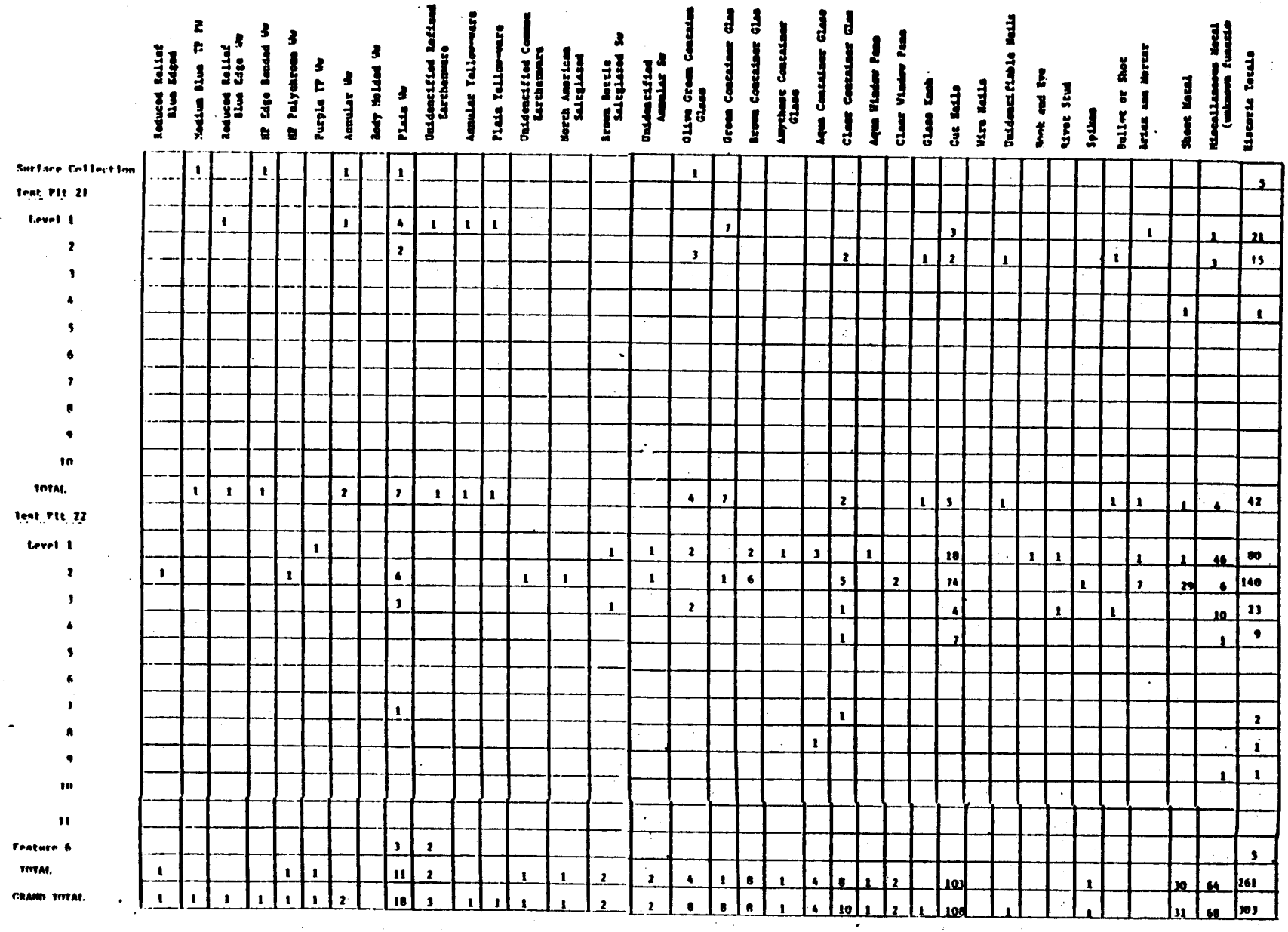
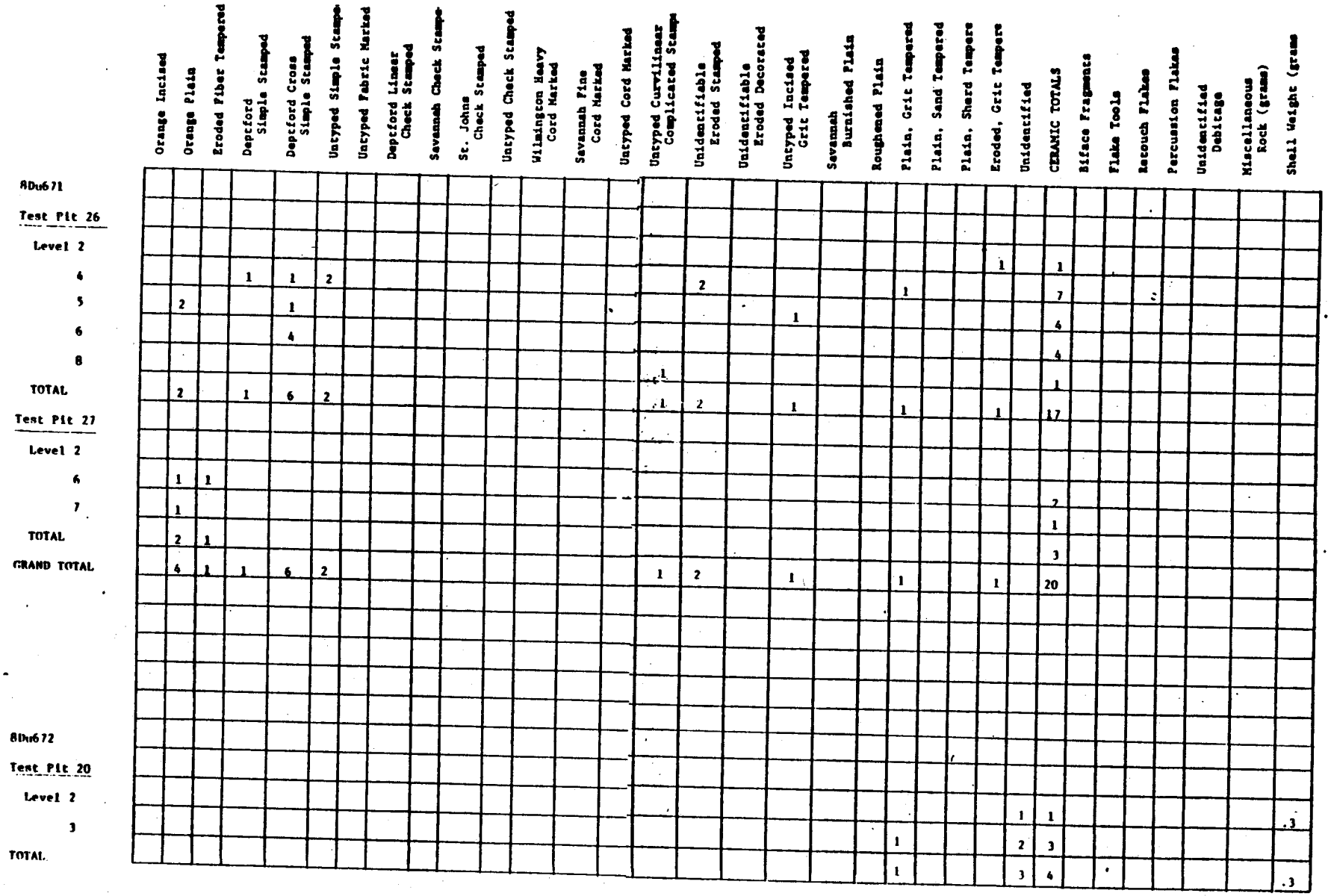


Table J-5. Historic Artifact Tabulations: 8Du670 (cont.)

Pw - Pearlware Sw - Stoneware TP - Transfer Printed

Ww - Whiteware HP - Hand Painted



	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
8Du671																																	
Test Pit 26																																	
Level 2																																	
4				1	1	2										2								1		1							
5		2			1										1						1					7							
6					4													1								4							
8															1											4							
TOTAL		2		1	6	2									1	2		1			1			1		17							
Test Pit 27																																	
Level 2																																	
6		1	1																							2							
7		1																								1							
TOTAL		2	1																							3							
GRAND TOTAL		4	1	1	6	2									1	2		1			1			1		20							
8Du672																																	
Test Pit 20																																	
Level 2																																	
3																									1	1							.3
TOTAL																					1				2	3							
															1						1				3	4		1					.3

Table J-6. Artifact Tabulations: 8Du671 and 8Du672

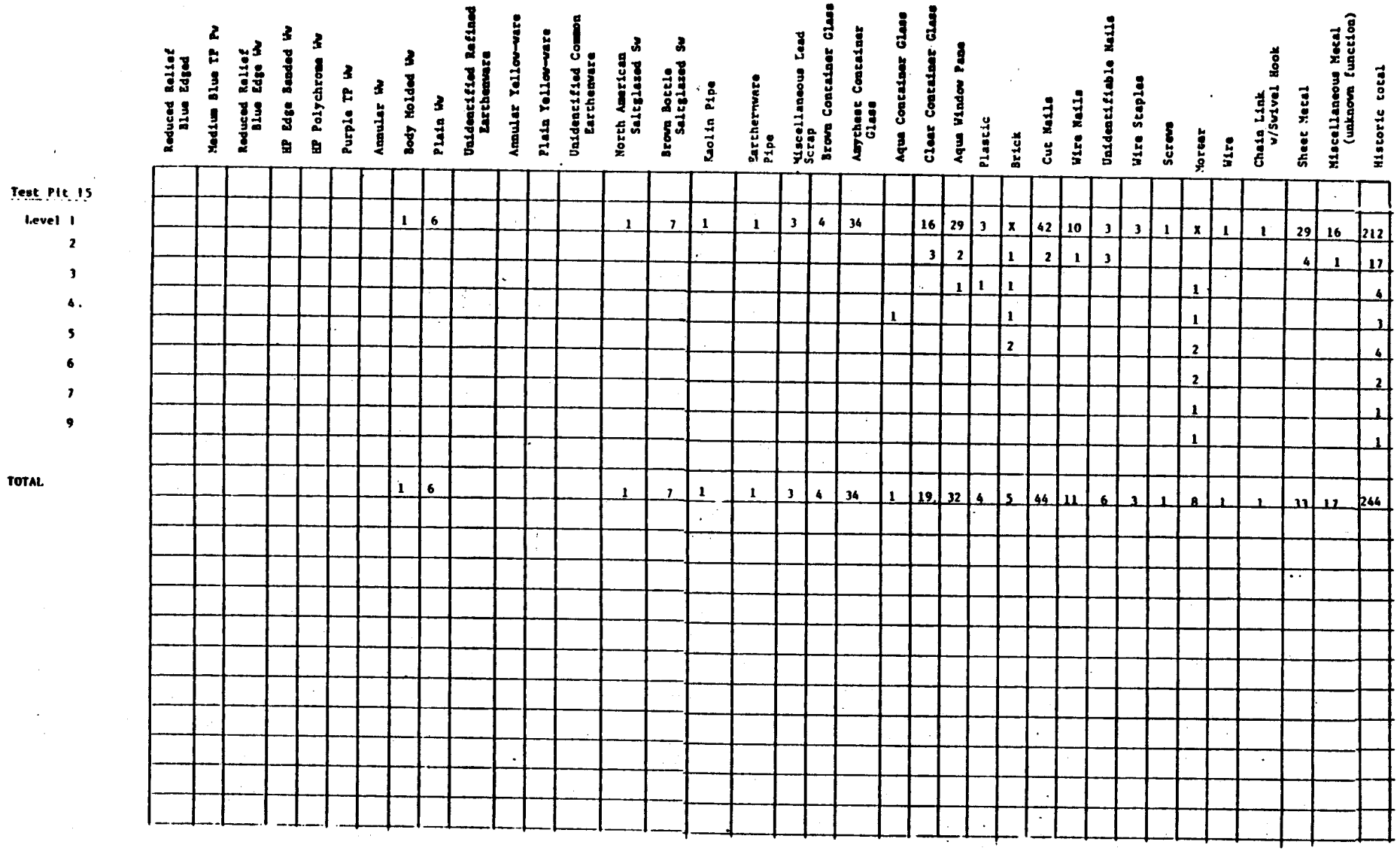
	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Test Pit 15																																	
Level 1														2			2				3			5	2	14			1			8.7	108.4*
2																					8	1		16	4	29						.5	
3			1																	1	3			2		7							
4																1					1			2	1	5							
5		1	4																					1		1							.5
6																										5							
7																										0							.5
9																1					2					2							
Feature 5													1	1							1	1			1	5							48.5
TOTAL		1	5										1	3		2	2			1	18	2		26	8	68			1			9.2	157.9

* sample

Table J-7. Prehistoric Artifact Tabulations: 8Du673

	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Sherd Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Test Pit 16																																	
Level 1																					1					1							
2																								6		6							
3		1	6	2		3															3					15	1	1	1			.6	
4		3	8	1											1	3					1			3	1	21							
5		9	8																		1					18							.6
6		5	18																					3		26							.4
7	4	1	18																		1					24							
8			26																							26			3				
9	1		37																					1		39					1	.2	
10	2	1	20	2	1			1														1			1	29							9
11			17																							17					1		
12	1		1																		1					3							2.5
13	1	2	16																							19							3.8
14	1	1	3																							5							
15			2																							2							
16			1																							1							
Feature 4		2	4																							6							
TOTAL	10	25	185	5	1	3		1						1	1	3					8	1		13	2	258	1	1	4		2	.8	16.3
GRAND TOTAL	10	26	190	5	1	3		1					1	3	1	5	2			1	26	3		39	10	326	1	1	5		2	10.0	174.2

Table J-7. Prehistoric Artifact Tabulations: 8Du673 (cont.)



	Reduced Relief Blue Edged	Medium Blue TP Pw	Reduced Relief Blue Edge Ww	HP Edge Banded Ww	HP Polychrome Ww	Purple TP Ww	Annular Ww	Body Molded Ww	Plain Ww	Unidentified Refined Earthenware	Annular Yellow-ware	Plain Yellow-ware	Unidentified Common Earthenware	North American Saltglazed Sw	Brown Bottle Saltglazed Sw	Kaolin Pipe	Earthenware Pipe	Miscellaneous Lead Scrap	Brown Container Glass	Amythest Container Glass	Aqua Container Glass	Clear Container Glass	Aqua Window Pane	Plastic	Brick	Cut Nails	Wire Nails	Unidentifiable Nails	Wire Staples	Screws	Yoreer	Wire	Chain Link w/Swivel Hook	Sheet Metal	Miscellaneous Metal (unknown function)	Historic total
Test Pit 15																																			
Level 1								1	6					1	7	1	1	3	4	34		16	29	3	X	42	10	3	3	1	X	1	1	29	16	212
2																						3	2		1	2	1	3						4	1	17
3																							1	1	1						1					4
4																					1				1						1					3
5																									2						2					4
6																															2					2
7																															1					1
9																															1					1
TOTAL								1	6					1	7	1	1	3	4	34	1	19	32	4	5	44	11	6	3	1	8	1	1	33	17	244

Pw - Pearlware
Ww - Whiteware
Sw - Stoneware
HP - Hand Painted
TP - Transfer Printed

Table J-8. Historic Artifact Tabulations: 8Du673

Test Pit 23	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Unstyped Simple Stamped	Unstyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Unstyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Unstyped Cord Marked	Unstyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Unstyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Level 1																										0							8.4
2																1							2		2	5							432.9
3														5							2		3		1	11							292.7*
4														2							1			4		7							126.1*
5																1									1	2							147.1*
6											1			4		1					1	1	2	1	2	13							147.2*
7													3	3		1										7							12.7
8							3															1				4							21.8
9													2	1		1					1	1				6							11.3
10																						1				1							2.8
11																										0							9.2
12											2															2							
TOTAL							3				3		5	15		5					5	4	7	5	6	58							919.5

* sample

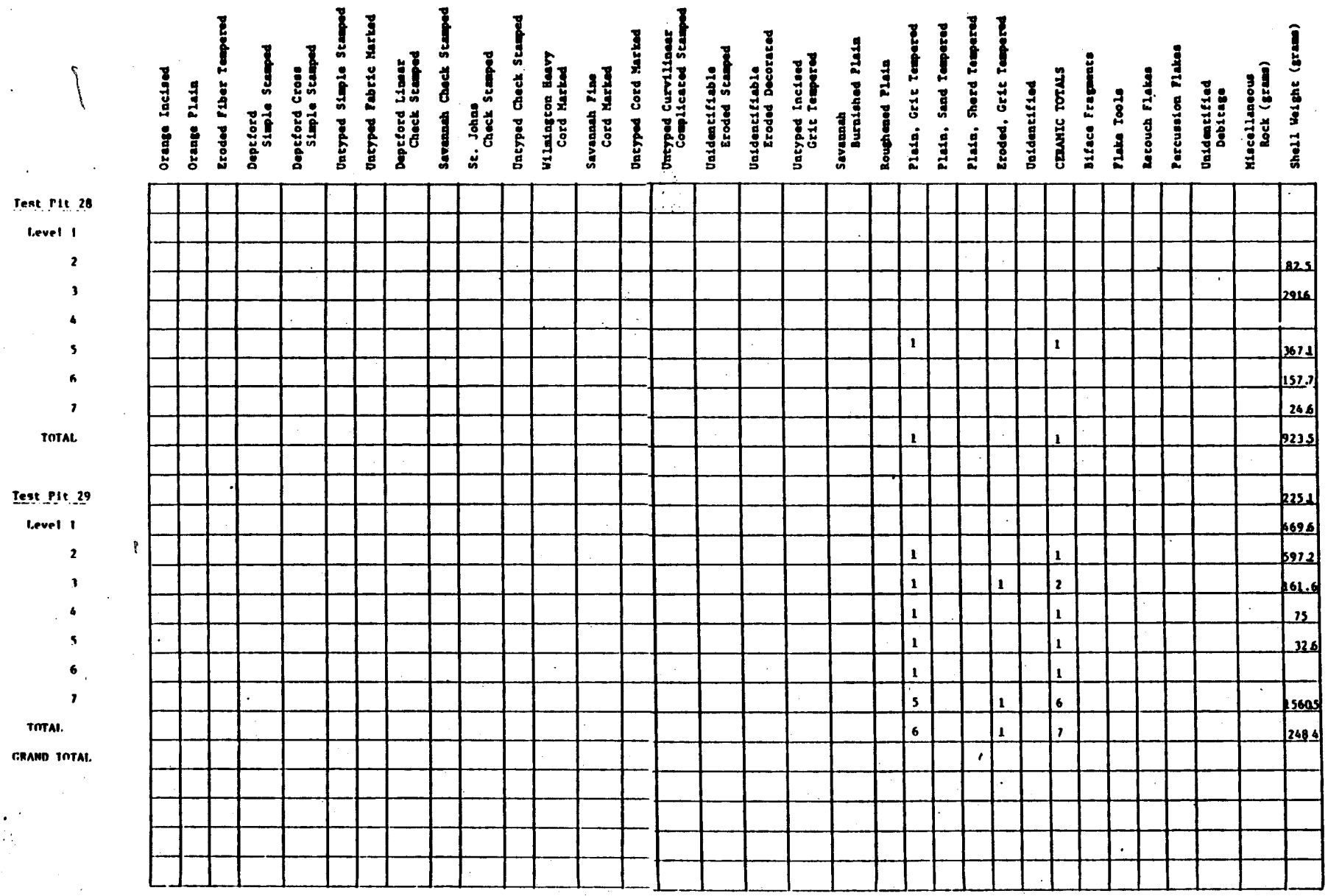
Table J-9. Artifact Tabulations: 8Du674

	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Sherd Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Test Pit 24																																	
Level 1																					1					1							
2										1				6								3		3	4	17							.2
3														11		3								2	2	18						.3	
4														1		1					2			2	4	10							.6
5										1			1	6		2					3	1		2	1	17							
6												2		2							2	1		3	1	11			1				
7																			1							1							
8																1				2					1	4							
9											1	1	1			1					1				1	6							
10																1										1						.3	
11												1		8		3			1	1	2	2			4	22							
12												1		3		4							1		3	12							
TOTAL										2	1	5	2	37		16			2	3	11	7	1	12	21	120			1			.6	.8
GRAND TOTAL							3			2	4	5	7	52		21			2	3	16	11	8	17	27	178			1			.6	920

Table J-9. Artifact Tabulations: 8Du674 (cont.)

	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
8 Du 675																																	
Test Pit 18																																	
Level 1																1					6				2	9							
2													2								1			3		6							
3													1								3			4	2	10							4.4
4												1	5								1	1				8							.1
5													1								2	1			1	5							
6													2			2					1	1				7			1				
7																3					1				1	5			1				
8																3					1	3				7							
9																		1			3				3	7							
10																									1	1					1		
11																										0							
TOTAL												1	11			9		1			19	6		7	10	65			2		1		4.5
8 Du 676																																	
Test Pit 19																																	
Level 2																							3			3	1						
3																						1		4		5							
TOTAL																						1	3	4		8	1						

Table J-10. Artifact Tabulations: 8Du675 and 8Du676

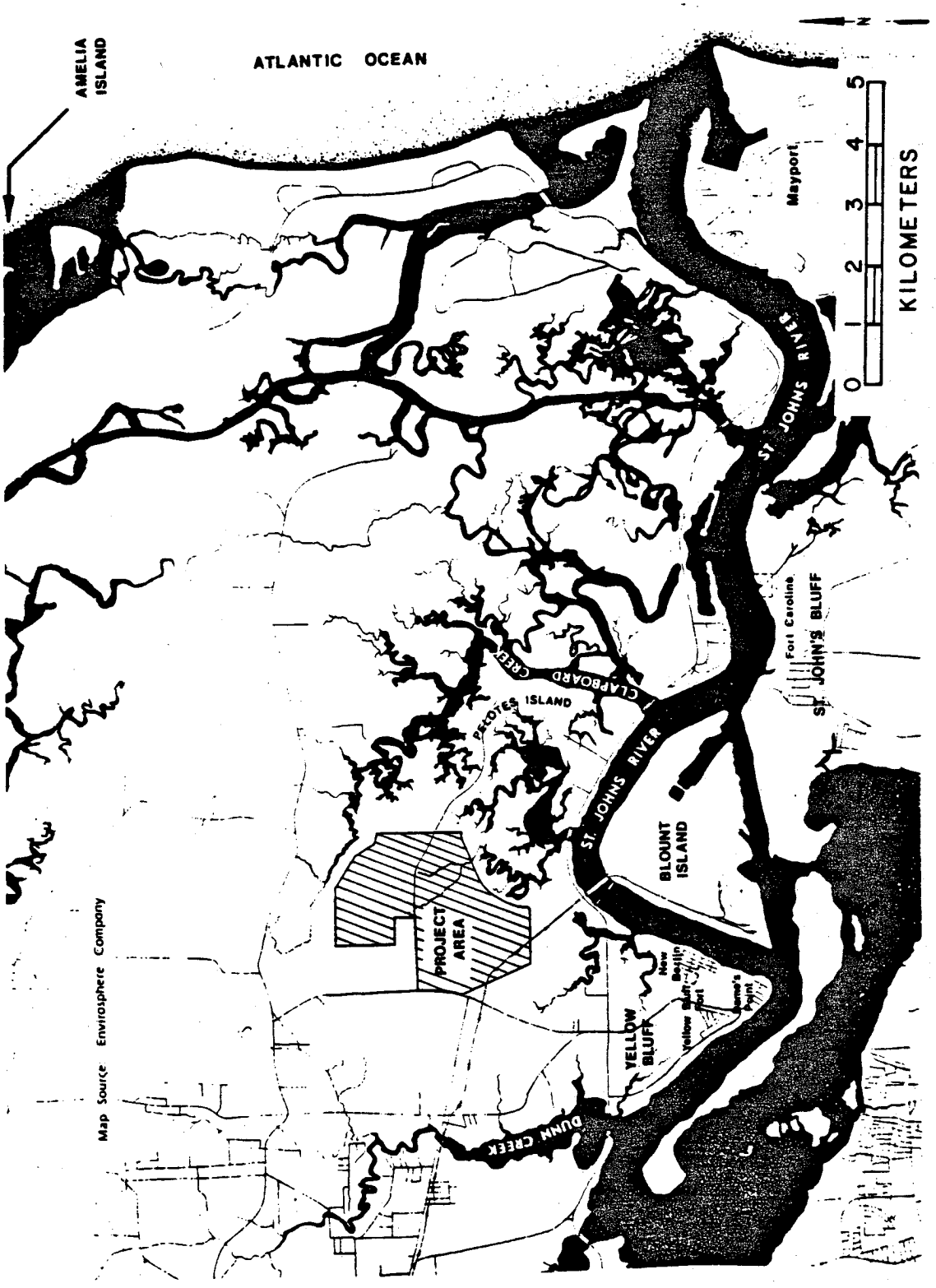


	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Ratouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Test Pit 28																																	
Level 1																																	
2																																	82.5
3																																	2916
4																																	
5																					1					1								367.1
6																																	157.7
7																																	24.6
TOTAL																					1					1							923.5
Test Pit 29																																	225.1
Level 1																																	669.6
2																					1					1							597.2
3																					1			1		2							461.6
4																					1					1							75
5																					1					1							32.6
6																					1					1							
7																					5			1		6							1560.5
TOTAL																					6			1		7							248.4
GRAND TOTAL																																	

Table J-11. Artifact Tabulations: 8Du677

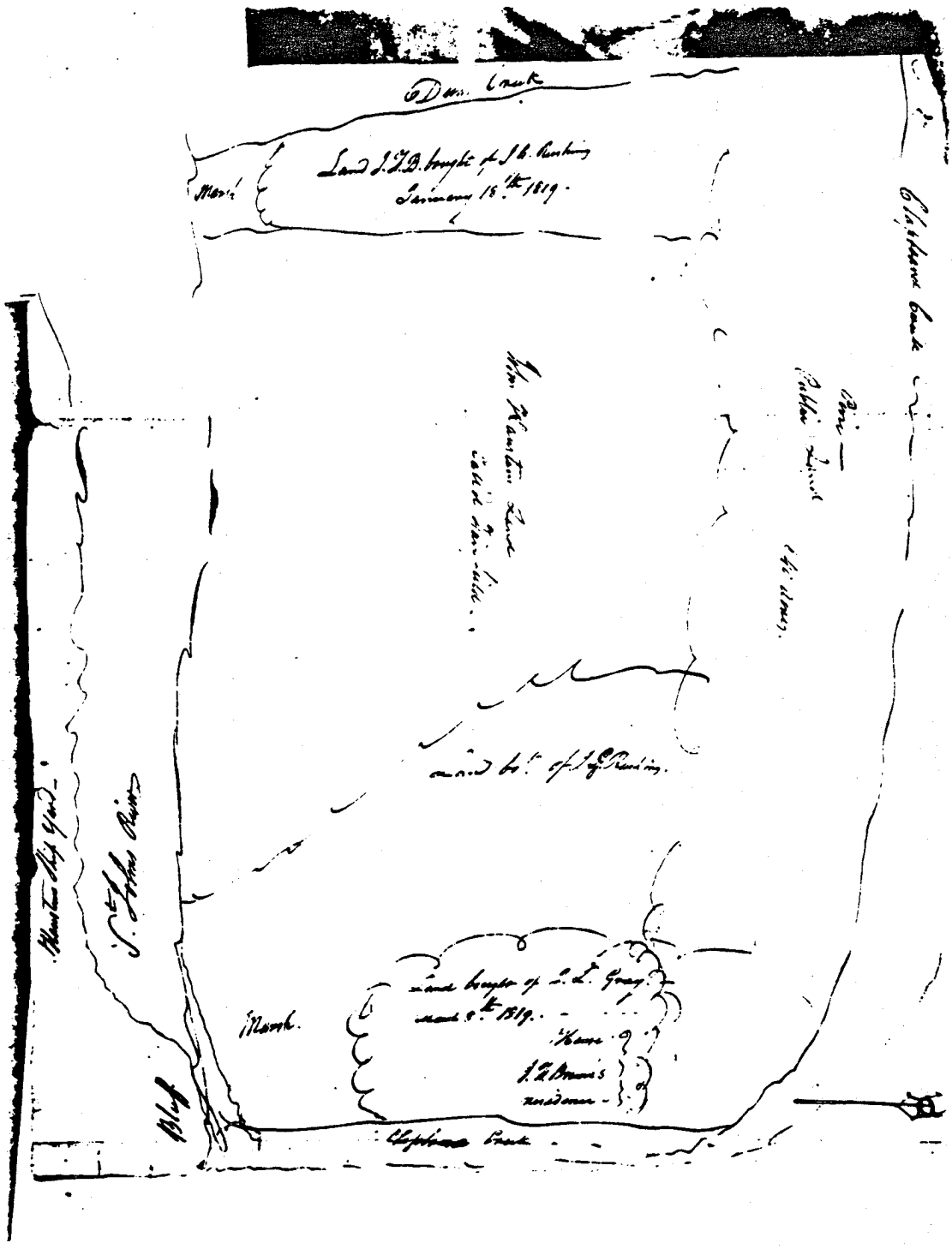
	Orange Incised	Orange Plain	Eroded Fiber Tempered	Deptford Simple Stamped	Deptford Cross Simple Stamped	Untyped Simple Stamped	Untyped Fabric Marked	Deptford Linear Check Stamped	Savannah Check Stamped	St. Johns Check Stamped	Untyped Check Stamped	Wilmington Heavy Cord Marked	Savannah Fine Cord Marked	Untyped Cord Marked	Untyped Curvilinear Complicated Stamped	Unidentifiable Eroded Stamped	Unidentifiable Eroded Decorated	Untyped Incised Grit Tempered	Savannah Burnished Plain	Roughened Plain	Plain, Grit Tempered	Plain, Sand Tempered	Plain, Shell Tempered	Eroded, Grit Tempered	Unidentified	CERAMIC TOTALS	Biface Fragments	Flake Tools	Retouch Flakes	Percussion Flakes	Unidentified Debitage	Miscellaneous Rock (grams)	Shell Weight (grams)
Test Pit 17																																	
Level 1																1					1				1	3							
2														2		2					6			2	1	13							
3													1	4		2					2	2				11							
4														1							2					3							
5												2		5							1			7		15							
6																								1		1							
7																					1					1							
9	1																									1							
TOTAL	1											2	1	12		5					13	2		10	2	48							

Table J-12. Artifact Tabulations: 8Du678



SOUTHEASTERN WILDLIFE SERVICES, INC.

Figure J-1 Project Area


Land I.F.B. bought of J.B. Rushing
January 16th 1819.
Mr. Rushing's land
Mr. Rushing
Mr. Rushing
Mr. Rushing

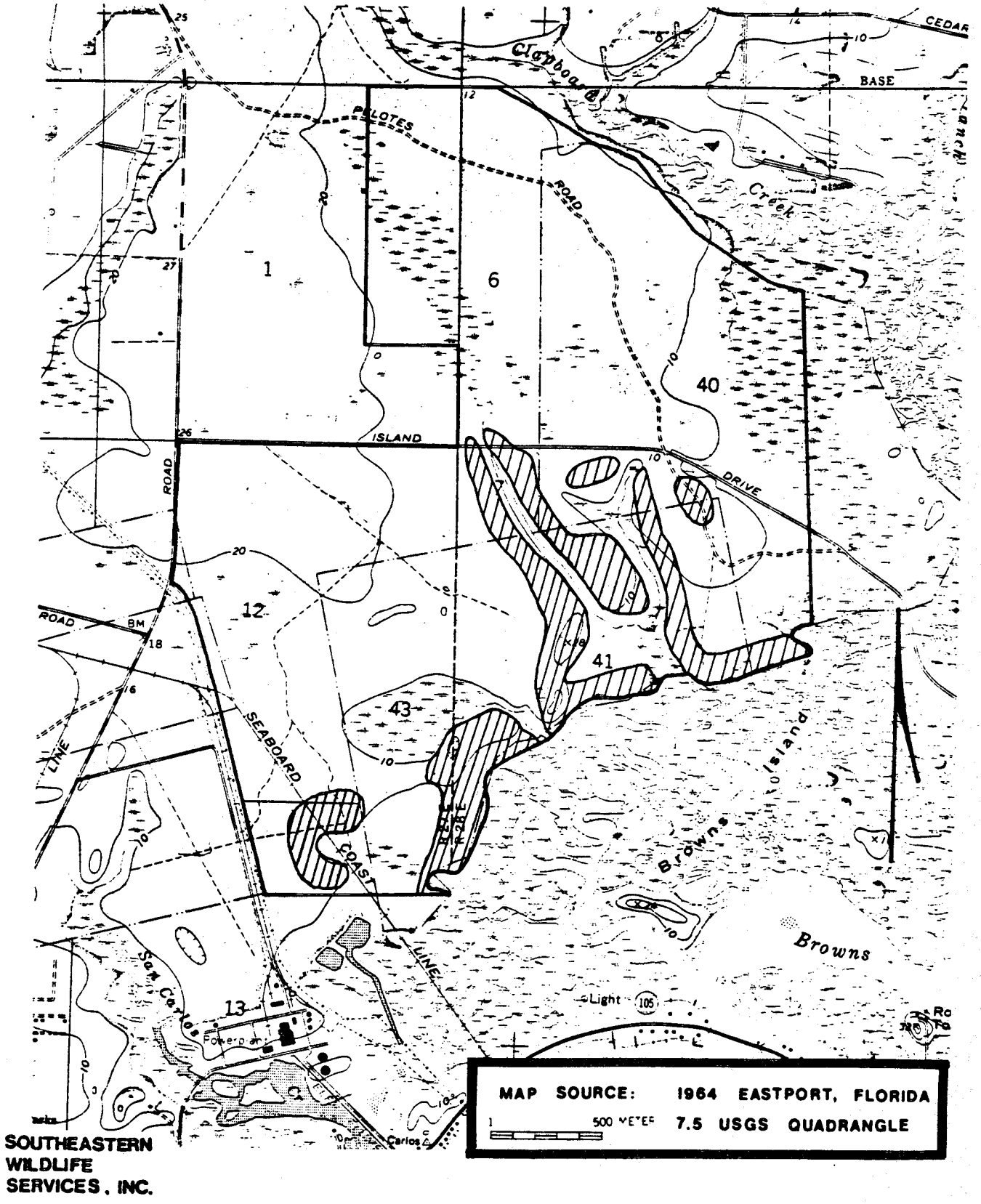


Figure J-3 High Probability Site Areas

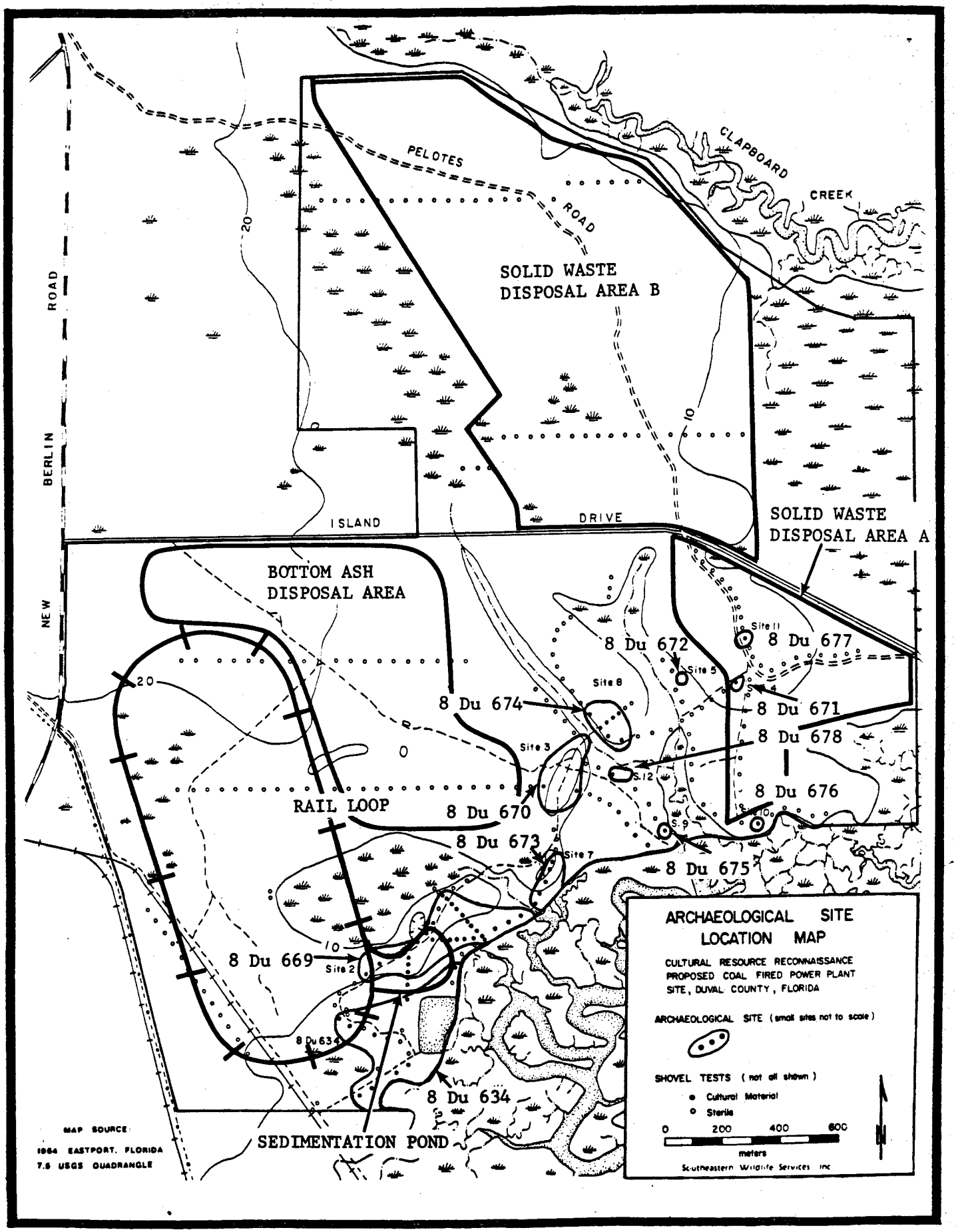


Figure J-4 Archeaological Sites Map

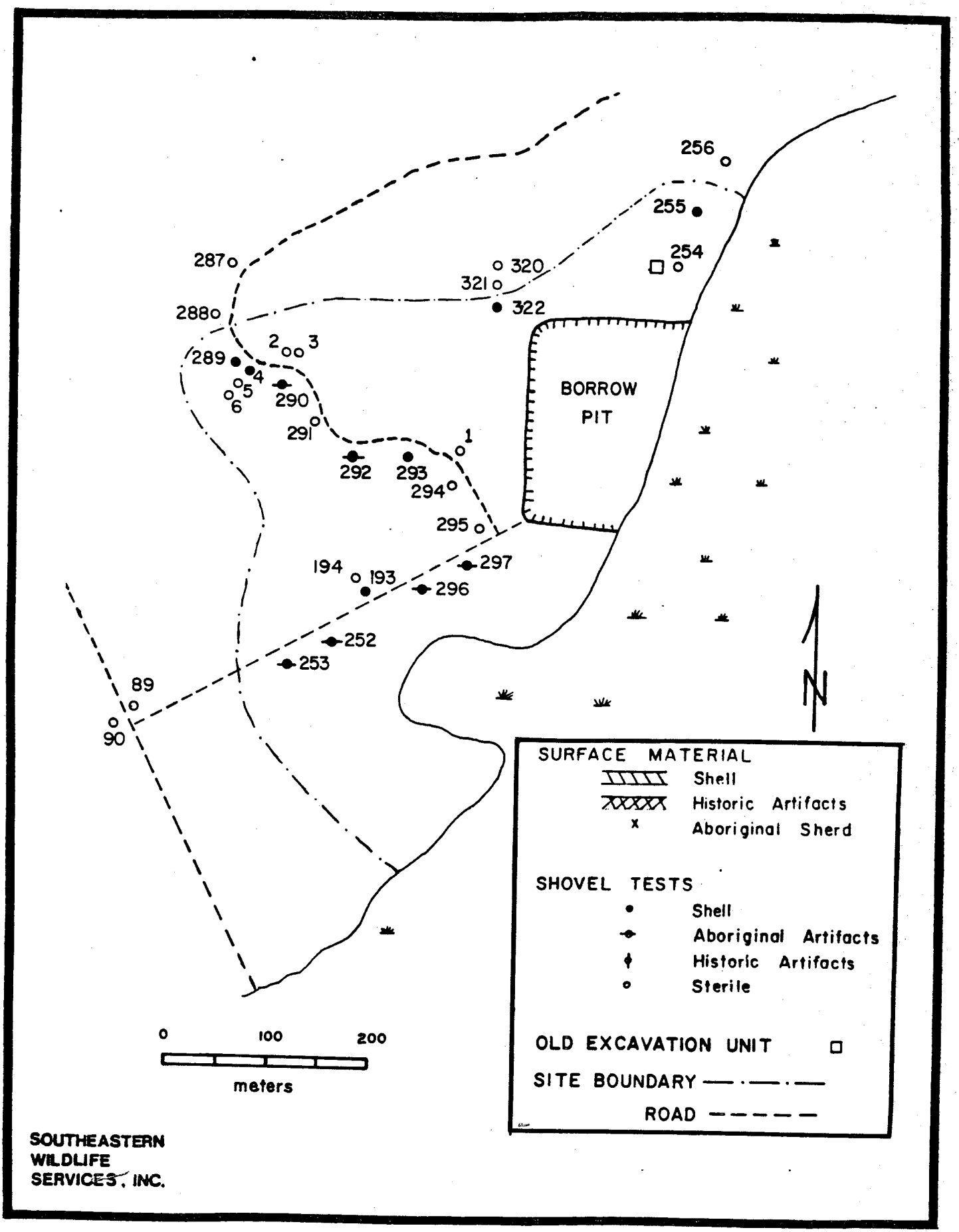


Figure J-5 8Du634 Map

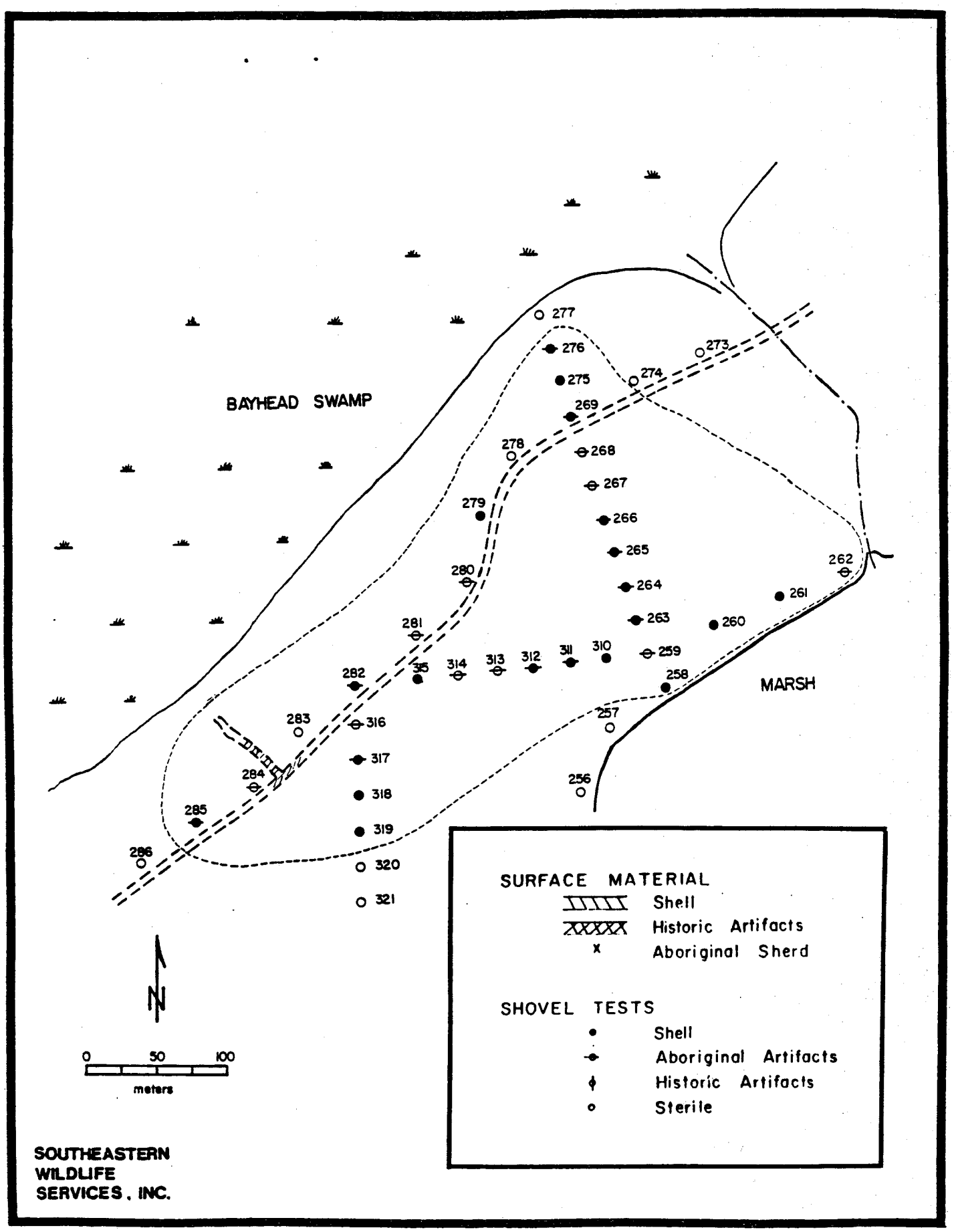


Figure J-6 Field Site 2 (8Du699) Map

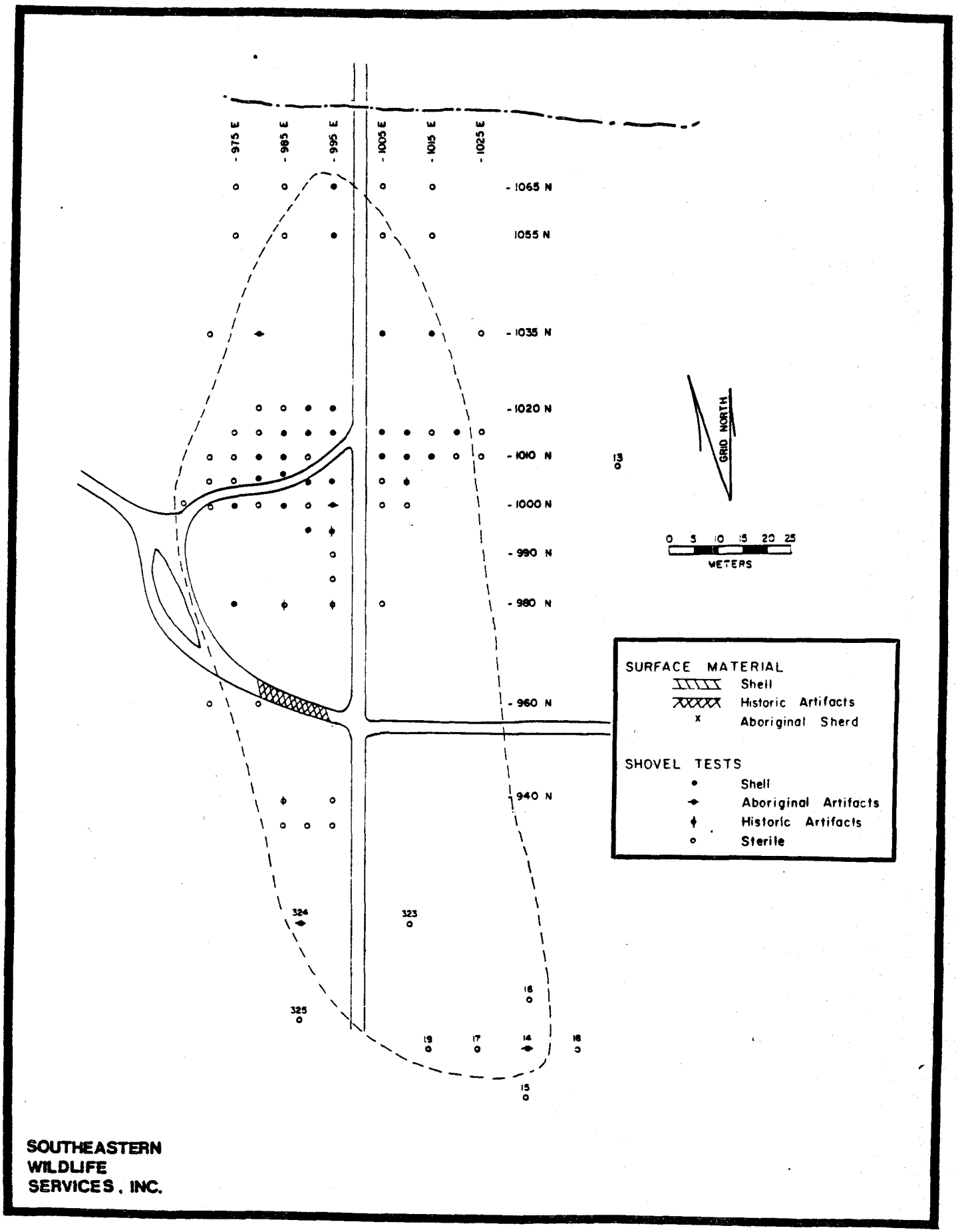


Figure J-7 Field Site 3 (8Du670) Map

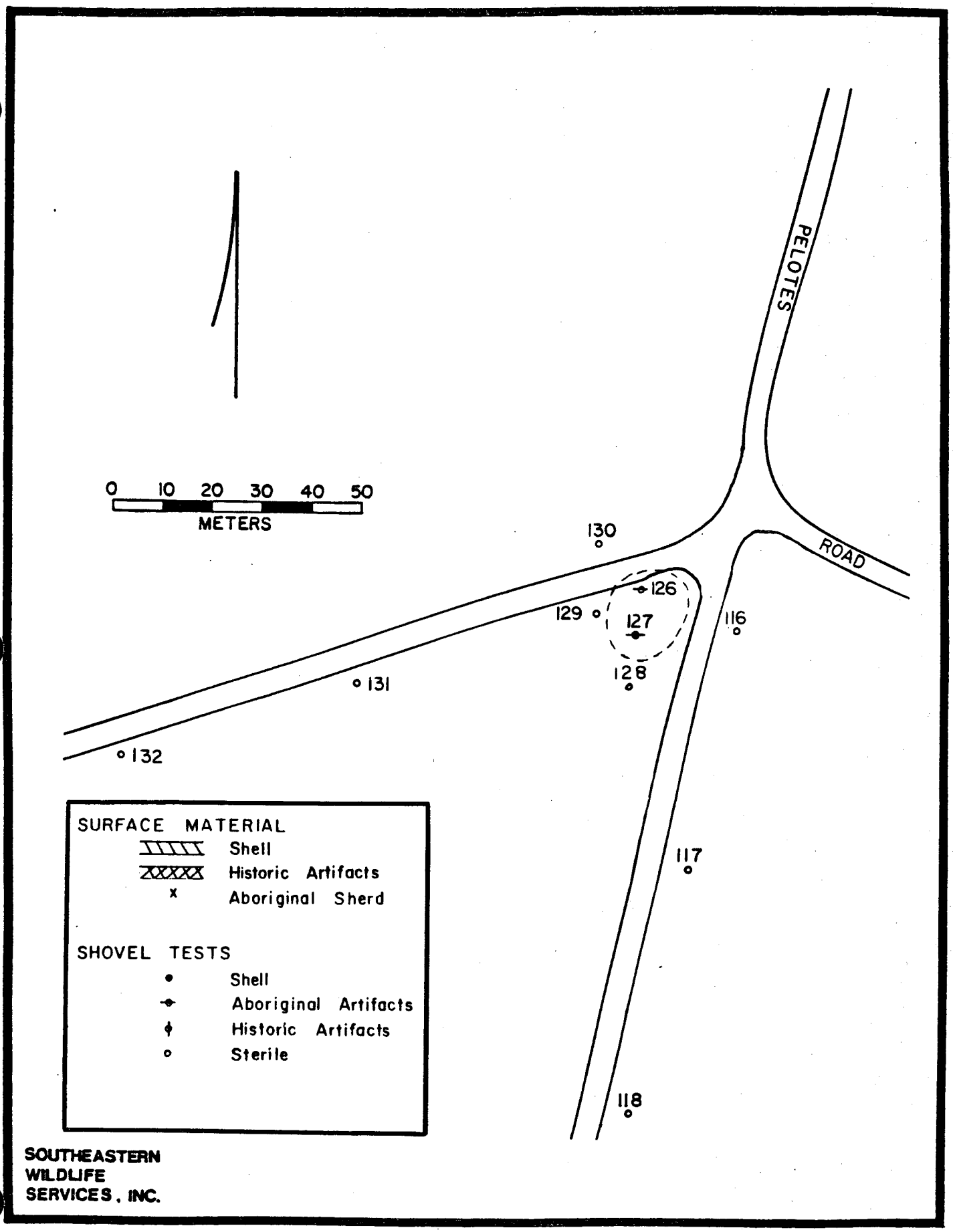


Figure J-8 Field Site 4 (8Du671) Map

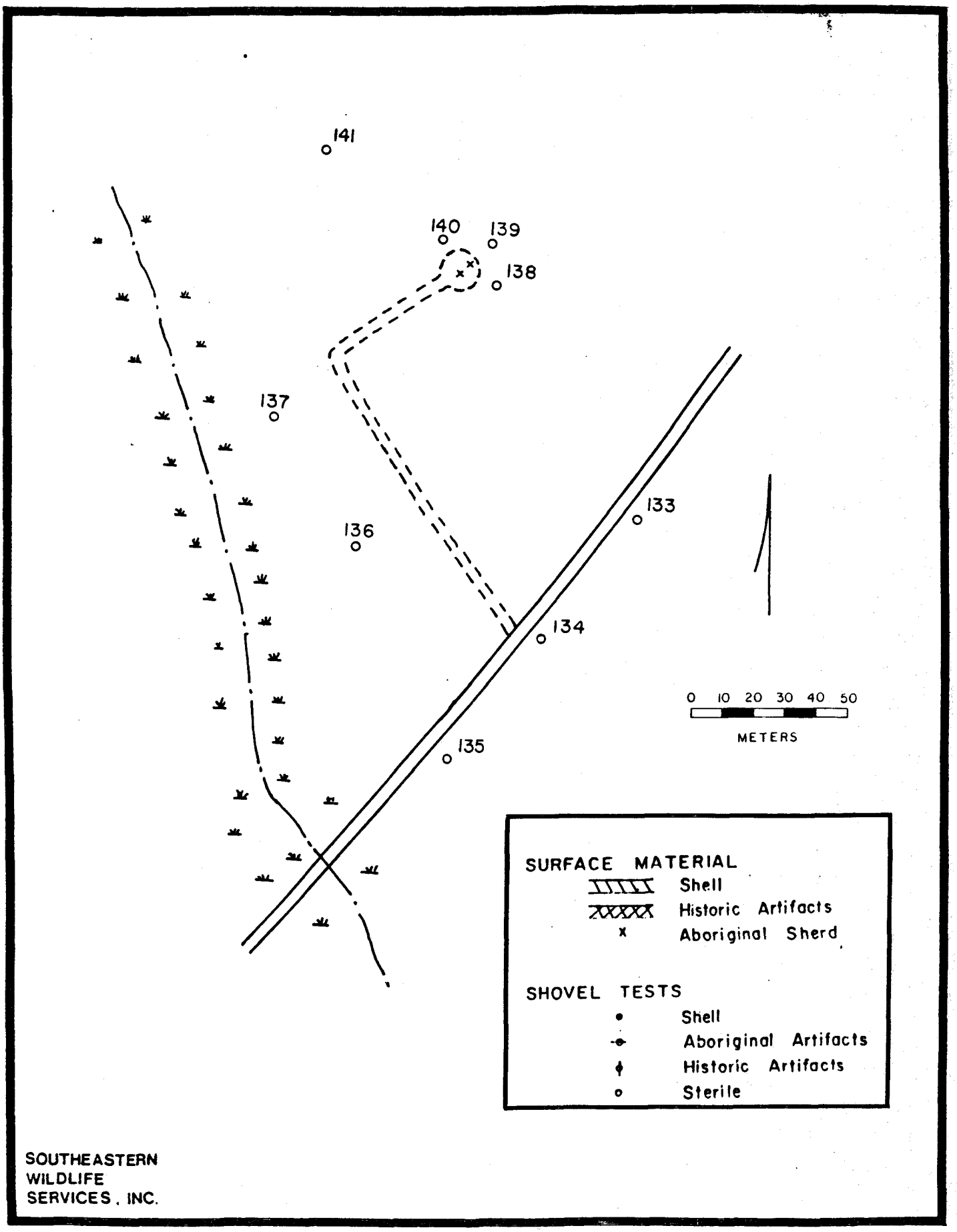


Figure J-9 Field Site 5 (8Du672) Map

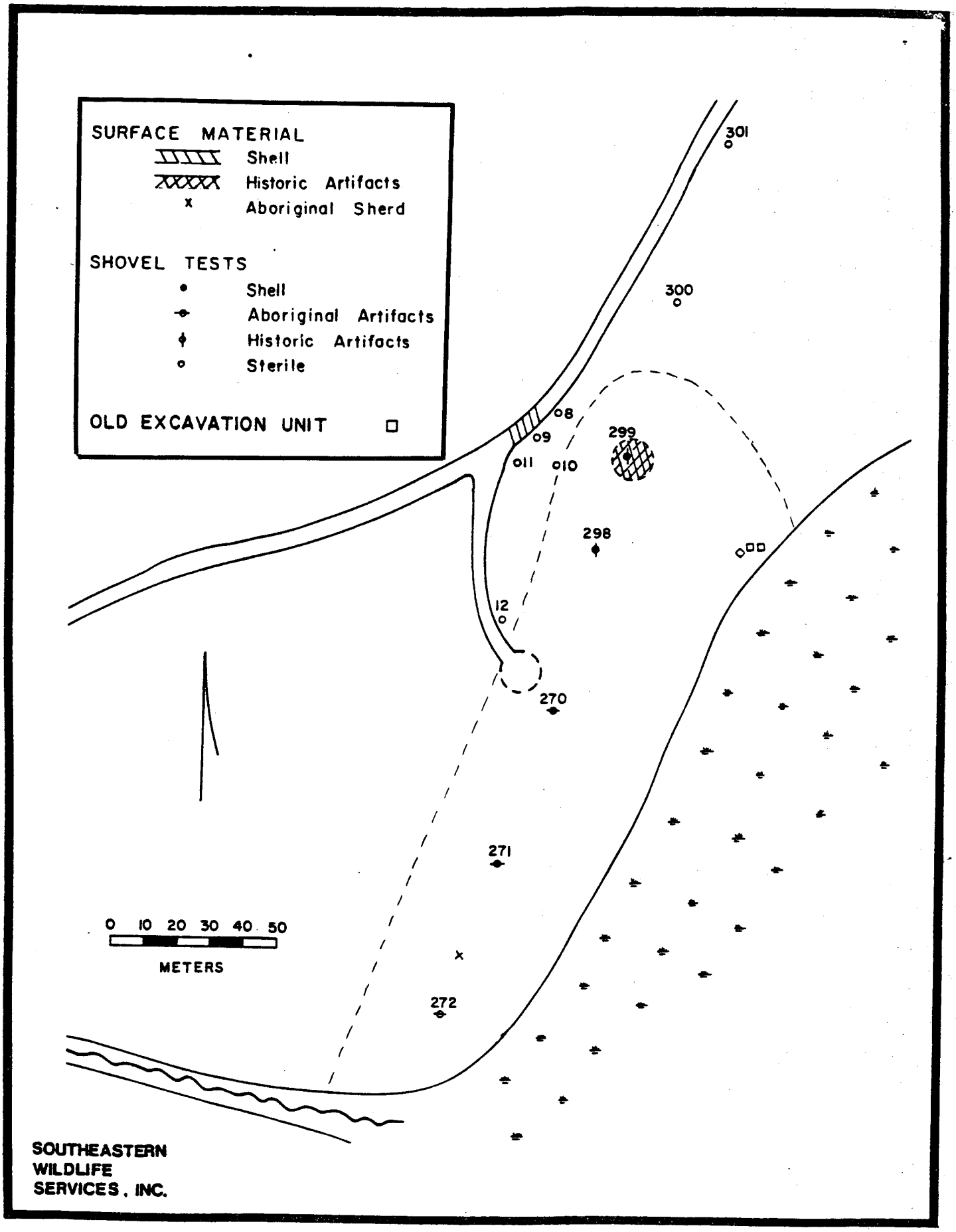


Figure J-10 Field Site 7 (8Du673) Map

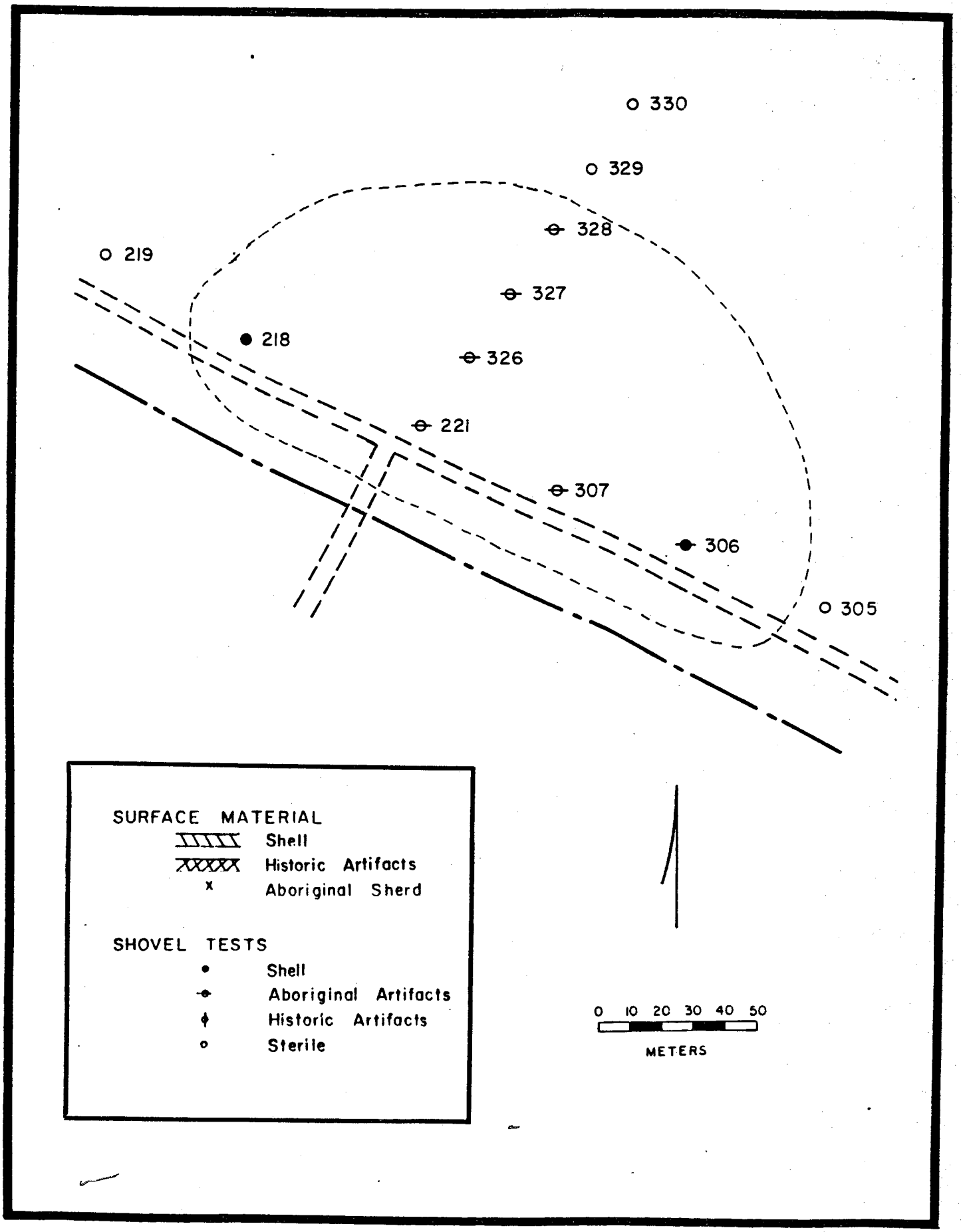


Figure J-11 Field Site 8 (8Du674) Map

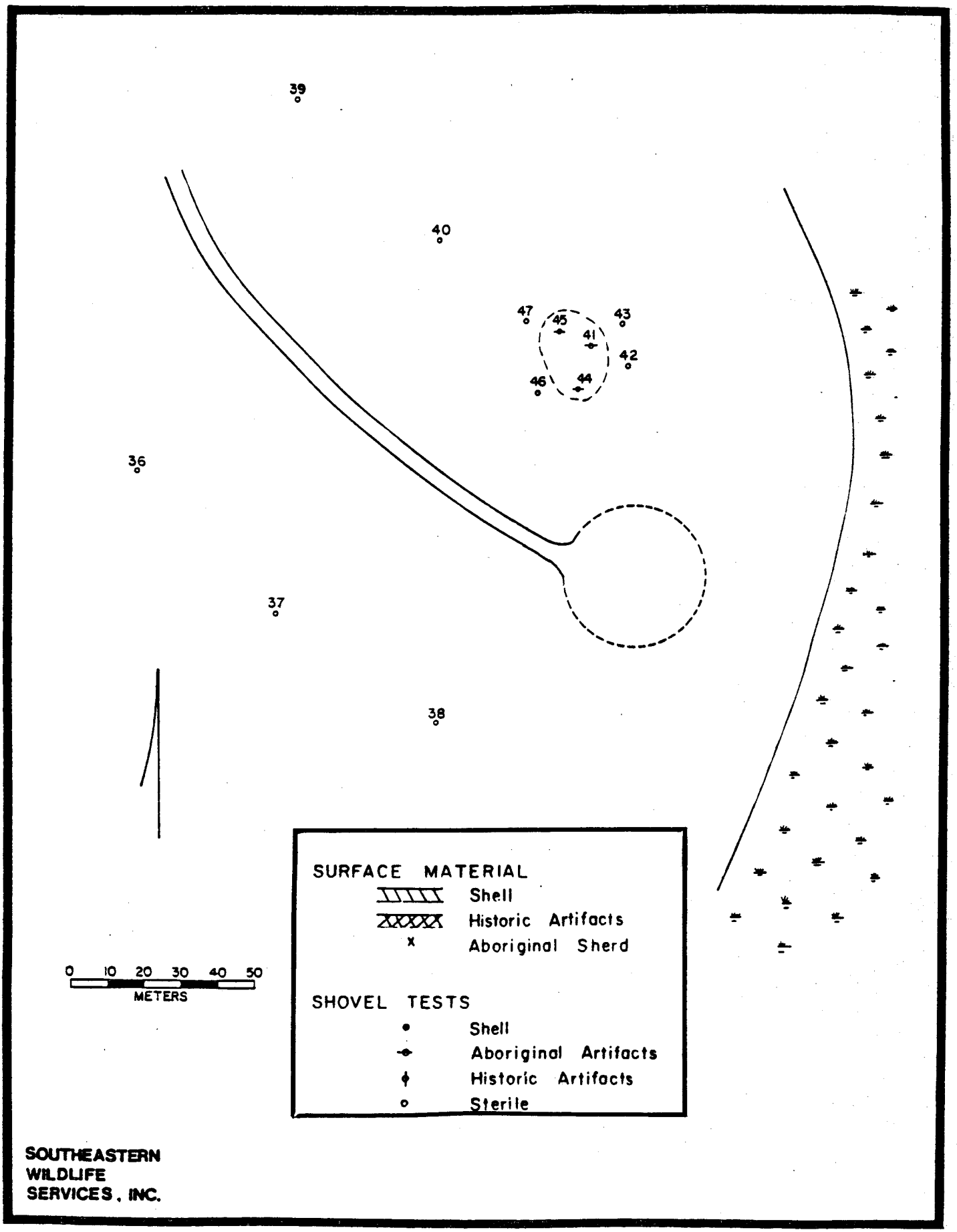


Figure J-12 · Field Site 9 (8Du675) Map

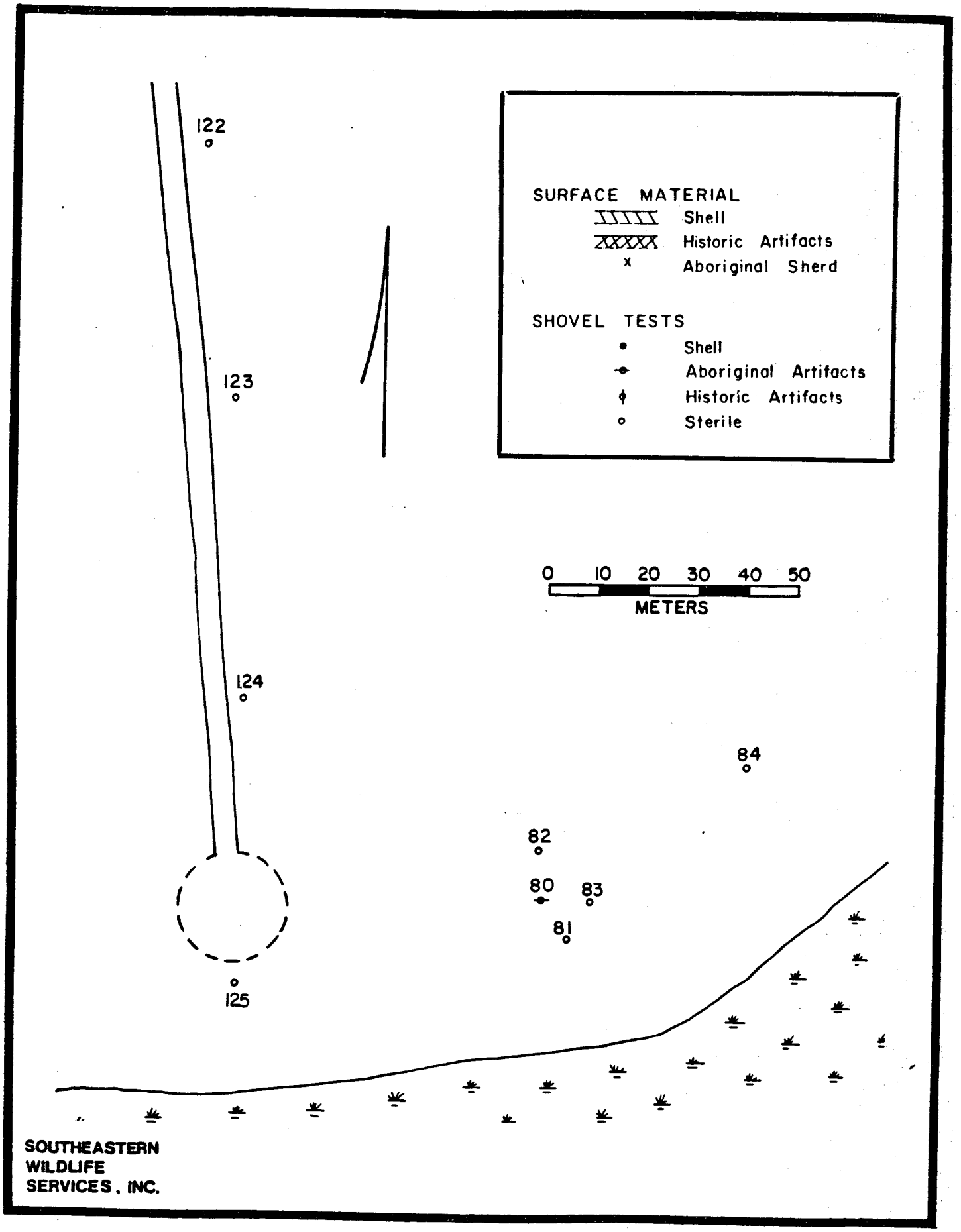


Figure J-13 Field Site 10 (8Du676) Map

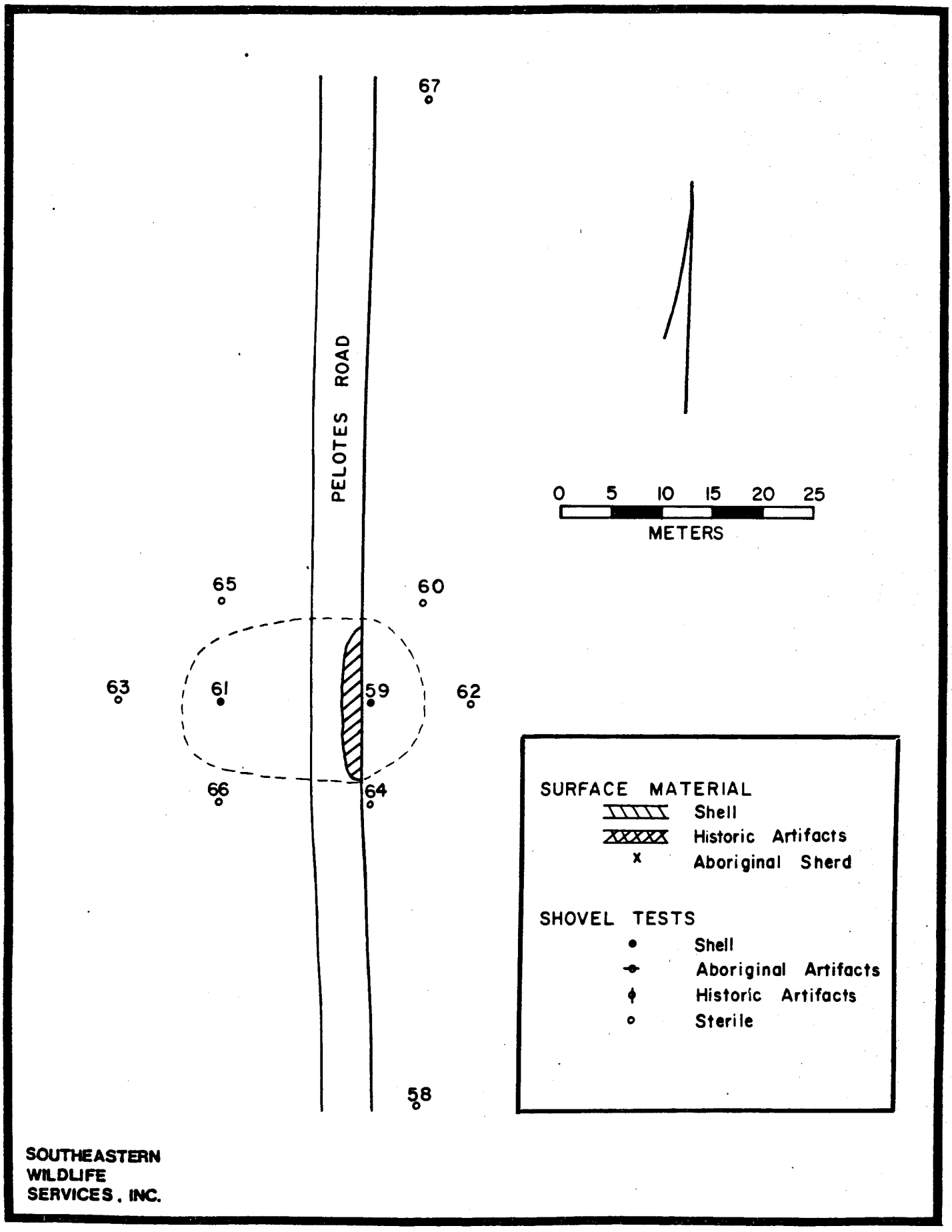


Figure J-14 Field Site 11 (8Du677) Map

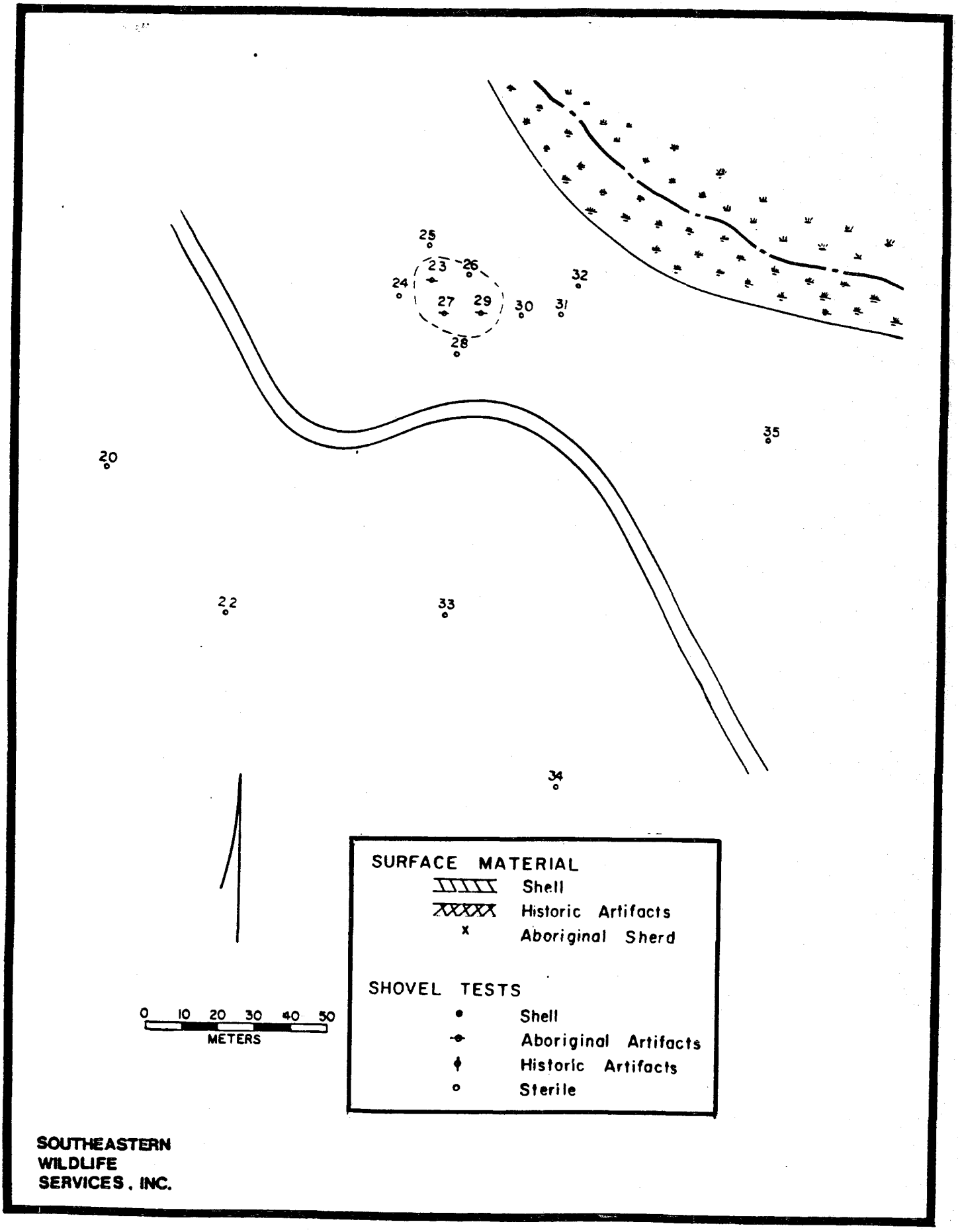


Figure J-15 Field Site 12 (8Du678) Map

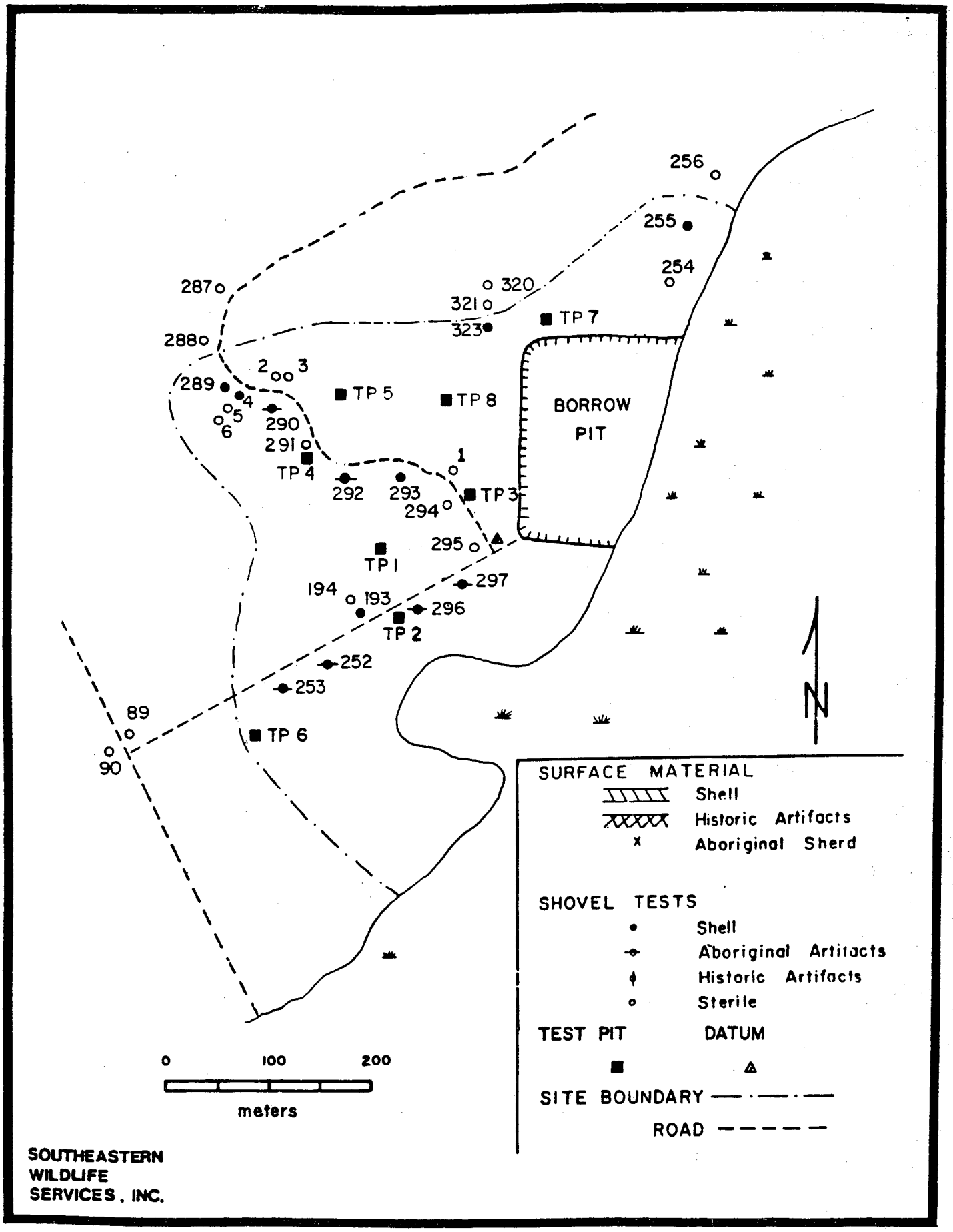
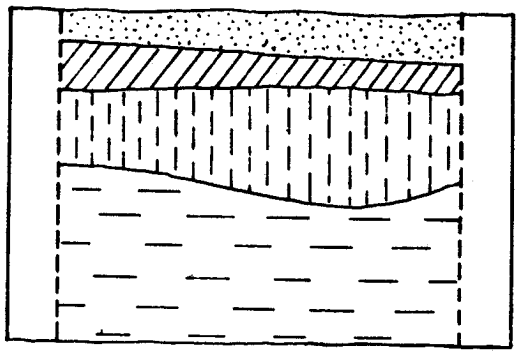
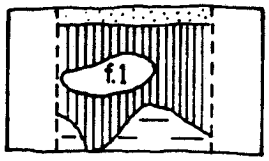


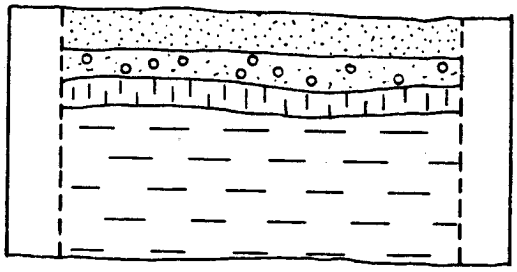
Figure J-16 Test Pits: 8Du634



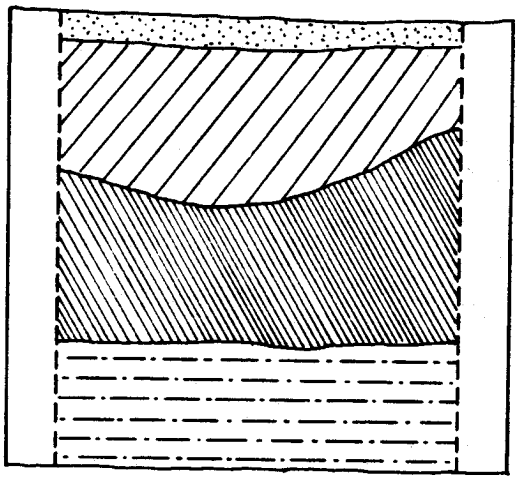
A. 8 Du 634
Test pit 2
Profile : South wall



B. 8 Du 634
Feature 1 Profile
Test pit 5



C. 8 Du 669
Test pit 13
Profile East wall



D. 8 Du 669
Test pit 11
Profile = East wall

TESTING OF ELEVEN ARCHAEOLOGICAL SITES IN THE VICINITY OF A PROPOSED POWER PLANT
DUVAL COUNTY, FLORIDA

SOUTHEASTERN WILDLIFE SERVICES, INC.

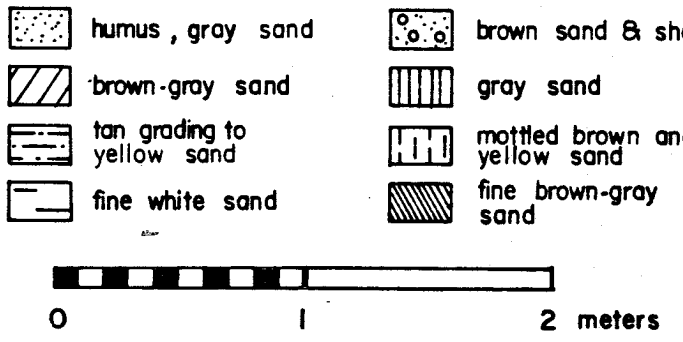


Figure J-17 Profiles: 8Du634 and 8Du669

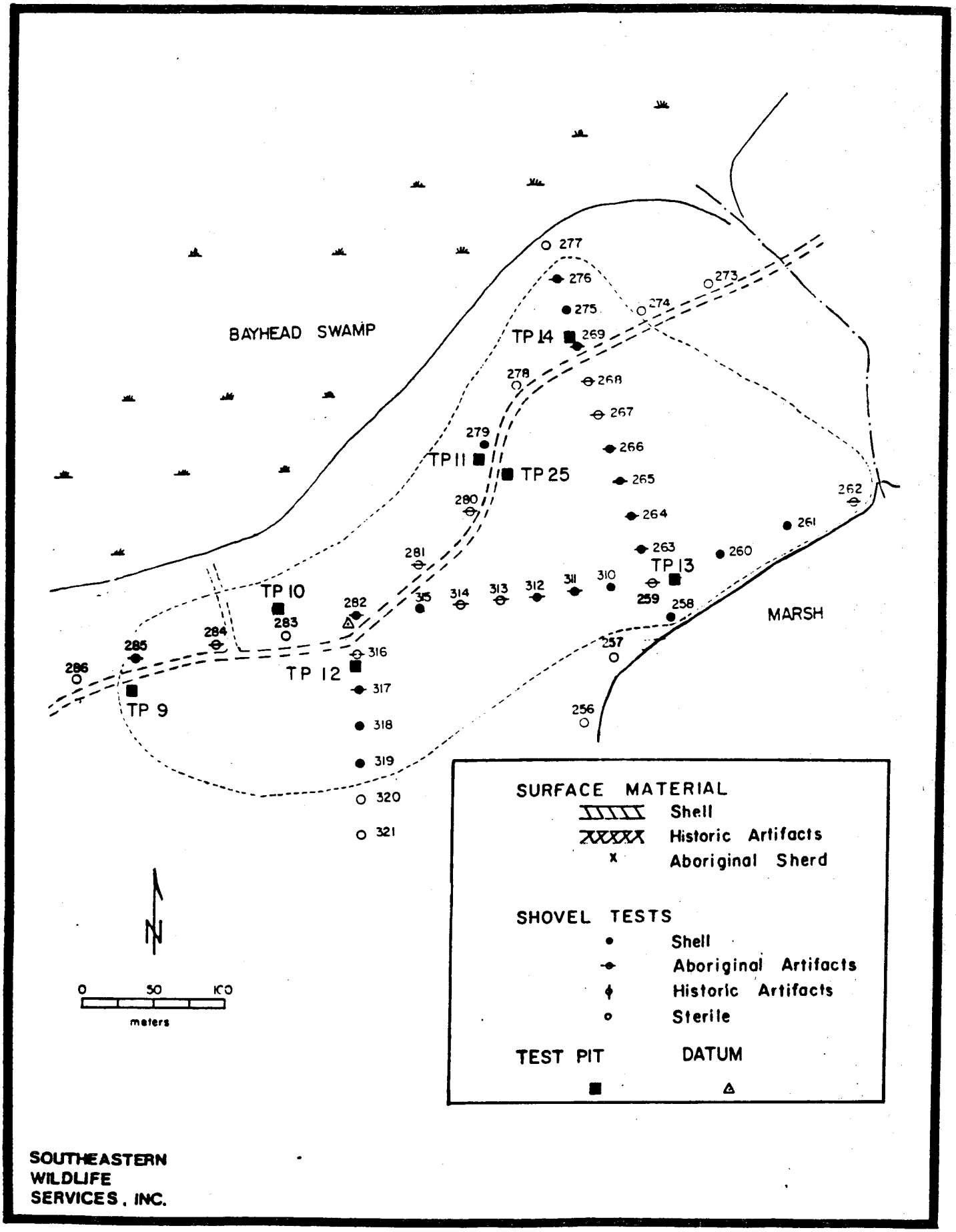
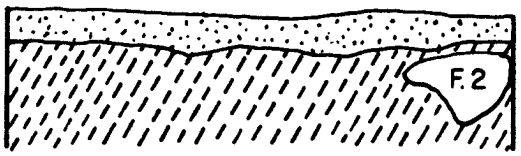
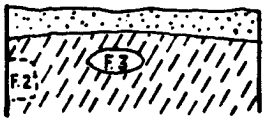


Figure J-18 Test Pits: 8Du669



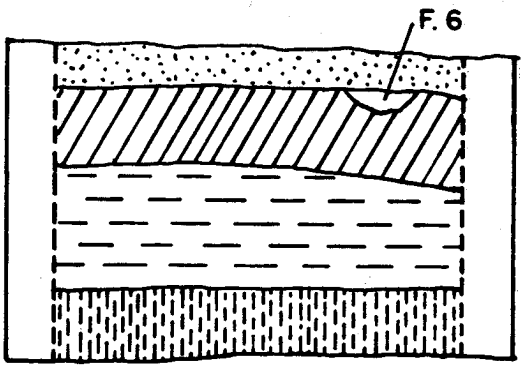
Feature 2

A.

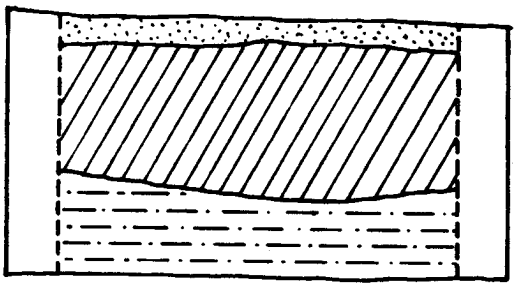


Feature 3

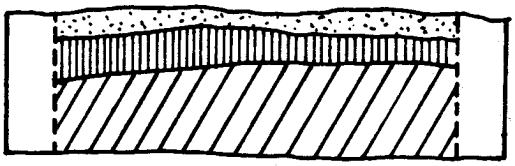
8 Du 669 Test pit 14



B. 8 Du 670
Profile West wall
Feature 6
Test pit 22



C. 8 Du 671
Test pit 26
Profile East wall



D. 8 Du 672
Test pit 20
Profile West wall

TESTING OF ELEVEN ARCHAEOLOGICAL SITES IN THE VICINITY OF A PROPOSED POWER PLANT
DUVAL COUNTY, FLORIDA

SOUTHEASTERN WILDLIFE SERVICES, INC.

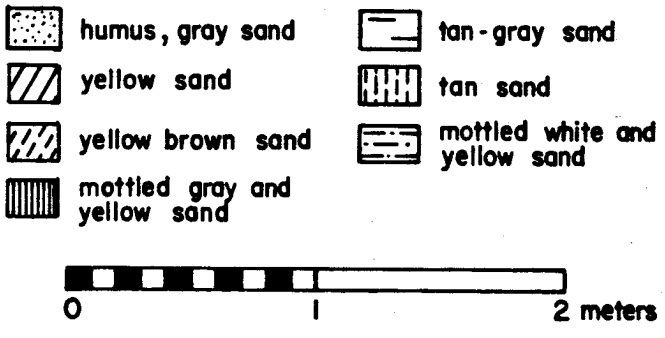
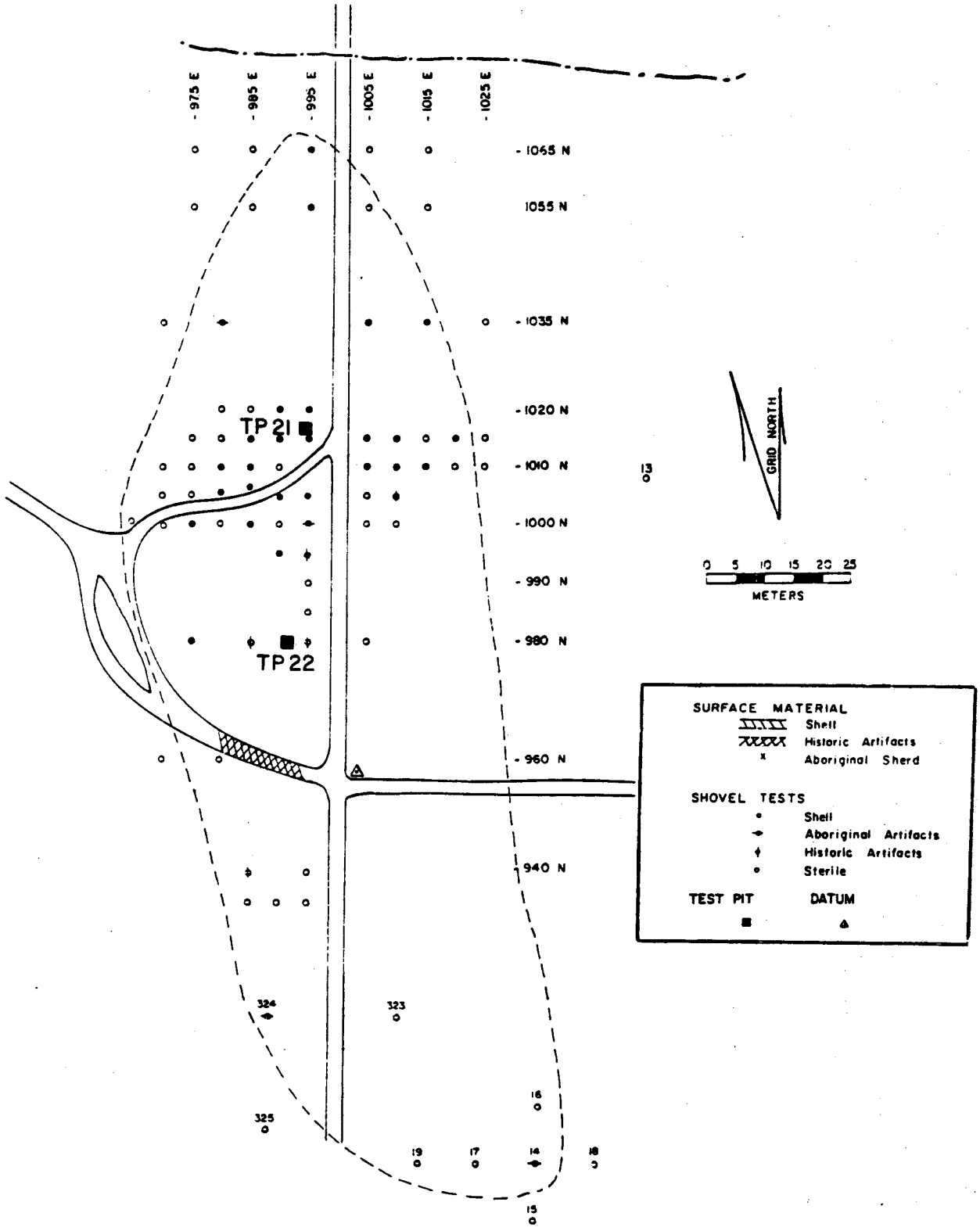


Figure J-19 Profiles: 8Du669, 8Du670, 8Du671, 8Du672



SOUTHEASTERN WILDLIFE SERVICES, INC.

Figure J-20 Test Pits: 8Du670

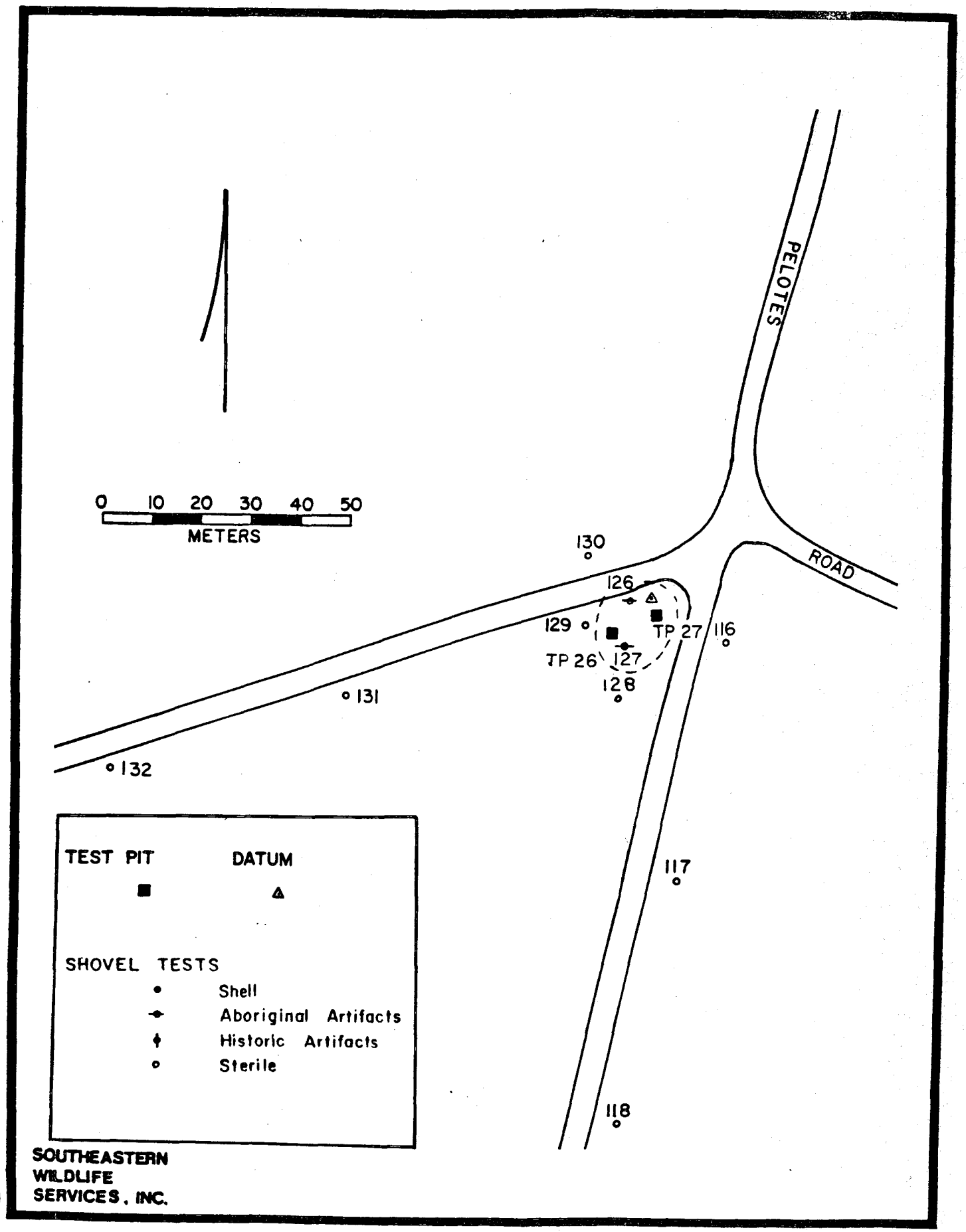


Figure J-21 Test Pits: 8Du671

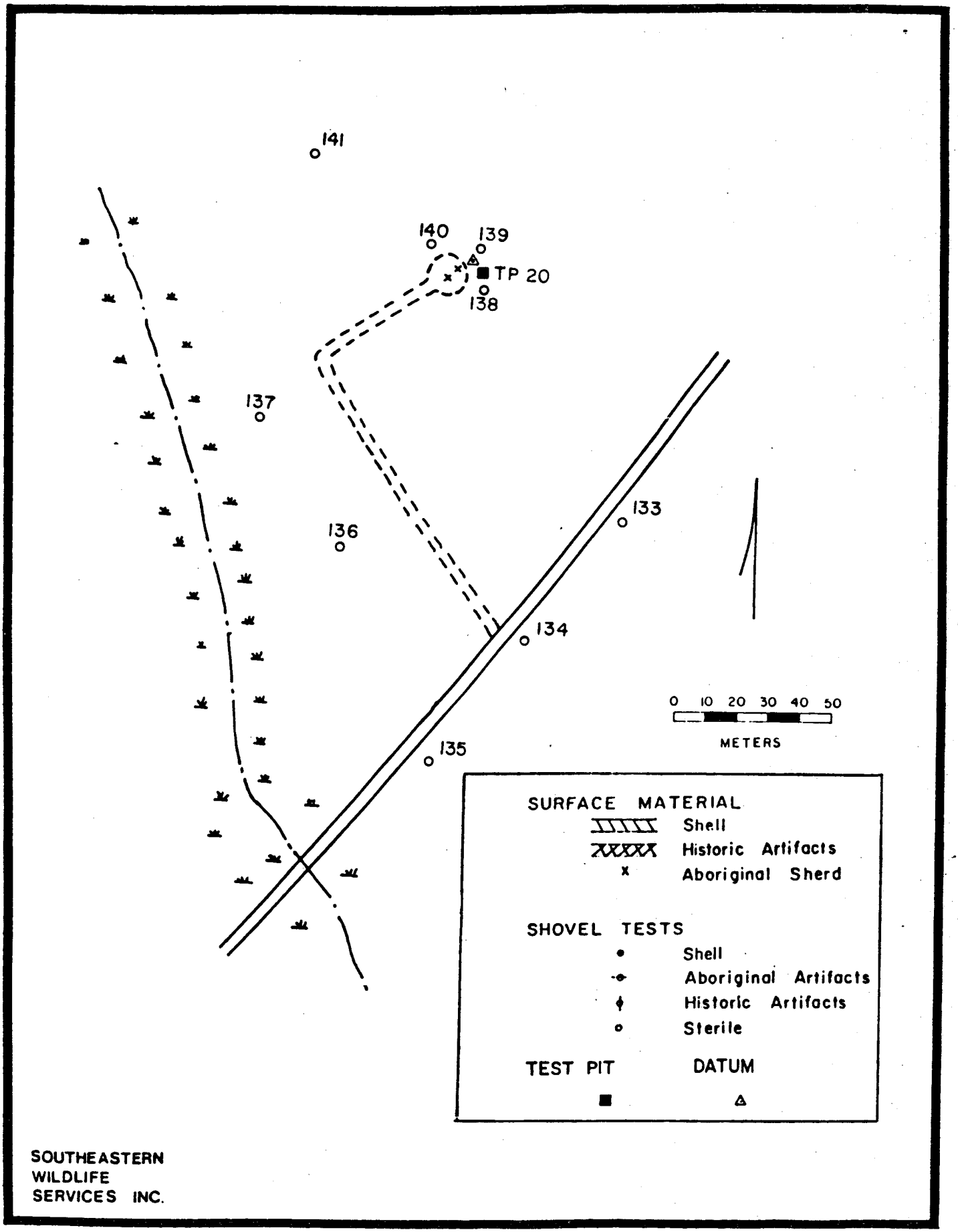


Figure J-22 Test Pit: 8Du672

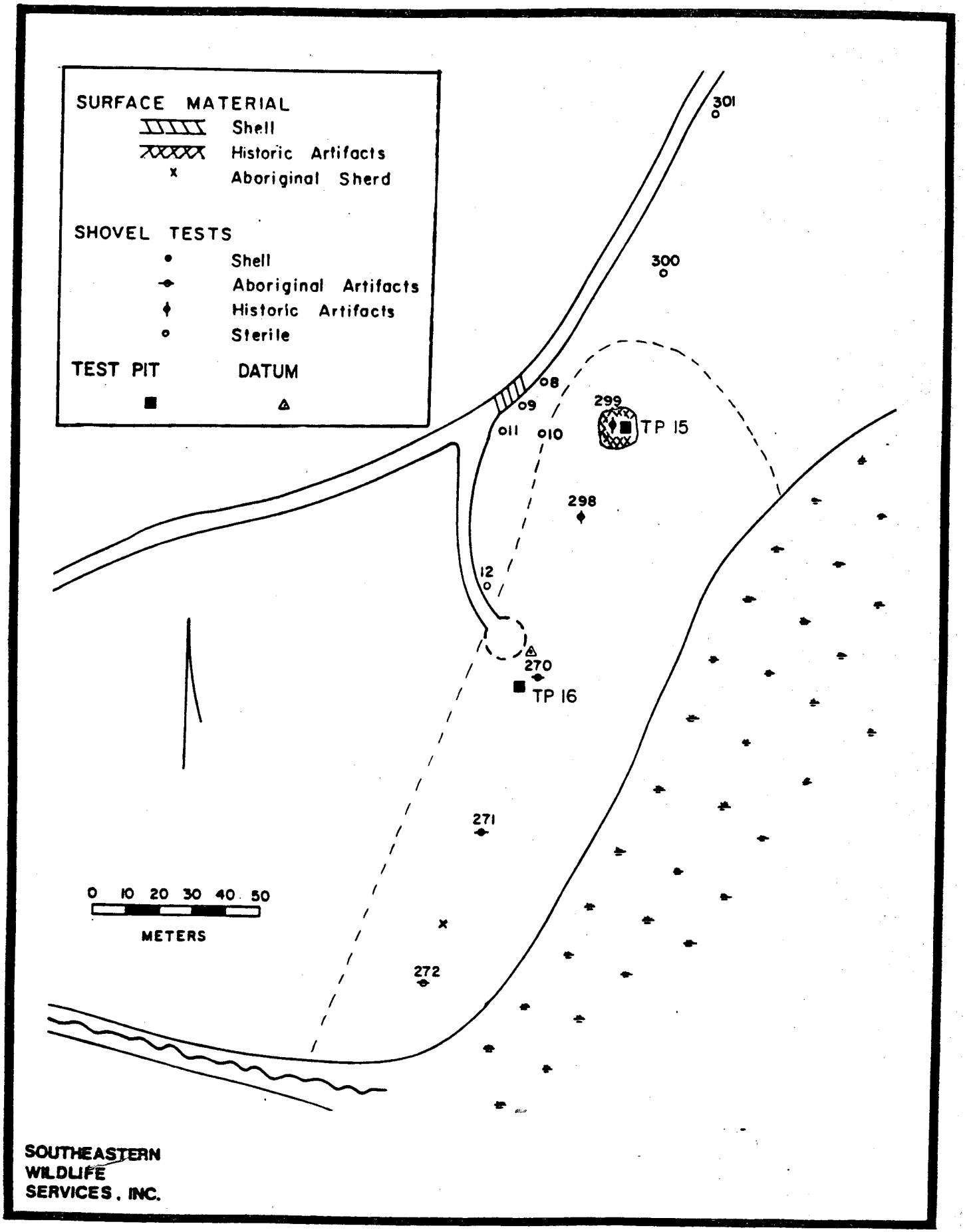
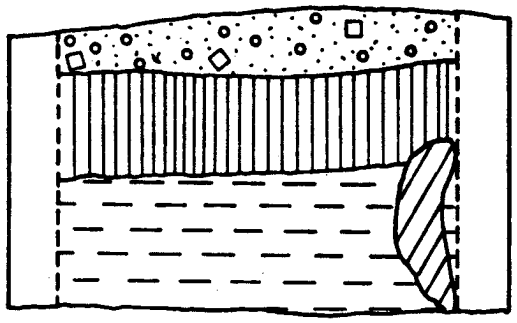
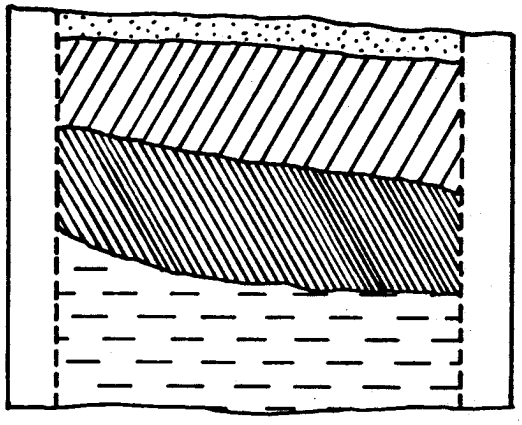


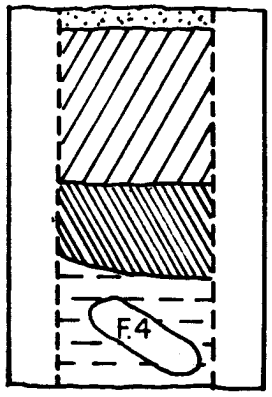
Figure J-23 Test Pits: 8Du673



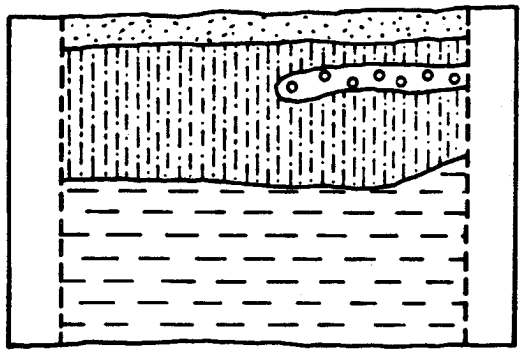
A. 8 Du 673
Test pit 15
Profile East wall



B. 8 Du 673
Test pit 16
Profile East wall



C. 8 Du 673
Feature 4 Profile
Test pit 16



D. 8 Du 674
Test pit 23
Profile North wall

TESTING OF ELEVEN ARCHAEOLOGICAL SITES IN THE VICINITY OF A PROPOSED POWER PLANT
DUVAL COUNTY, FLORIDA

SOUTHEASTERN WILDLIFE SERVICES, INC.

humus, gray sand
humus, gray sand brick and shell
yellow sand
mottled brown and gray sand
shell scatter
dark gray midden stain
yellow brown sand
fine tan sand

0 1 2 meters

Figure J-24 Profiles: 8Du673 and 8Du674

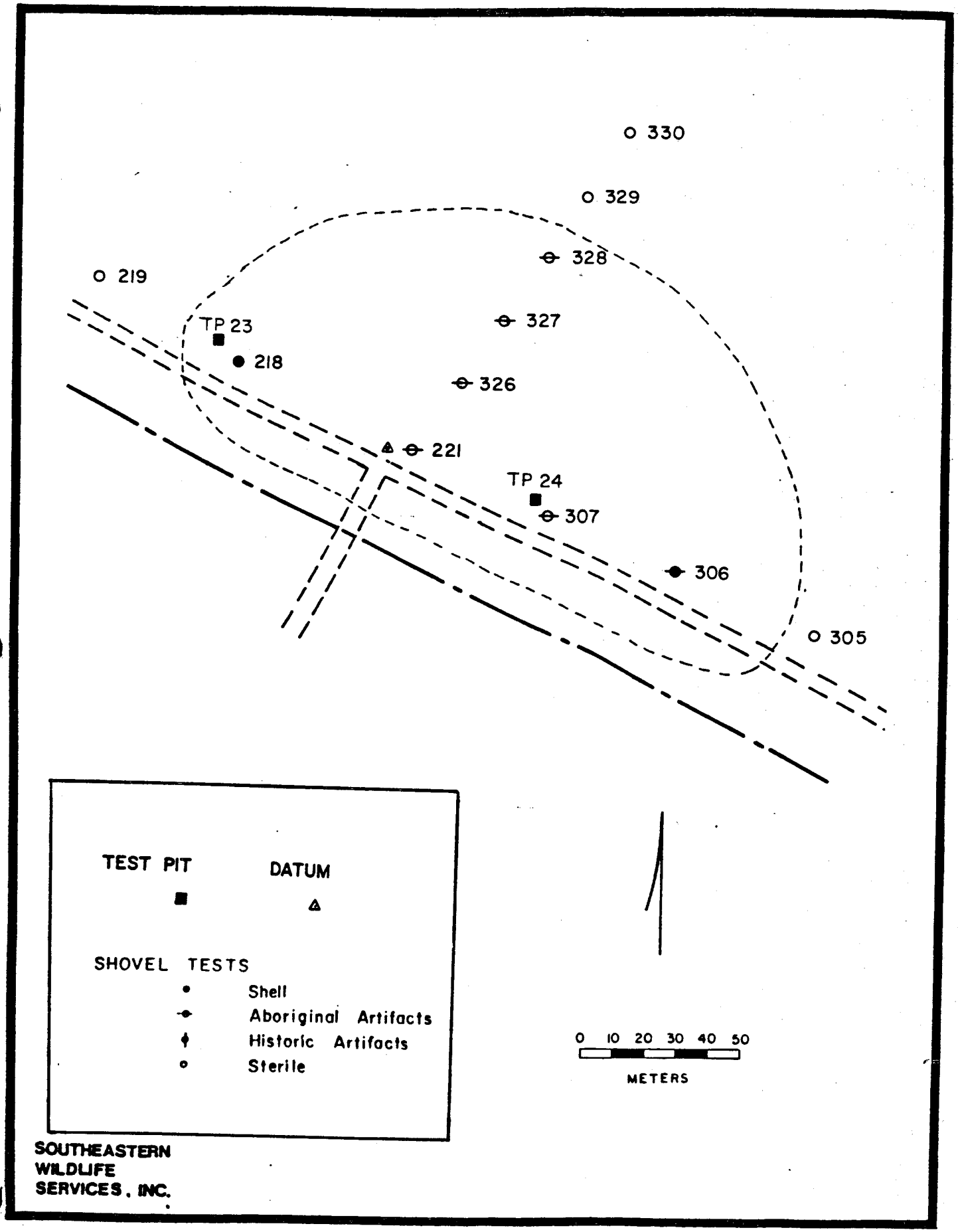


Figure J-25 Test Pits: 8Du674

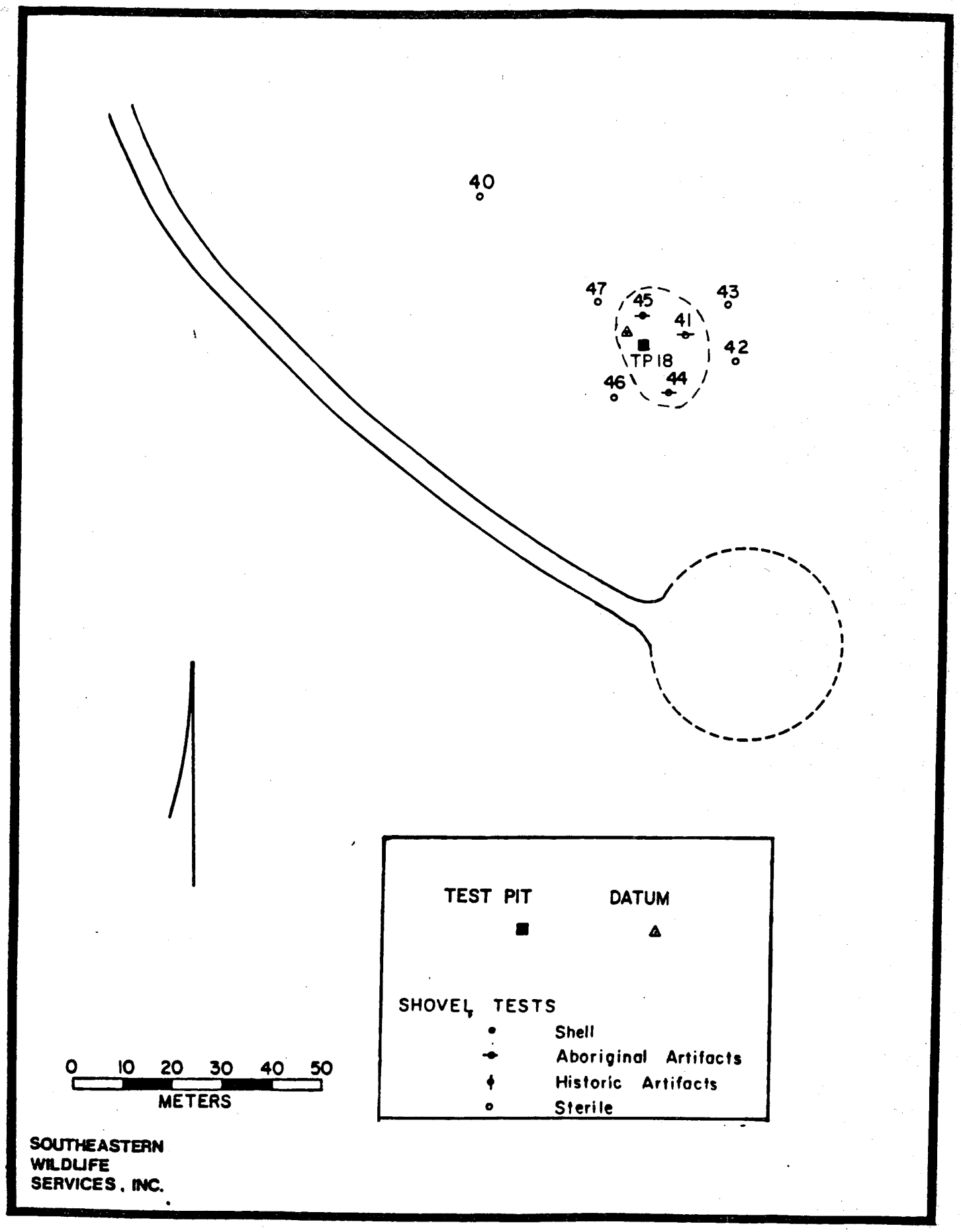
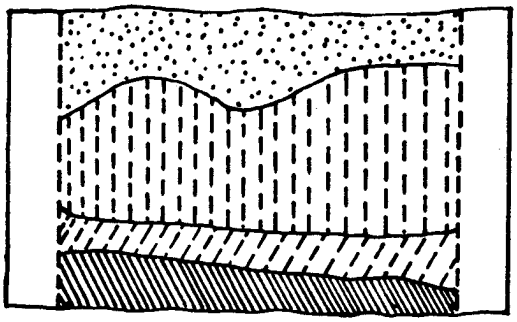
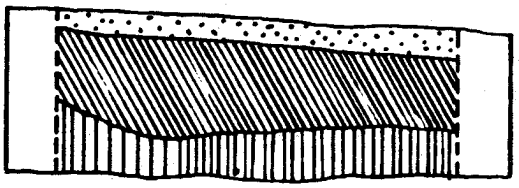


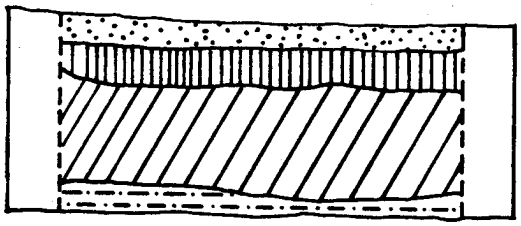
Figure J-26 Test Pit: 8Du675



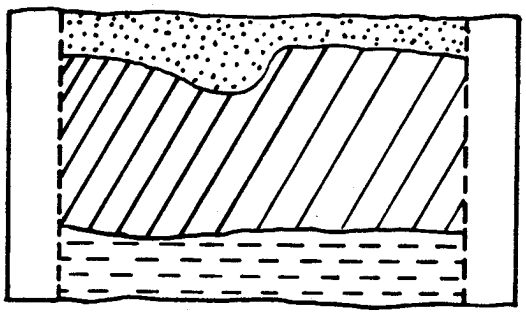
A. 8 Du 675
Test pit 18
Profile East wall



B. 8 Du 676
Test pit 19
Profile East wall



C. 8 Du 677
Test pit 28
Profile East wall



D. 8 Du 678
Test pit 17
Profile East wall

TESTING OF ELEVEN ARCHAEOLOGICAL SITES IN THE VICINITY OF A PROPOSED POWER PLANT
DUVAL COUNTY, FLORIDA

SOUTHEASTERN WILDLIFE SERVICES, INC.

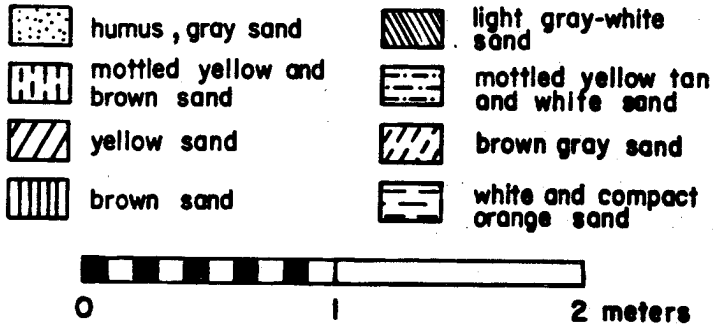


Figure J-27 Profiles: 8Du675, 8Du676, 8Du677, 8Du678

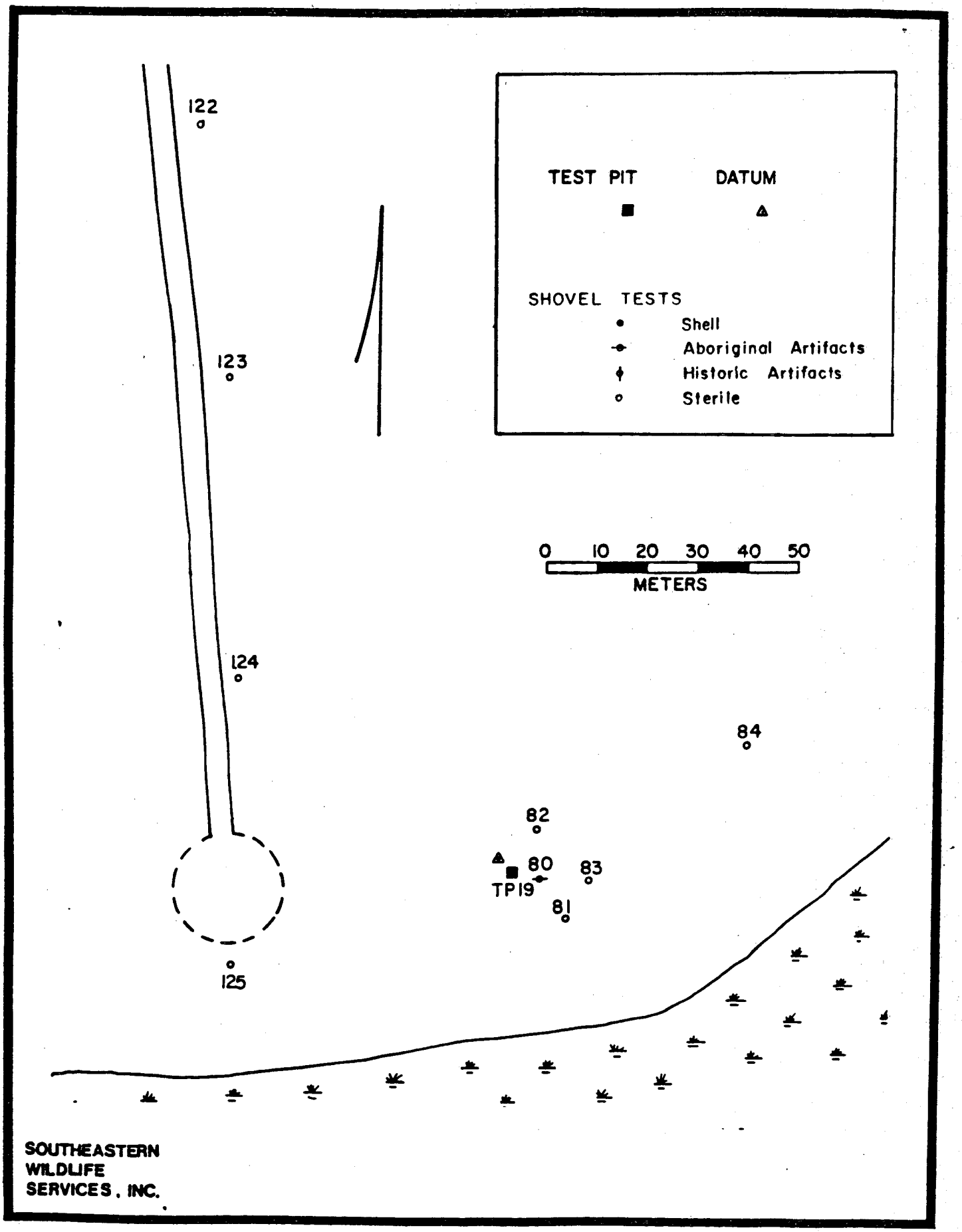


Figure J-28 Test Pit: 8Du676

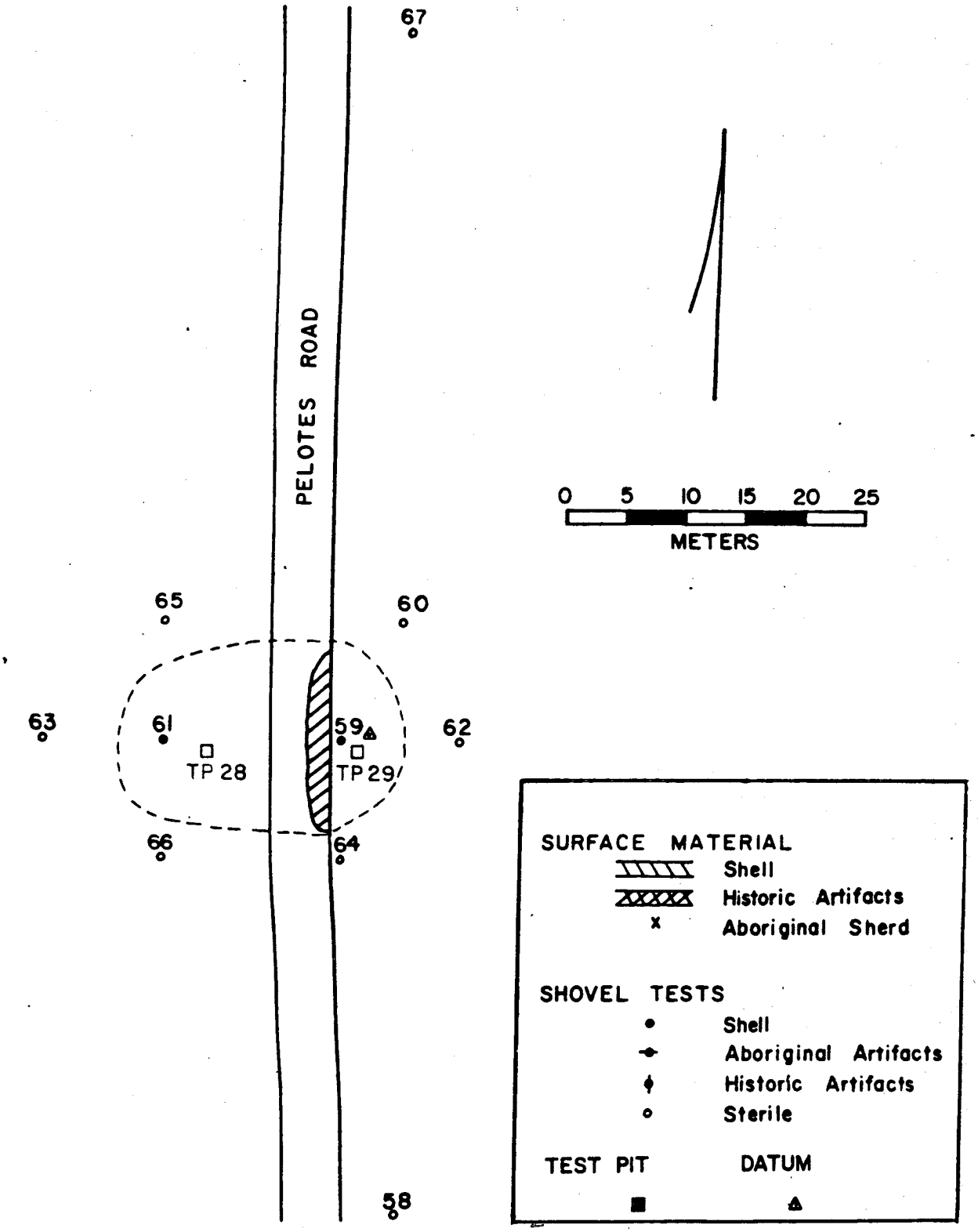


Figure J-29 Test Pits: 8Du677

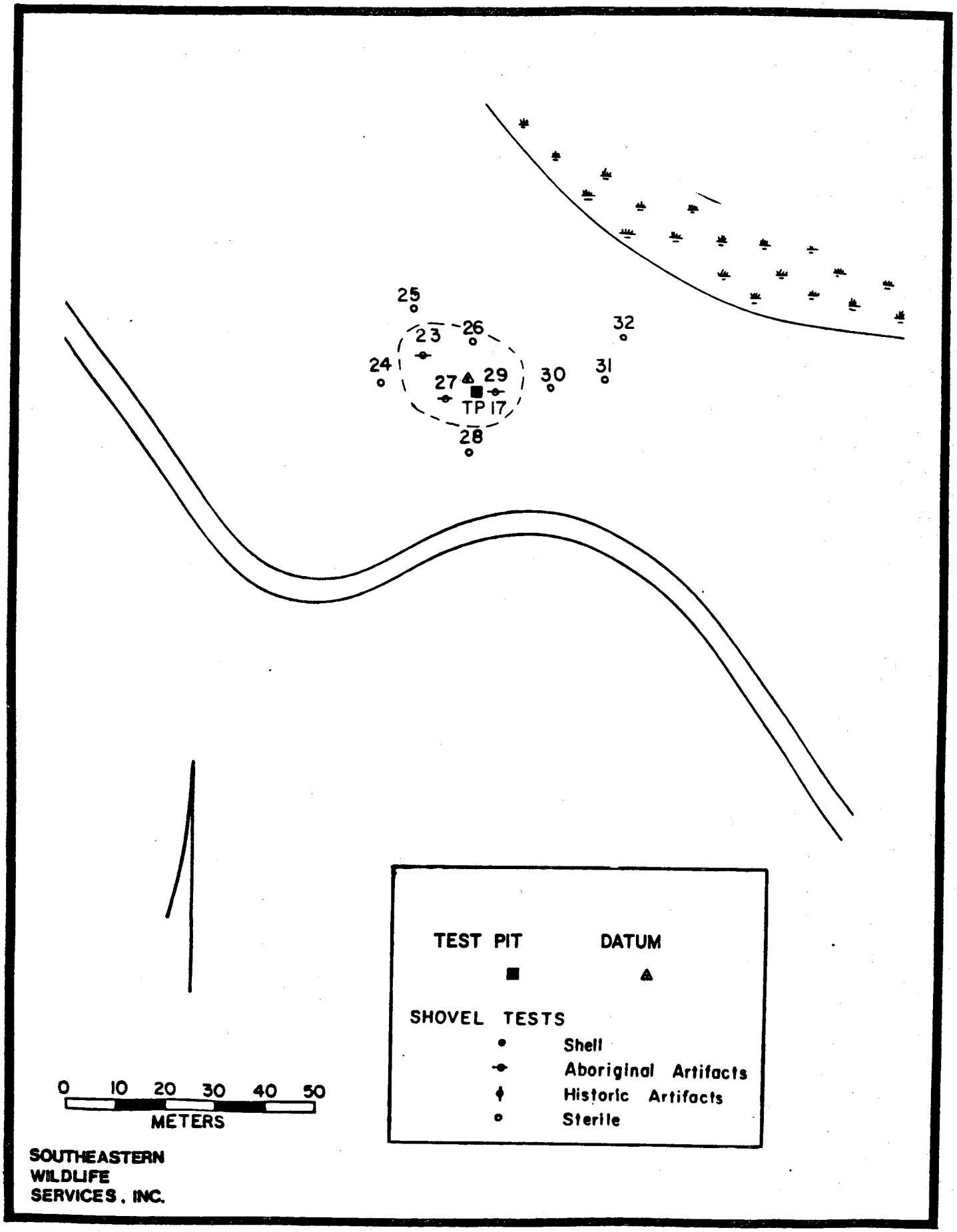


Figure J-30 Test Pit: 8Du678

K

TRANSMISSION CORRIDORS

APPENDIX K

PHOTOGRAPHIC DEPICTION OF PREFERRED TRANSMISSION CORRIDOR

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APPENDIX K

PHOTOGRAPHIC DEPICTION OF PREFERRED TRANSMISSION CORRIDOR

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K-3 Preferred Transmission Corridor and Local Sensitive Areas

K-4 Preferred Transmission Corridor and Local Sensitive Areas

K-5 Preferred Transmission Corridor and Local Sensitive Areas

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K-7 Preferred Transmission Corridor and Local Sensitive Areas

K-8 Preferred Transmission Corridor and Local Sensitive Areas

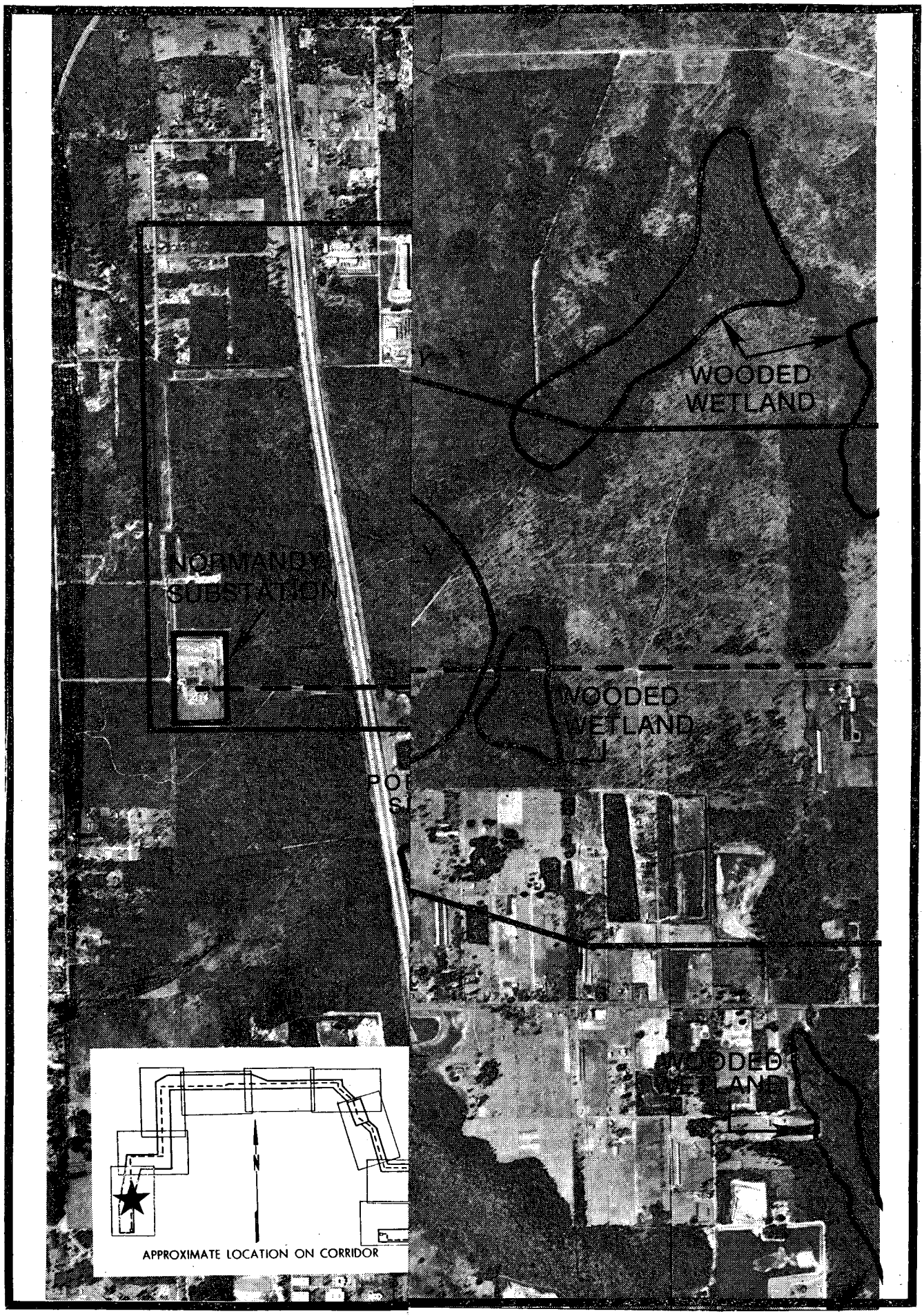
K-9 Preferred Transmission Corridor and Local Sensitive Areas

APPENDIX K

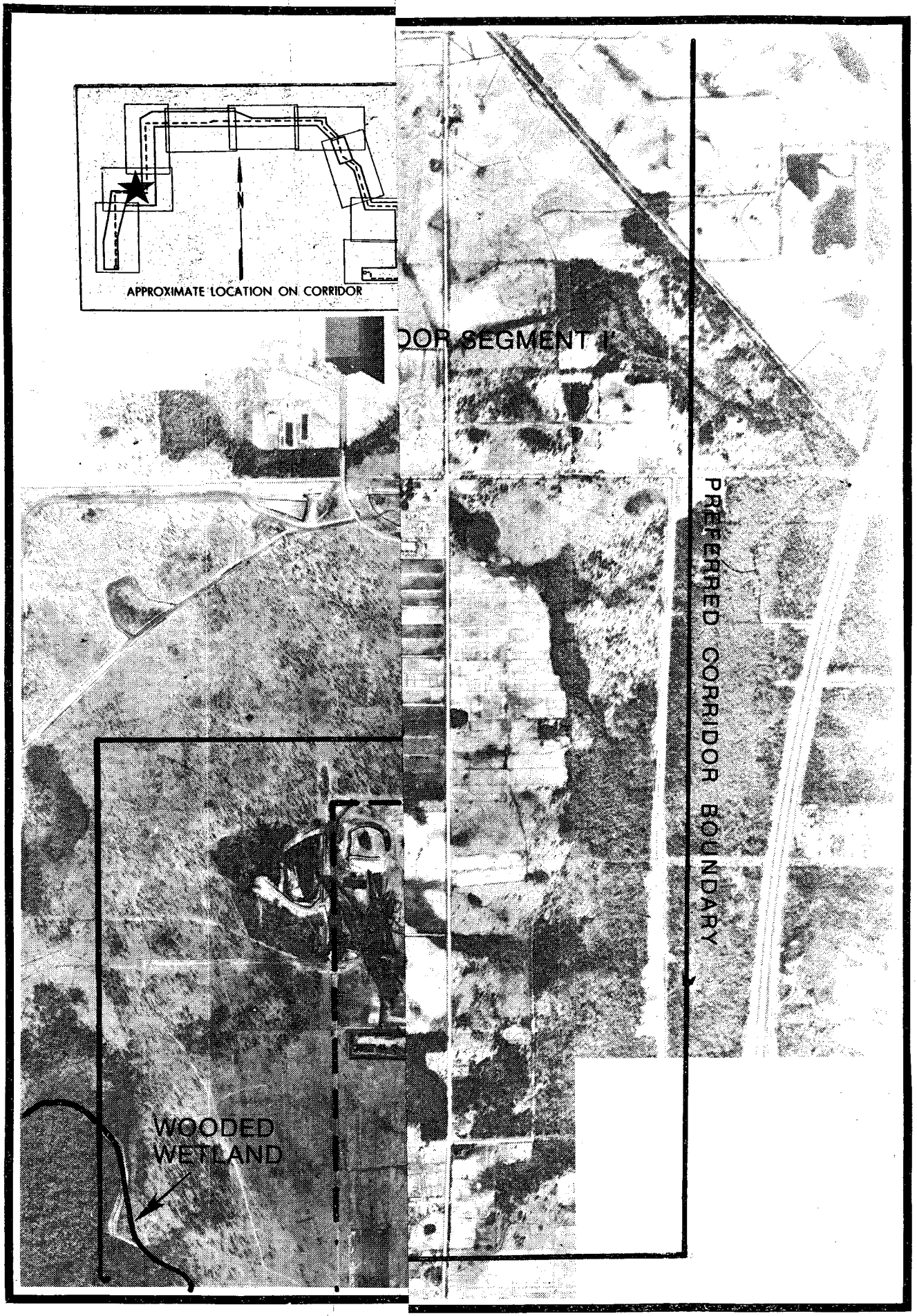
PHOTOGRAPHIC DEPICTION OF PREFERRED TRANSMISSION CORRIDOR

K.1 INTRODUCTION

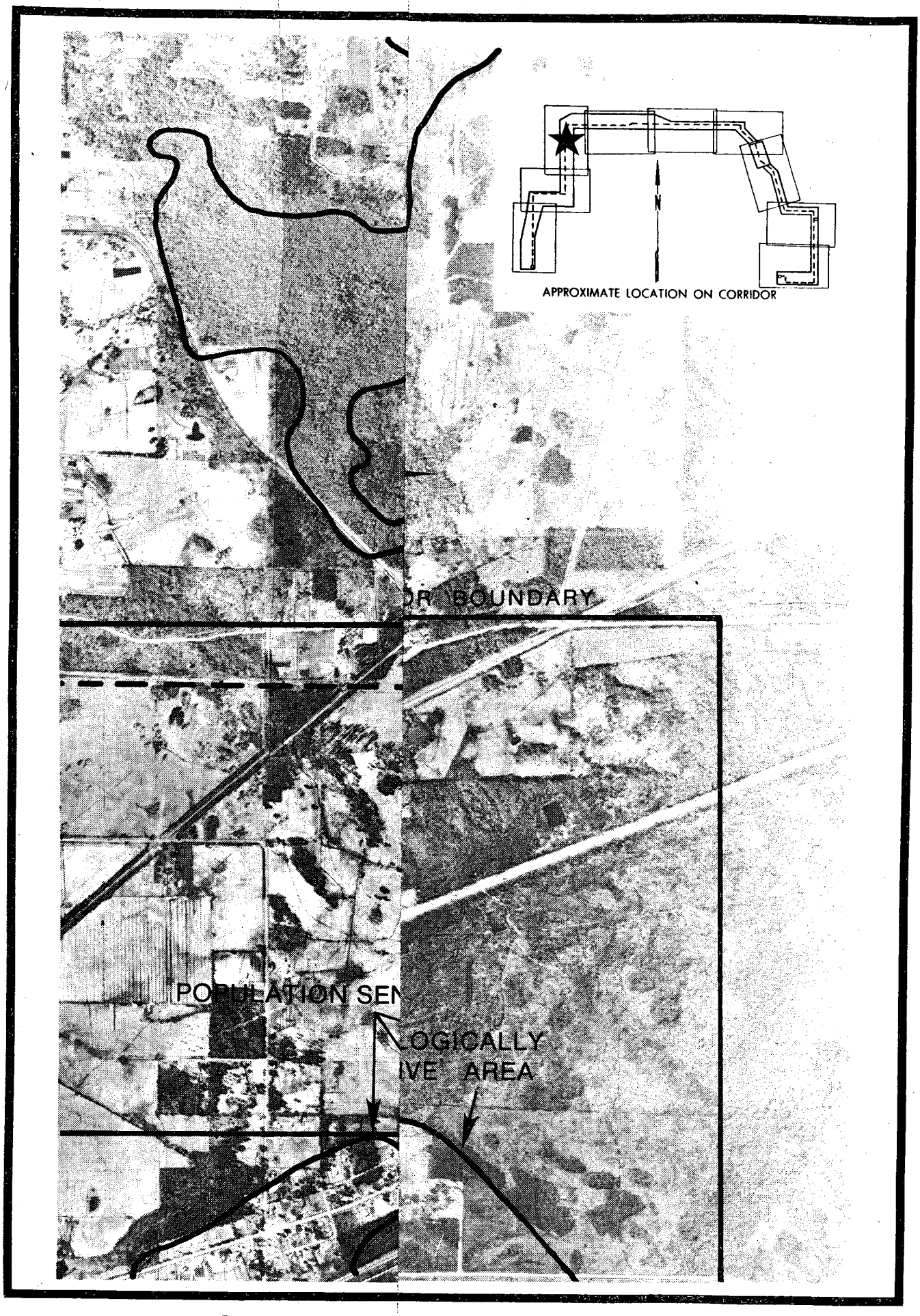
Appendix K is composed of nine photomosaics which depict the route of the preferred transmission corridor from the Normandy Substation (Figure K-1) to the proposed plant site (Figure K-7) to the Robinwood Substation (Figure K-9). The position of each photograph on the overall route is indicated by a star in the corner reference map. The locations of population sensitive areas, archeologically sensitive areas, and wooded wetlands in and around the existing right-of-way (dashed line) and preferred corridor are depicted on each figure.



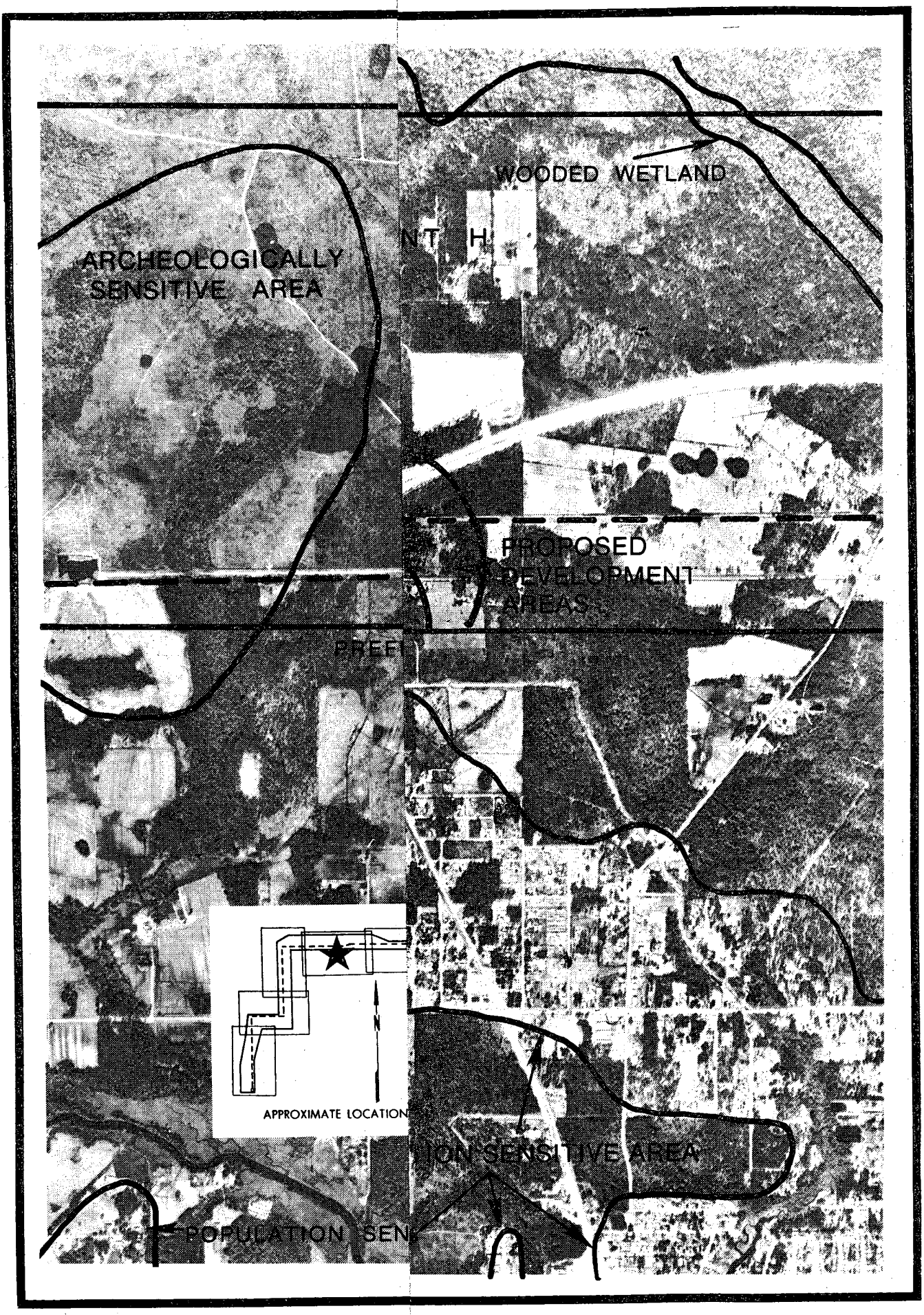
ransmission Corridor and Local Sensitive Areas



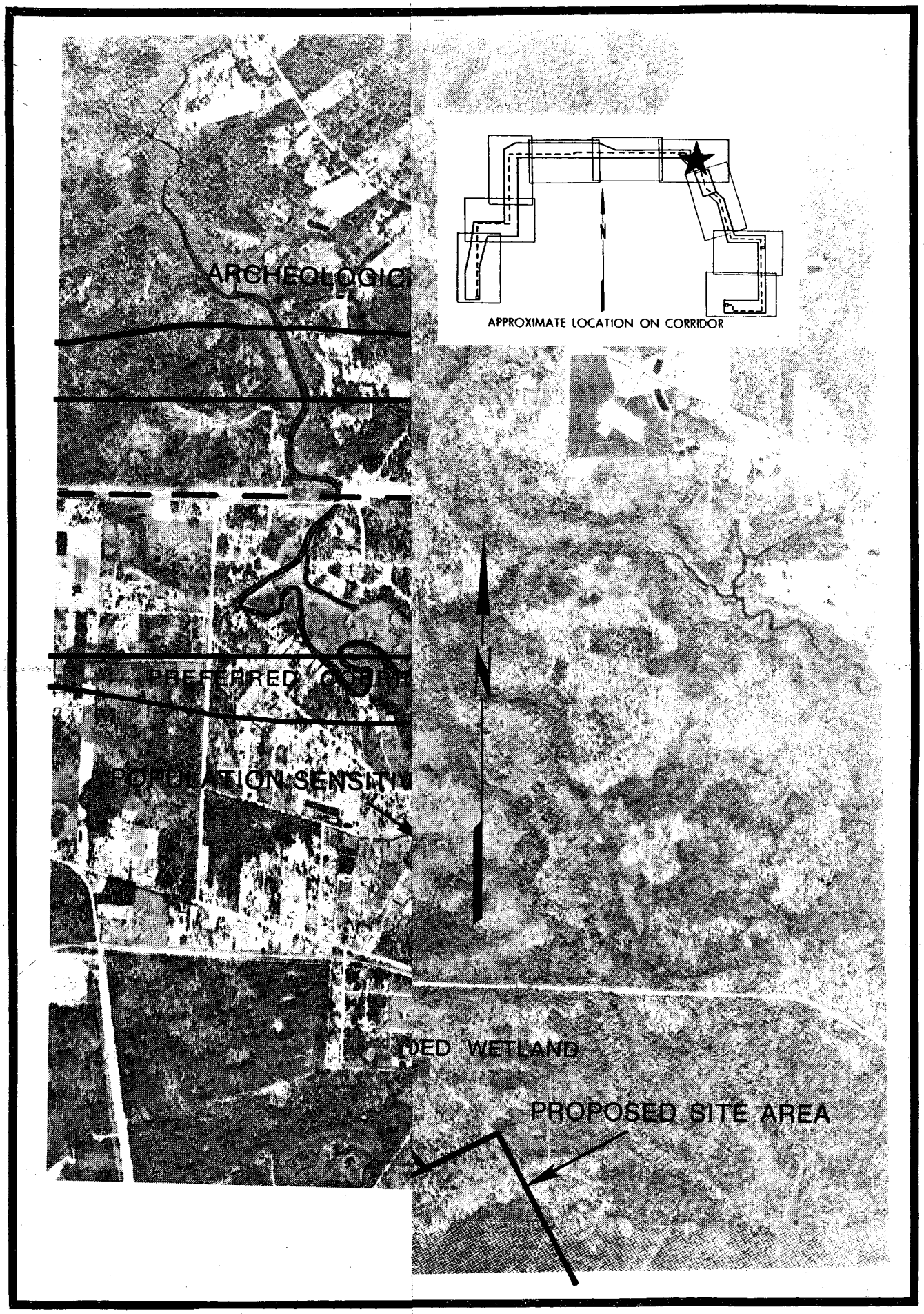
ransmission Corridor and Local Sensitive Areas



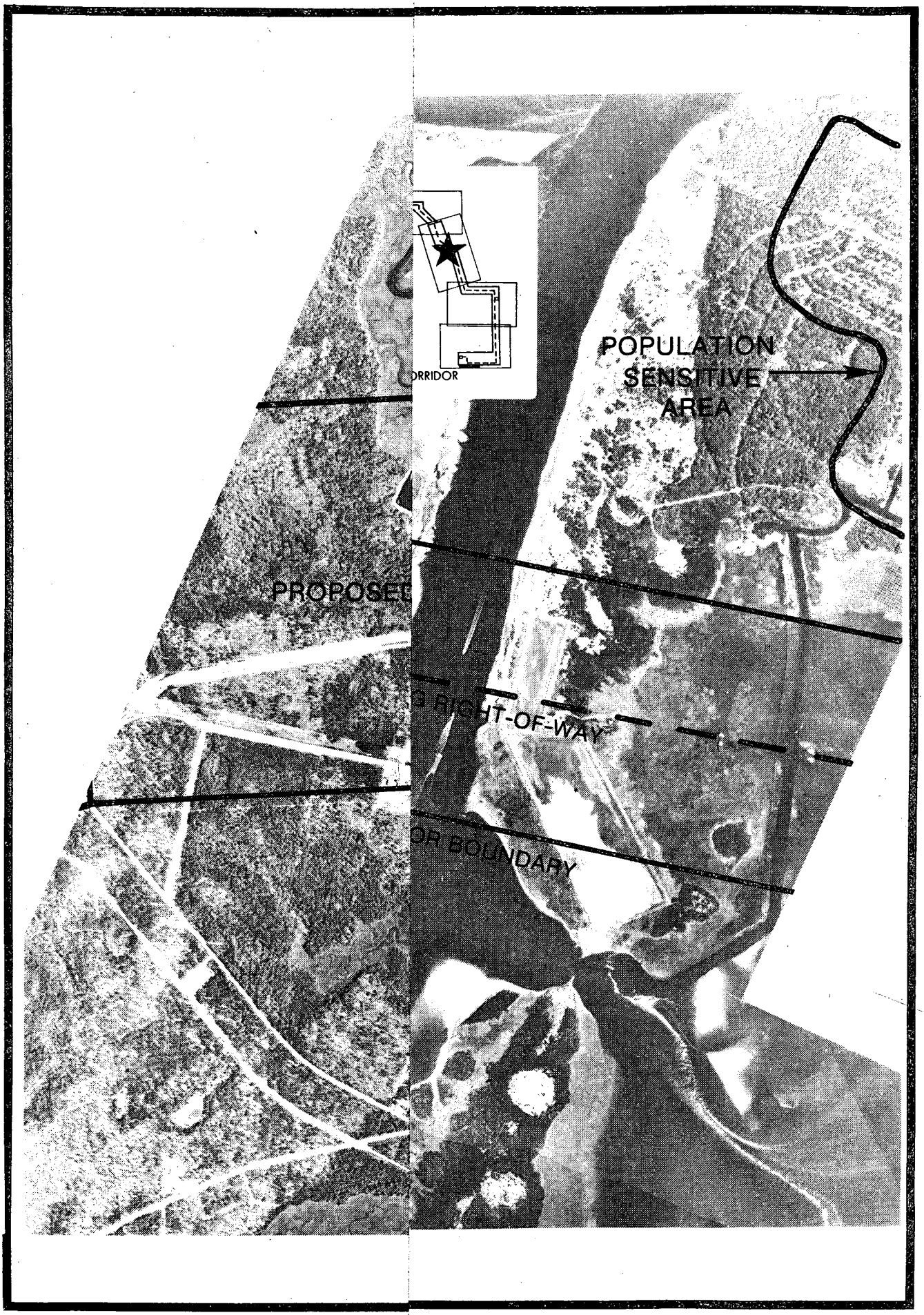
Transmission Corridor and Local Sensitive Areas



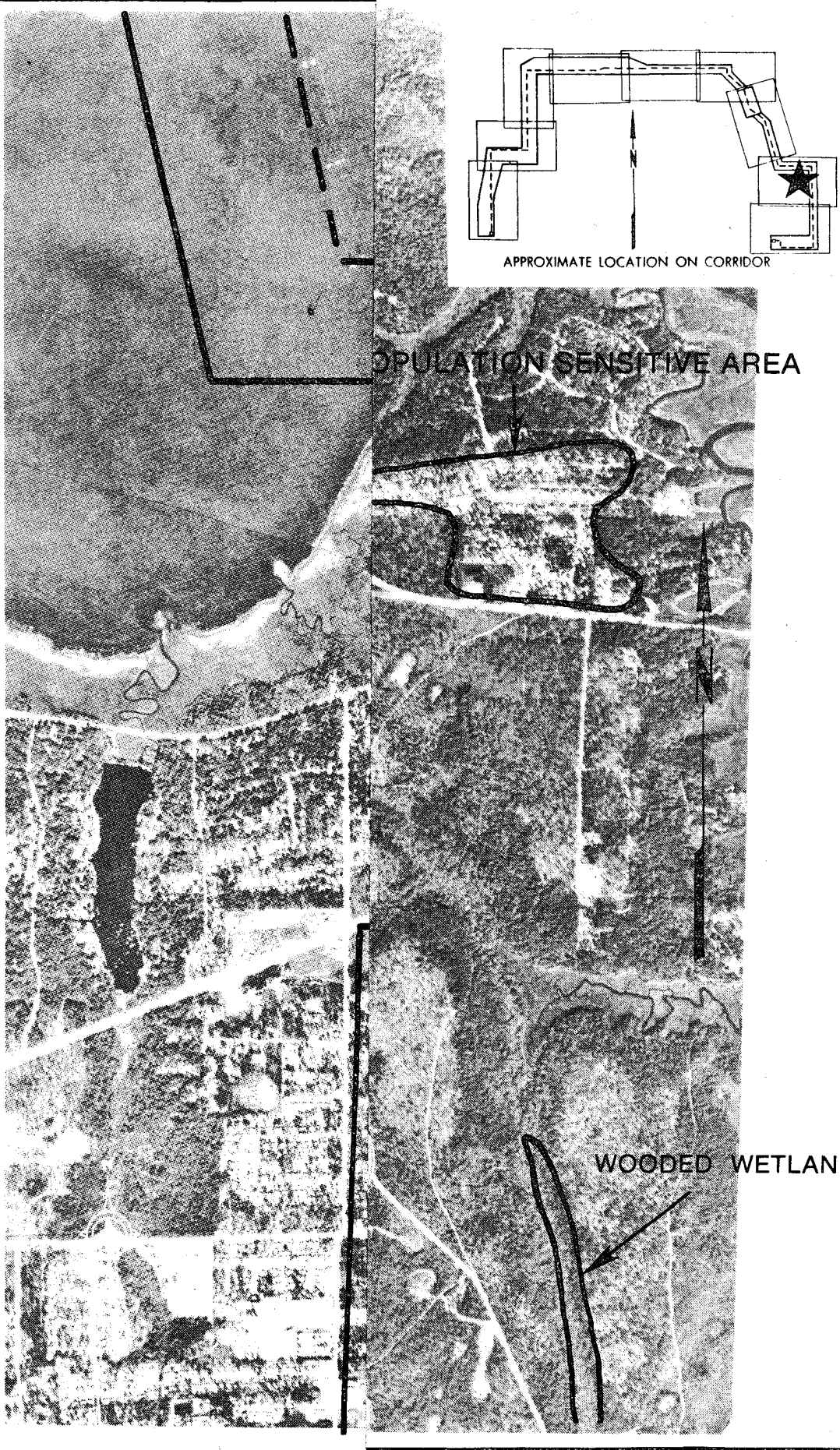
ransmission Corridor and Local Sensitive Areas



ransmission Corridor and Local Sensitive Areas



ansmission Corridor and Local Sensitive Areas



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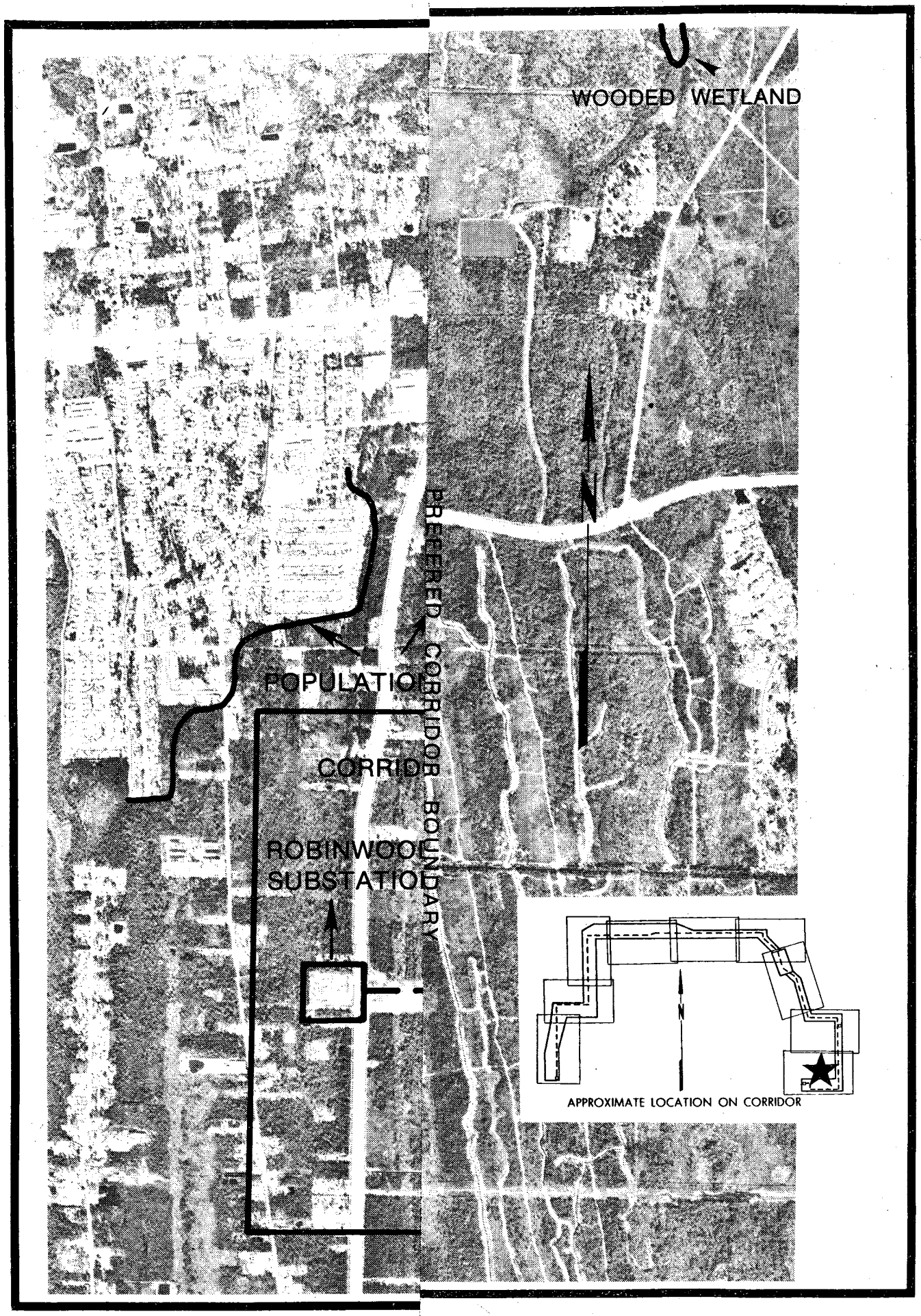

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ACID RAIN

APPENDIX L

ACID RAIN

LITERATURE REVIEW

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APPENDIX L

ACID RAIN

LITERATURE REVIEW

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L.1 INTRODUCTION

In recent years increasing concern has been expressed over the chemical character of precipitation and, in particular, the question of rainfall acidity. A large body of data has been gathered to suggest that rainfall over portions of North America and Europe is quite acidic. It has been suggested that this phenomenon may be of relatively recent origin and may stem from man made emissions to the atmosphere. Controversies have developed over possible causes of this phenomenon as well as its potential effects on aquatic and terrestrial ecosystems. Attention has been focused on the possibility that utility power plant emissions (particularly SO_2) may be an important contributor to rainfall acidity. The purpose of this section is to briefly review what is known about certain aspects of acid rain.

The review is organized with the intent of tracing the route of acid rain from its source, be it natural or industrial in origin, to the vegetation and soils, ultimately ending in the aquatic system. Attention is focused upon discrete portions of this route including emission sources, SO_2 conversion to SO_4, the rates and mechanisms of conversion, the atmospheric removal processes, the long range transport, and the effects on terrestrial and aquatic species. The available literature on each of these topics was reviewed and summarized in the following sections. Each of these topics has been addressed as a separate entity. It is apparent that there are definite linkages or interactions between each of these topics or components of the acid rain issue. However, due to paucity of data in the literature regarding these interactions, no attempt has been made to address the interactions between these component parts of the acid rain issue. In fact, a number of these interactions are currently being investigated by the scientific community.

As was previously stated, the lack of data prevented the preparation of a discussion regarding the linkages between major components as well as the assessment of the effects of acid rain from a new point source such as the proposed plant. However, the subject of acid rain as it applies specifically to the State of Florida is summarized in a section of the following review. The last section of this review briefly identifies some of the research projects currently underway or planned in the near future.

L.2 RAINFALL ACIDITY

As pointed out by Marsh (1978), the acidity of precipitation is governed by the overall balance of charge for all ions present in a droplet solution. The term "acid rain" is, however, something of a misnomer since most rainfall tends to be acidic by virtue of the chemical interactions between liquid water and atmospheric CO_2. The equilibrium pH of an aqueous solution in equilibrium with gaseous CO_2 at a pressure of $10^{-3.25}$ atm is approximately 5.65 (Stumm and Morgan, 1970). This equilibrium is consistent with the observation that typical rainfall pH measurements in many rural areas tend to fluctuate around pH 5.6-5.7. Hence, it is generally agreed that pH values of this magnitude may be considered to be a reference point for comparison of measured rainfall pH values.

A variety of research studies (Braekke, 1976; Semb, 1976; Brezonik et al., 1980; Likens et al., 1980) have indicated that rainfall pH levels over portions of North America and Europe fall considerably below the pH value (5.6) expected for an unpolluted atmosphere. Isopleths of rainfall pH for the eastern United States (Figure L-1) indicate that the annual average pH for much of the region is below 5. For portions of the northeastern U.S., including much of New York State, average values approach pH 4.0. In contrast, measured pH levels across much of the western U.S. tend to exceed pH 5.6. Over some arid areas even slightly alkaline pH values have been recorded, apparently as a result of interactions with wind blown dust (Winkler, 1976).

Long term precipitation chemistry data from Hubbard Brook have been analyzed by Likens et al. (1980) in an effort to establish current trends in rainfall acidity. Changes in pH for the period 1964-1977 are presented in Figure L-2 and suggest little observable evidence of distinctive long term trends. Values range from 4.00-4.20 with short term (yearly) fluctuations tending to mask any evidence of longer term trends.

A number of indirect lines of evidence have also been presented to support the contention that rainfall pH levels have decreased. Likens (1976) has suggested that pH analyses on glacial snow-packs indicate that precipitation in areas now receiving acidic rainfall was substantially less acidic during the 1800's. Similar arguments have been made on the basis of the chemical characteristics of lake sediments in the northeastern U.S. (Norton et al., 1980).

Some evidence has been presented to suggest that both the areal extent and intensity of rainfall acidity may be increasing. In a review of acid rain, Likens (1976) has suggested that since 1955 rainfall pH levels have decreased essentially everywhere in the eastern U.S. (Figure L-1). It is argued that many areas of the southeastern U.S., including Florida (Brezonik et al., 1980), appear to have experienced pH decreases from pH 5.6 to annual average values of pH 4.5. The pH of rainfall varies both spatially and temporally (Wolf et al., 1977). These investigators noted that there was some site to site variability among eight monitoring sites studied in the Manhattan area, and denoted that the pH varied according to storm type. Storms with a continental origin were found to have a lower pH than storms originating over the ocean, and storms travelling from the north and east had the highest pH's, while those from the south and southwest had the lowest pH's. The lowest pH's were associated with cold front air mass type precipitation and high summertime sulfate concentrations. Hendry (1977) also studied variations in the content of elements in single precipitation events, and noted significant variations of pH and its constituents from several individual rain storms in Florida.

There are many indications that the phenomenon of acid rain and the phenomenon contributing to acid rain varies seasonally. Pack (1978) analyzed data from the MAP3S (Multi-State Atmospheric Power Production Pollutant Study) for 1976 to 1977 of H^+, $SO_4^=$, and NO_3^- concentrations in precipitation from five sites in the eastern United States between Virginia and upstate New York and found large seasonal sulfate variations in precipitation. Cogbill (1976) measured seasonal

variations in rain pH in 1970 and 1971, and found the variations to be erratic and site-specific, although he was able to conclude that the pH values tended to be lower in summer than in winter. Hornbeck et al. (1976) determined that precipitation at nine stations in the northeastern United States was most acidic during the growing season (May to September) and least acidic during winter (December to February).

Numerous efforts have been completed which characterize the variability of the ionic species which account for increased acidity in rain. Representative values for the chemical composition of rainfall in the northeastern U.S. (Hubbard Brook, New Hampshire) are presented in Table L-1. These data represent weighted mean average concentrations for the years 1964-1977. Analyses of these data (Likens et al., 1980) indicate that H^+ contributes 69 percent of the total cation milli-equivalents contained within rainfall at this location. The sulfate ($SO_4^=$) and nitrate (NO_3^-) anion percentages were found to be 62 percent and 23 percent, respectively. The data also suggest a decrease in $SO_4^=$ and an increase in NO_3^- concentration over the period studied (Figure L-3). The $SO_4^=$ and to a lesser extent the NO_3^- ions have been similarly identified as the predominant anions occuring in precipitation over the southeastern U.S. (Brezonik et al., 1980) and portions of Europe (Marsh, 1978). As pointed out in the latter study, while all ions contribute to rainfall pH, those present at concentrations equivalent to or greater than hydrogen ion concentrations will tend to control pH values. It should be noted that the dominant anion in rainfall appears to be a function of geographic location. For the eastern U.S. and Europe, the $SO_4^=$ ion appears to dominate anion concentrations. However, for portions of the western U.S., evidence (Liljestrand and Morgan, 1978) indicates that the NO_3^- ion predominates. Work in England (Gorham, 1958) has suggested that in some locations Cl^- concentrations may be of primary importance.

Unfortunately, as pointed out by Davis (1980), historical comparisons of rainfall pH data may be more qualitative than quantitative in applicability. A number of problems exist in attempting to evaluate

potential variations over long time periods. Prior to 1960 there was relatively little rainfall data on which to evaluate possible trends. Jansen (1980) has criticized the method of calculation of rainfall pH levels used by Cogbill and Likens (1974). He pointed out that the precipitation network used to gather data was set up to assess deposition patterns of certain atmospheric constituents rather than for the express purpose of measuring rainfall pH. It is suggested that gaps in the measured data base may lead to errors in calculated pH values. Kramer (1978) has suggested that data, based on such calculations, may be only accurate in determining differences in hydrogen ion concentrations which are greater than 10^{-5} molar (M). Other potential sources of error in evaluating historical trends include systematic errors introduced in sampling, as well as experimental errors introduced from changes in monitoring equipment and sample preservation.

It has been argued that the acidity of rainfall is closely related to atmospheric $SO_4^{=}$ and NO_3^{-} concentrations, and that the atmospheric concentrations of these species have been influenced by increases in energy production and fossil fuel consumption since 1900. The assumption is made that the primary gaseous pollutants of energy production (nitrogen oxides and sulfur oxides) undergo chemical conversion to the $SO_4^{=}$ and NO_3^{-} species. It has been estimated (EPA, 1978) that more than 90 percent of the overall U.S. sulfur oxide emissions result from "stationary sources", principally fossil fuel power plants. Nitrogen oxide emissions are estimated to originate about equally from transportation (mobile) sources and stationary sources which include industrial and power plants as well as residential and institutional heating equipment (Davis, 1980).

The processes involved in controlling rainfall acidity are complex and it is extremely difficult to clearly establish qualitative and quantitative relationships between sulfur oxide emissions and acid rain formation. This stems in part from the fact that to explain acid rain measurements in remote areas, it is necessary to postulate the transport of acid rain precursor emissions over many hundreds of miles. This long distance

between possible locations of cause and effect introduces a large number of chemical and meteorological variables into the problem. Jansen (1980) has pointed out that global emissions of SO_2 from natural sources are estimated to be similar in magnitude to those from anthropogenic sources while natural sources of NO_x (150 x 10^6 tons/yr) significantly exceed global inputs from fossil fuel combustion sources (20 x 10^6 tons/yr). Moreover, on a regional basis atmospheric sulfate concentrations often show a poor correlation with SO_2 emissions. This is exemplified by data on power plant emissions at one location in Ohio (Figure L-4). Although utility SO_2 emissions are relatively constant over a monthly period, measured sulfate aerosol concentrations fluctuate widely. However, caution should be exercized in evaluating such data since the analyses have not taken into account changes in meteorological conditions occuring during the study period.

In summary, there is an abundance of literature which indicates that pH levels in rain are decreasing (i.e., acidity of rain increasing), particularly in the northeast. However, there are significant problems in comparing much of the historical rainfall data due to inconsistent sampling techniques and the lack of continuous long term data. In addition, the link between pH reductions, $SO_4^=$ levels and SO_2 emissions has still not been quantified. These statements point out the complexity of the atmospheric and chemical variables that affect rainfall acidity and the difficulties involved in clearly establishing cause and effect relationships.

L.3 REACTION RATES AND REMOVAL MECHANISMS

In an effort to clarify various aspects of the processes involved in acid rain formation, a significant research effort has been undertaken to identify the potential role of power plant emissions. The following sections review several aspects of this work as a means of outlining what is and is not known about the relationship between power plant emissions and rainfall acidity.

Most of the attention regarding acid rain precursors has, in recent years, been given to the sulfur oxides (Semb, 1977; EPA, 1974). In many cases, the estimates lag several years behind current emissions--creating evaluation problems as pollution emission controls are increasingly employed. Inventory techniques are being improved, however, and much more detail has been incorporated into ongoing programs (Perhac, 1978; McCraken, 1979). Among the questions which have received particular attention are the following;

1. What are the rates and magnitude of conversion of power plant SO_2 emissions to atmospheric sulfate?

2. What are the chemical mechanisms involved in the conversion of SO_2 to $SO_4^=$? What are the chemical or physical variables affecting this process and its products?

3. What are the processes by which sulfur oxides may be removed from the atmosphere?

Attempts have been made to characterize the relative effects of anthropogenic emissions from various sources. In this regard, a considerable effort has been devoted toward evaluating atmospheric emissions from power plant plumes versus the general plumes associated with urban areas. One objective of such studies is to determine whether there exist any differences in the atmospheric chemistry of the respective systems which could affect precipitation acidity. Characteristic of these

studies is work by Husar et al. (1977) which compared the sulfur budgets of power plant plumes in the St. Louis area against urban plumes containing emissions from low stacks (less than 100 meters) and near ground sources. In urban plumes sulfur depletion was found to follow an exponential decay rate with a typical decay time of 3-4 hours and new sulfate aerosol was undetected for distances of up to 50 miles. Measurements in the power plant plumes suggested oxidation rates of SO_2 to sulfates of 1/2 percent to 5 percent per hour, with the highest conversion rates taking place during the day time hours. Of the 30-45 percent of SO_2 from the power plant stack that is eventually converted to particulate sulfur, half is converted on the first day.

L.3.1 Atmospheric Oxidation Rates

Similar rates of atmospheric oxidation of SO_2 to sulfate have been reported in a variety of studies (Table L-2). Oxidation rates appear to be strongly influenced by light intensity. Daytime oxidation rates (0.5-5.0 percent/hr) appear to be much higher than rates observed at night (0.5 percent/hr). In addition some evidence has been presented (Larsen, 1980) to suggest that rates during the early history of some plumes (less than 25 minutes) may under certain conditions be appreciably higher (up to 20 percent/hr) than those observed at longer time periods. Alkezweeny and Powell (1976) calculated SO_2 to sulfate transformation rates of 5 to 14 percent per hour down wind of the industrial area of St. Louis during the first day of transport. Georgii (1977) has documented some cases where sulfate formation was observed very close (less than 50 km) to SO_2 sources in the Ruhr Valley in Germany.

Although relatively little data is available on nitrogen chemistry in power plant plumes, limited studies suggest that in urban atmospheres nitrogen oxides are converted to peroxyacetyl nitrate (PAN) (60-70 percent), nitric acid (HNO_3) (10-30 percent), and particulate nitrates (trace) (Battelle, 1978). Transformation rates remain uncertain but may be

on the order of 1-10 percent/hr during daylight. This would imply tropospheric residence times for nitrogen oxide contaminants may be on the order of several days.

The differences in the rates of sulfur losses from lower level urban versus higher elevation power plant plumes have been ascribed by Husar et al. (1977) to differences in rates of dry deposition. Tall stacks (greater than 200 m) may significantly reduce the rate of plume sulfur loss from dry deposition and have an important effect on possible power plant contributions to rainfall acidity. They would appear to favor longer distance transport of SO_2 and possibly NO_x species. Increasing SO_2 residence times would, in turn, favor increased conversion of SO_2 to aerosol sulfates. The rates at which such conversions occurred and the distances which gaseous species might be transported strongly depend on specific meteorological conditions.

L.3.2 Mechanisms of Atmospheric Oxidation

The following discussion deals with the current state of knowledge concerning the chemical mechanisms potentially involved in atmospheric conversion of SO_2 to sulfate aerosols. As pointed out by Wilson (1978), it is crucial to establish the quantitative relationship between SO_2 emission concentrations and the amount of sulfate produced. Differences in the general order of oxidation mechanisms with respect to SO_2 concentrations may exert a significant effect on the possibility for altering rainfall acidity by controlling SO_2 emissions. For instance, conversion mechanisms which are first order with respect to SO_2 concentrations would suggest greater likelihood of success in controlling atmospheric sulfate concentrations via decreases in SO_2 emissions than would reactions whose rates are essentially independent of SO_2 concentrations.

A prime difficulty in establishing a general reaction order for sulfate formation stems from the apparent complexity of the conversion processes and the potential variety of factors affecting reaction

pathways. Evidence suggests that SO_2 oxidation may occur via gas phase (homogeneous) or liquid and solid phase (heterogeneous) reaction processes. As indicated by Larsen (1980), the two pathways are closely related since gas phase reactions may subsequently involve condensation of reaction products (SO_3 and H_2SO_4) on the surfaces of existing particles. The rate of the gas phase reaction should be independent of the chemical form of the particles produced while liquid and solid phase SO_2 oxidation processes would be expected to be product dependent. Wilson (1978) has summarized the reactions believed to be of primary importance in atmospheric sulfate formation (Table L-3). The gas phase reactions (reactions 1 and 2) are indicated as being first order in SO_2. It is tentatively suggested that the liquid and solid phase reactions (reactions 3,4,5) may be near 0 order with respect to SO_2 and of potential importance only under conditions of high relative humidity.

The observations of Husar et al. (1977), Dittenhoeffer and DePena (1978) and others that sulfate aerosol formation appears to be closely related to light intensity suggests the potential dominance of gas phase reactions. In reviewing potential gas phase pathways, Calvert et al. (1978) have suggested that the predominant homogeneous reactions appear to involve photochemical interactions with hydroxyl (OH), hydro-peroxyl (HO_2) and organic hydro-peroxy (RO, RO_2) radicals. These reactants are produced from the photochemical interactions of nitrogen oxides and reactive hydrocarbons. Representative reactions involving these species are listed in Table L-4. As indicated, the relative importance of the respective gas phase reactions appear to depend on chemical and meteorological variables. Light intensity represents a major variable and changes with both time of day and season. It is suggested that under relatively unpolluted summer atmospheric conditions, oxidation rates may approach 1.5 percent/hr, while for more polluted conditions values may exceed 4 percent/hr. Under the O_2 depleted, NO, and SO_2 rich atmosphere of a power plant plume, reaction 5 (Table L-4) may predominate. It is postulated that oxidation rate changes which occur during the history of a plume may result, in part, from the suppressive and catalytic effects of the specific gaseous chemical components present at a specific time.

Gillani and Wilson (1980) in a consideration of power plant plume chemistry have suggested that the oxidation of NO_2 emissions may also proceed by photochemical processes involving OH^- and O_3 as reactants. Depending on the plume conditions, calculations suggest that NO_2 oxidation may be up to an order of magnitude faster than rates of SO_2 oxidation.

The gaseous HNO_3 produced may subsequently be converted to a particulate species through chemical reaction with atmospheric ammonia. Differences in oxidation rates between nitrogen and sulfur oxides suggest that predominant chemical contributions of plume emissions to rainfall acidity may vary for short vs long distance transport.

The heterogeneous oxidation of SO_2 in the liquid phase has been reviewed by several authors (Hegg and Hobbs, 1978; Larsen, 1980; Urone and Schroeder, 1978). In general, it is believed that the liquid phase mechanism probably proceeds as a free radical related process, which may involve HSO_3^- and $SO_3^=$ chain propagation intermediaries (Hegg and Hobbs, 1978). Evidence suggests that under relatively "clean" atmospheric conditions O_3 and O_2 may catalyze the process. The reaction is known to be catalyzed and supressed by a variety of chemical contaminants including solid phase carbon and trace metals. The chemical effects of contaminants may be synergistic, making rate predictions very difficult.

The interactions of SO_2 with solid phase particles have been reviewed by Liberti et al. (1978), and Larsen (1980), among others. Evidence suggests that the primary initial process involves SO_2 adsorption to particle surfaces. The rate of SO_2 absorption to solid surfaces appears to be relatively independent of the particle composition, (Leberti et al., 1978). However, while oxidation to sulfate appears to occur readily at high humidity on industrially emitted particles such as carbon and fly ash, it does not appear to occur as readily on typical urban dust particles. It is suggested that depending on conditions, SO_2 may

bond by either weak (physical) or strong (chemical) adsorption. Oxidation on solid phases appears to be most probable in regions of high particle concentrations such as in the immediate vicinity of a stack.

L.3.3 Atmospheric Removal Processes

The nature and magnitude of potential acid rain formation and transport is determined by atmospheric removal process operating on the various sulfur species. As previously indicated, the potential for formation of atmospheric sulfate may depend in part on the residence time of atmospheric SO_2. Longer residence times appear to favor greater percentage conversion of SO_2 to $SO_4^=$, as well as more extensive atmospheric transport of both species.

Sulfur dioxide, sulfates, and other pollutants are removed from the atmosphere by wet deposition (incorporation directly or indirectly in the precipitation process) and by dry deposition (direct transfer in the absence of precipitation). Removal of SO_2 or sulfate aerosols by wet deposition can occur either by washout (removal via scavenging of pollutants by the falling precipitation below the cloud) and rainout (removal by incorporation of pollutants into cloud droplets within the cloud and subsequent deposition in rain). Smith and Jeffrey (1975), Hales (1978), Garland (1978), Hogstrom (1978), Chamberlain (1975), Slinn et al. (1978) and Rodhe (1977), among others, have reviewed the processes involved in the scavenging of sulfur compounds from the atmosphere. Recent attention has been particularly devoted to assessment of dry deposition processes which may be responsible for the principal contributions of sulfur to aquatic and terrestrial ecosystems. The term "deposition velocity" of airborne matter represents the ability of the surface to absorb liquid and gases and collect aerosol particles.

The dry deposition velocity for aerosols depends primarily on their size and density, the amount of turbulent mixing in the surface layer and surface roughness. Very fine particles (less than 1×10^{-6}M) diffuse to

surface by random Brownian motion, particles between 1 x 10^{-6}M and 50 x 10^{-6} are transported to the surface by turbulence and large particles deposit mainly by sedimentation. Evidence suggests that dry deposition may account for up to 50 percent of all sulfur removed from the atmosphere (Rodhe, 1977). In a comparison of deposition velocities, Garland (1978) has suggested that deposition rates for SO_2 (less than 0.8 cm/sec) are substantially greater than those observed for aerosol sulfates (less than 0.1 cm/sec). Based on empirical calculations, Garland (1978) has speculated that atmospheric SO_2 residence times may be on the order of several days.

Wet removal of sulfur compounds from the atmosphere may involve incorporation into cloud droplets (rainout) or removal through falling precipitation (washout). It has been suggested (Hales, 1978) that 50 percent of the atmospheric sulfur content may be removed by wet processes. Wet removal processes may be up to an order of magnitude more efficient for sulfate aerosol species than for SO_2. On the basis of available literature data and using empirical estimates of reaction processes, Garland (1978) has suggested values for the relative importance of the factors contributing to wet removal of sulfur compounds. These values are presented in Table L-5. As indicated, the prime contribution of sulfate to rainwater appears to result from rainout of condensation nuclei. This is indicative of the importance of rainout rather than washout processes. Analyses based on such calculations indicate that perhaps only 3-10 percent of measured SO_2 concentrations may be removed within 30-50 km of a plume origin. Enger and Hogstrum (1978) found that two thirds of the emitted sulfur from a power plant is deposited within 80-120 km. These results suggest that measurements of SO_2 concentrations at a given location may not show a good correlation with rainfall pH levels.

Glover *et al.* (1980) have utilized what is known of rainfall scavenging processes in simplified empirical equations to suggest the possible effects of atmospheric SO_2 levels on rainfall pH; assuming that washout is the only process operating. The interesting aspect of this

computation is the conclusion that as rainfall pH levels decrease below pH 5, changes in atmospheric SO_2 levels have substantially reduced effects on rainfall acidity. This would suggest that in areas where rainfall is generally acidic (pH = 5) variations in localized emissions of SO_2 may show relatively little correlation with changes in rainfall pH levels in the immediate area.

One difficulty in characterizing wet removal mechanisms stems from a current lack of knowledge of the chemical aspects of cloud droplets, the precursors of rain drops. Barrie (1977) documented the complexities of the reversible SO_2 washout with water as well as the complex circulations within a droplet which complicate the air/water SO_2 exchange process. Oden (1976) showed that the sulfur deposition process is sensitive to factors other than just SO_2 emissions. He reviewed the reversibility (desorption and absorption) of the SO_2 washout process as well as the looping (rediffusion into the atmosphere of sulfur compounds originally deposited to the soil) of SO_2, both of which tend to enlarge the transport and deposition patterns downwind. Wolf and Thorp (1975) also discussed the unresolved complexities of wet SO_2 removal including cooling tower plume and smoke stack plume interaction as well as desorption.

In summary, SO_2 may be oxidized to sulfate in gas phase, liquid phase, and solid surface reactions. Current evidence suggests that photochemical oxidation in the gas phase may be the most important mechanism for oxidation of both SO_2 and NO_x species. It appears that rates of oxidation of SO_2 may be strongly affected by the presence of a variety of atmospheric contaminants. Hence, in many regions, atmospheric sulfate levels may be affected and perhaps even controlled by the presence of non-sulfur anthropogenic emissions from non-utility sources. The inefficiency of washout processes suggest that increases or decreases in SO_2 emissions from an individual power plant may have relatively little effect on rainfall acidity in areas directly adjacent to such a plant. This possibility is reinforced by the previously discussed calculations by Glover et al. (1980) which suggest that in areas where rainfall acidity is

already high (pH less than 5), very large increases in atmospheric SO_2 concentrations would be required before washout would significantly affect pH. Such a plant may still affect the regional character of rainfall through rainout processes or by dry deposition of SO_2. Accurate quantitative estimates of the possible impact of a given plant on local versus regional rainfall acidities must, however, await a considerably more detailed understanding of the factors involved in acid rain formation.

L.4 LONG RANGE TRANSPORT

The long range transport of sulfur dioxide and its related compounds from a given source is controlled by three main processes: dispersion, transformation, and removal. The most common approach for studying these atmospheric processes is by measurements in the atmosphere or laboratory or by theoretical calculations using mass conservation or "budget" calculations to estimate the space and time averages of such processes. The current literature regarding the various removal and transformation mechanisms which take place during and after transport was discussed in Section L.3. The following paragraphs address some field measurement studies and modelling efforts regarding the transport of sulfur compounds from major pollution sources. In addition, the current level of understanding of the various aspects of transport are summarized.

A number of the field measurement studies include the aspects of wind trajectory. Pack et al. (1977) compared the observed air quality and wind trajectory data to calculations and quantitatively evaluated the differences using airborne air quality observations and measurements from point and area sources. The comparison of observed atmospheric transport with calculated trajectories showed that large computational errors could occur, and the computational errors increased rapidly with trajectory extrapolation time. Good agreement between measured and calculated SO_2 concentrations were found by Szepesi (1977) who simulated continental scale pollution processes by constructing 72-hour 850 millibar back trajectories and surface winds. Large scale dispersion was simulated by using an air trajectory, box model. The removal process was simulated by using scale dependent decay rate constants currently available from the literature. Szepesi (1977) concluded that regional background stations are capable of detecting long range transportation of SO_2 if continental, regional, and local scale processes are taken into account separately, and it is possible to model and check country-wide environmental impacts of regional abatement policies. However, it was not possible to accurately quantify the effects of an individual source.

Husar, et al. (1977) studied the sulfur budget of a power plant plume near St. Louis via aircraft data, a ground monitoring network, and a two layer box model. He found that of the 30-45 percent of the SO_2 which is eventually converted to particulate sulfur, half of it is converted on the first day. The remaining portion is removed as SO_2 at varying distances depending on meteorological dispersion. The transformation and removal occurred during the day, while downwind transport of SO_2 (200-400 km) was fastest at night. Smith and Jeffrey (1975) found similar transport and removal ratios from measurements along the east coast of England. Granat and Rodhe (1973) studied precipitation events around an oil-fired plant in Sweden, and estimated the long-term additional acid rain deposition due to the power plant to be 10-15 percent higher than at 15 km. Also, less than 10 percent of the emitted sulfur was deposited within 15 km, indicating that there was probably significant transport farther downwind.

DeWys et al. (1978) used a simple plume box transport model to calculate transport and deposition over a variety of surfaces, and found that 60 percent of the SO_2 emissions still remained in the atmosphere at 200 km. From 5-10 percent of the emitted sulfur is left in the atmosphere after three days, which corresponds to a transport distance of 1000 km. Significant percentages of $SO_4^=$ were not deposited until after 200 km. Eliassen (1978) used emission data together with a one layer atmospheric dispersion model and wind trajectories to determine the movement of pollutants over a large region containing major emission sources. He found that maximum deposition of sulfates appeared in areas of high precipitation. The highest annual wet sulfate deposition amounted to 4 g/m^2 in northern Europe.

One indicator of the uncertainty of the development and use of atmospheric transport models in recent years that a variety of approaches and representations in simulating the horizontal movement of pollutants have been employed. Examples of current state-of-the-art models are summarized by McCraken (1979):

NOAA/ARL model (1977) - Trajectory winds are developed using an interpolation scheme that determines transport wind by using hourly surface data adjusted by factors derived from an interpolated field of 12-hourly uppper air data.

BNLMET model (1976) - Mass, energy, and momentum constraints are used to adjust interpolated arrays of wind data derived from radiosonde observations to assure conservation in material layers formed by complex topography and meteorologically varying conditions.

LRTAP model (1977) - Observed surface and 850-mb radiosonde data are spatially interpolated to a 127 km grid at 6-hour intervals. Local winds for movement of pollutants puffs are calculated using linear interpolation in time and spatial interpolation of the nearest four grid point values. Surface wind trajectories are used only for very stable stratification; otherwise, surface geostrophic or 850 mb trajectories are used in transport pollutants.

EURMAP model (1977) - Twelve hourly 850 mb data are interpolated objectively to the locations of individual puffs at 3-hour intervals. The average layer transport wind is taken to be 0.75 of the 850 mb wind, and the direction is backed by 15^{o} ($D = D(850\ mb) - 15^{o}$).

ERT/ACHEX model (1977) - LRTAP data are extensively hand-analyzed to determine streamlines (some models have used such data without further processing) are adjusted iteratively to obtain an objectively generated divergence-free wind field.

These models, as well as a variety of other simpler approaches, all have shortcomings such as their neglection of vertical shear and tranport as well as vertical pollutant gradients, due to the necessity to incorporate averaging time or interpolation. If there is to be a suitable model simulation of a rainstorm scavenging pollutants, treatment of vertical transport processes must be improved (McCraken, 1979). At the

present time, many models choose among 850 mb, surface, geostropic or vertically integrated two dimensional wind patterns. In terms of quantifying the sulfur emissions and nitrogen compounds, all models will always be subject to the sometimes gross input errors which result from poor emission inventories.

There have been a wide variety of theoretical, laboratory and field experiments directed toward understanding the atmospheric chemistry of sulfur and nitrogen compounds, as well as other species (ammonia, chlorine, trace metals, etc.). Collectively, these experiments indicate that both homogeneous and heterogeneous processes play important roles. However, the range of transformation rates, residence times, the conditions by which they vary, and the actual mechanisms are still, for the most part, beyond simulation capabilities. Because most models have been trajectory models with superposition of plumes, linear chemistry has been a necessity. The simplification of the range of species is just as important a factor in predicting precipitation chemistry as is the present over-simplification of the transformation mechanisms.

The existing transport models treat removal mechanisms in several different ways. Pack et al. (1977) summarized the parameterization schemes used in a selection of current numerical transport models. An empirical nonspecific decay term which treats both wet and dry removal processes is the simplest method employed, but it is usually based on estimates of pollutant lifetimes over varying meteorological and chemical conditions. Another approach is to address dry and wet deposition separately. Dry deposition is usually computed by using a deposition velocity. The velocity is derived by dividing the measured downward flux by the concentration at a given height above the surface. The velocity is then multiplied by a predicted concentration (often, unfortunately, an average concentration for the entire mixed layer) to arrive at a pollutant mass flux to the surface. This action, however, tends to overestimate deposition. Some models now being developed have multiple vertical levels which allow a more detailed treatment in calculating surface

concentrations. Deposition velocities can be varied in such models as a function of time of day, surface conditions, and vertical stability. The net effect on sulfur deposition of this new formulation in the Battelle, PNL model (Powell et al., 1977) has been to decrease SO_2 deposition by about 20 percent and to increase sulfate deposition several fold.

Representation of wet scavenging has been more difficult. Washout coefficient rates for SO_2 and $SO_4^=$ vary widely among various modelers with little agreement on even which pollutant is scavenged more efficiently (Table L-6). To a large extent, the values chosen are based on matching model results with observations. The actual scavenging of pollutants by precipitation is an exceedingly complex phenomenon; and more detailed consideration is obviously needed. The PNL model (Scott, 1978) probably offers the most detailed representation of pollutant scavenging being used in regional models. This model uses variable washout coefficients which change with solubility, rainfall rate, vertical pollutant gradients, and ground level pollutant concentration. The PNL model described by Powell et al. (1977) is one of the few models which goes beyond sulfur deposition prediction to attempt to predict long-term averages of precipitation acidity. It assumes that all of the sulfate in the atmosphere is present as sulfuic acid, and that nitrate contibutes an additional 30 percent to the acidity.

Merging the individual representations of the various physical processes together into a single model poses additional difficulties. The methods chosen to solve the transport processes are all related to the methods used to solve the non-linear chemistry. Horizontal grid size influences the way in which the deposition processes can be formulated. In the U.S. models, most of the fine tuning is based on atmospheric concentrations only because deposition measurements do not exist in enough quantity to be useful. Therefore, the task of model verification becomes increasingly difficult. Finally, it should be noted that the errors inherent in the background measurements, as well as the emissions

inventories, are often as large as the errors in the modelling calculations. All of this supports the conclusion that realistic acid rain modelling remains a formidable goal rather than a reality.

L.5 EFFECTS OF ACID RAIN ON TERRESTRIAL ECOSYSTEMS

The effects of acid rain on terrestrial ecosystems are extremely complex and to a large extent not that well known or understood. Effects on both soil and vegetation have been postulated, but the evidence is inconclusive. The following discussions present a generalized review of the literature on the effects of acid rain on soils and vegetation.

L.5.1 Soils

Acid rain may destabilize clay minerals, promote runoff, reduce cation exchange capacity, promote chemical denudation and accelerate podzolisation (Varshney and Dochinger, 1979). Norton (1976) has reported that iron and aluminum oxides and hydroxides may be dissolved and redox sensitive elements leached preferentially. Wirklander (1973) related the acidification of soils to the degree of base saturation and cation exchange capacity. The acidification reaction involves the replacement of exchangeable bases such as Ca^{++}, Mg^{++}, and K^{+} by H^{+} from acidic precipitation. The pH, base saturation, cation exchange capacity of the soil, and the concentration of exchangeable cations in precipitation control the efficiency of this replacement. Reuss (1975) has observed that the H^{+} concentration increases if sulfates accumulate from acid precipitation or other forms of air pollution. As the cations on clay or organic matter are replaced by H^{+}, the bases may be leached from the soil in association the anion, $SO_4^{=}$. Overrein (1972) has demonstrated, under laboratory conditions, the leaching of calcium from soils by sulfuric acid solutions (H_2SO_4) at pH values of less than 4.0. Estimates made for forest soils in Sweden have shown that one meter of rain at pH 4.0 would remove the cation equivalent of 30 kg Ca^{++}/hectare. Assuming that the forest soils in Sweden contain 1200-2000 kg Ca^{++}/ha, it has been estimated that it would take approximately 40 years for soil cations to decrease. Likens and Bormann (1974) also recognize the potential for leaching of calcium and other nutrient elements, although they feel such losses would be small for some ecosystems and unlikely to result in any

significant short term damage to arable land. Abrahamsen et al. (1975) found that simulated acid rain of pH 3 increased the acidity of humus and decreased the base saturation of a podzolic soil.

Soil microbiota are also influenced by shifts in soil acidity. Modifications in soil microbe populations and processes may be related to changes in soil chemistry. An increase in soil acidity could inhibit the growth of bacterial populations and enhance the development of fungi. Popovic (1976) reported that CO_2 evolution decreased significantly in short term incubation experiments with acidified humus. Soil respiration (CO_2 evolution) is generally regarded as a general expression of soil organism activity. Inhibition of nutrification by soil acidification has also been demonstrated in both laboratory and field studies (Tamm et al., 1976). However, studies have shown that the nitrogen fixation process is of little importance in well drained coniferous forests. Forest trees are not obligate nitrate plants. It has been suggested that the reduced nitrification may be beneficial if less of the available nitrogen is turned into readily leachable nitrate. This nitrification remains beneficial provided that enough available nitrogen in the form of ammonia is released during the decomposition process. In short term experiments, ammonification was found to increase in acidified samples. However, in the field, the tendency has been for a decrease in ammonification rather than an increase.

There are a number of other biological processes which may be affected by changes in soil acidity or sulfate concentrations due to acid precipitation (Tamm, 1976). The relationship between mycorrhiza and roots is one such process. Mycorrhizal roots occur predominately within the soil organic layer which is the first layer to receive acidic precipitation. Symbiotic relationships between plants and mycorrhizal forming fungus are thought to be sensitive to increased soil acidity. It is also thought that other rhizosphere organisms, such as nitrogen-fixing bacteria, may also be affected. Shriner (1974) found that simulated acid rain (primarily H_2SO_4) inhibited nodulation and other nitrogen fixing processes of kidney bean and soybean.

The release, with increasing acidity of aluminum and other heavy metals, is another process with biological implications. Many of these heavy metals are toxic to plants (see Appendix A). The release of these metals, especially aluminum, is expected when acid rain continues for a long period of time. There is also supporting evidence for a correlation between the distribution pattern of acid rain and other industrial pollutants such as lead. The accumulation of metals is considered to be an exchange phenomena. Heavy metals are bound as stable complexes by the organic components of liter, humus and soil (Tyler, 1972). The acidic precipitation alters the equilibria of the metal complexes and may have an adverse effect upon the residence time of the heavy metals in soil and litter (Tyler, 1972).

Soil biological processes, which are sensitive to soil acidity changes, are linked together in a complicated system of both positive and negative interactions. As a result, it is difficult to predict the ultimate outcome of soil acidification on soil biological processes. However, on the basis of studies conducted in laboratories and observations made of Scandinavian forest ecosystems, it would seem likely that acidic precipitation means less soil productivity and less soil stability over extended time periods.

L.5.2 Vegetation

The effects of acid rain on forest vegetation are varied and extremely complex. However, forests are important avenues of study since they are widespread and constantly exposed, contain a growth history in tree rings, and are economically and biologically important (Cogbill, 1977). A decrease in forest growth has been suggested by data collected in both the northeastern United States and Sweden. Both the mechanisms and the effect of acidity on forest growth have been investigated. Studies in which plants are subjected to an artificial or simulated acid rain have been conducted as well as studies in which actual field measurements have been obtained.

Vegetation intercepts the rainfall and is postulated to alter its chemistry to various degrees. Eaton et al. (1973) have been able to demonstrate the uptake of H^+ by the forest vegetation in both coniferous and deciduous forests. The capacity of these plant canopies to alter the acidity of precipitation varies from species to species (Varshney and Dochinger, 1979). The nature of throughfall and stemflow is also affected differently by different species (Glass et al., 1978)

Symptoms of simulated acid rain on vegetation are typically manifest as lesions or zones of dead tissue on the upper epidermis at the base of trichomes, in guard cells and in epidermal cells above veins (Jacobson, 1978; Wood and Bormann, 1977). Evans et al. (1977) observed that in leaves injured by simulated acid rain, collapse and distortion of epidermal cells on the upper leaf surface is frequently followed by injury to palisade cells and ultimately both leaf surfaces are affected. Premature leaf abscission of leaves of bean plants has also been associated with exposure to simulated acid rain.

The development of foliar symptoms was found to be dependent on the duration and frequency of exposure, the length of time between rain events, and the intensity of the rainfall (Jacobson and van Leuken, 1977). The environmental conditions during and after a precipitation event also play a role in the response exhibited by the affected plant. These conditions can alter physiological processes, change the degree of contact with the precipitation which governs the quantity of precipitation remaining on the leaf surface, or the rate of evaporation after the precipitation event (Jacobson and van Leuken, 1977).

The results from recent experiments have indicated that acid precipitation can damage foliage, accelerate cuticular erosion, alter responses to pathogens, symbionts and saprophytes, affect the germination of conifer and deciduous seeds, and affect the establishment of seedlings (Glass et al., 1978). Cohen and Ruston (1925), in one of the first studies of acid precipitation, found that the growth of timothy was reduced when

plants were treated with sulfuric acid solutions at concentrations between 10 and 320 ppm. Wood and Borman (1974) exposed yellow birch seedlings to artificial acid mists ranging in pH from 4.7 to 2.3 for up to 15 week periods. Foliar tissue damage was observed at pH 3.0 and below, while significant growth reductions were measured at pH 2.3. Hindawi et al. (1977) observed foliar injury on bush beans exposed to a simulated acid mist at a pH level below 2.5.

Lee et al. (1980) exposed 28 crops to a simulated sulfuric acid mist at pH values of 4.0, 3.5 and 3.0. Plants were exposed at a rate of 6.7 mm/hr, 1.5 hours per day, 3 days per week for a total of 30 mm/week throughout the growing season. Of the 84 possible crop treatment combinations, 32 showed no effect on either yield or foliar injury. Foliar injury without yield effects was observed in 30 combinations, while yield effects without foliar injury appeared in six combinations. All but five of the 46 treatments in which foliar injury symptoms were observed occurred at pH 3.0 or 3.5. These investigators concluded that yield of dicot plants is more likely to be affected than monocots. Within the dicot category, the yields of crops likely to be affected are, in decreasing order, root, leaf, cole and tuber crops. Grain crops are unlikely to be affected while monocotyledenous forage crops may be more productive under acid rain conditions. Lee et al. (1980) do caution against drawing conclusions from their experimental results due to the laboratory nature of their work.

Acidic precipitation has also been implicated in the abnormal development of pine needles. Hindawi and Ratsch (1974) found that the misting of Scotch pine needles with dilute solutions of H_2SO_4 at pH of 2.0 and less resulted in a greater number of short needles than were observed at higher pH values. In another study, Gordon (1972) found that the length of developing pine needles exposed to H_2SO_4 solutions with pH values less than four were shorter than control plants. There may be an external factor involved in the expression of needle length, such as a biotic agent as suggested by Wood and Pennypacker (1974).

The effects of acid precipitation on forest tree growth has been investigated by tracing the development of tree rings during the time periods when the precipitation pH was postulated to decrease. Johnson and Sundberg (1972) analyzed forest growth in southern Sweden from 1896 to 1965, observing a 2 to 7 percent reduction in growth between 1950 and 1965. This growth reduction was attributed to acidification of precipitation. Similar studies by Abrahamsen et al. (1976), Cogbill (1977), and Abrahamsen et al. (1977) have not produced similar results.

It appears that most injury to foliage by simulated acid rain or mist occurs on expanding or recently expanded leaves. Birch seedlings 14 days old were found to be more sensitive than seedlings six weeks old (Wood and Bormann, 1974). Evans et al. (1978) were able to demonstrate that leaves from various clones of poplar which had just reached full expansion were more sensitive to simulated acid rain than those not yet expanded or those that had been expanded for some period of time. In conifers, inhibition of needle elongation was observed when simulated acid rain solutions were applied to immature pine fasicicles (Hindawi and Ratsch, 1974).

Cuticular erosion is also an effect attributed to acid rain. Shriner (1974) demonstrated that a simulated acid rain of pH 3.2 destroyed the waxes on the leaf surfaces of willow, oak, and kidney beans. It is thought that the removal of leaf waxes may influence transpiration, frost tolerance, ionic exchange and the tolerance of plants to biotic pathogens (Martin and Juniper, 1970; Shriner, 1974).

Another effect acid rain has on vegetation is the leaching of chemical elements from exposed plant surfaces. Tukey (1970) has identified a wide range of materials in plant leachates including all of the essential elements, amino acids, carbohydrate growth regulators, free sugars, pectic substances, organic acids, vitamins, alkaloids, and alleopathic substances. Both environmental and plant specific factors influence the quantity and content of plant leachates. Differences exist between species as well as between individuals of the same species or even the same plant.

The physiological age of the leaf tissue appears to have an effect on the leachate quality. It has been observed that young actively growing tissues are relatively immune to leaching of mineral nutrients and carbohydrates. Mature tissue, which is near senescence, appears to be very susceptible. Other factors which influence leaching include stage of plant development, temperature, and acidic precipitation. Abrahamsen et al. (1976) and Wood and Bormann (1975) have both demonstrated that increased acidity can increase the leaching of various cations and organic carbon from tree canopies. They found that increased acidity of an artificial acid mist increased the loss of potassium, magnesium, and calcium from bean plants and maple seedlings. Significant increases in leaching occurred between a pH of 3.3 and 4.0 with no noticable leaf injury, while below pH 3.0, tissue damage ensued (Wood and Bormann, 1975). Hindawi et al. (1977) noted a correlation between increased acidity of acid mist and foliar leaching of nitrogen, calcium, phosphorous, and magnesium. Injury to foliage, such as cuticular erosion, may increase the leaching of inorganic and organic substances from leaves (Weber and Lee, 1977). However, Wood and Bormann (1975) found that leaching occurred in the absence of any injury.

Contradictory results were noted in other experiments. Abrahamsen and Dollard (1978) observed that in spite of increased leaching at the lowest pH treatment, no change in the cation content of Norway spruce was recorded. No changes in the calcium, magnesium and potassium content of the needles of eastern white pine were observed by Wood and Bormann (1975). It is also thought that the loss of nutrients through leaching stimulates nutrient uptake by the plants (Tukey, 1970). It is thought that little to no injury will occur as long as the roots are able to absorb the amounts of nutrients lost to leaching. As would seem evident based on the conflicting data, the effects of increased leaching of substances from vegetation by acidic precipitation remain unclear.

Beneficial effects to plants from acid rain have also been reported. Wood and Bormann (1977) observed an increase in needle length and weight of eastern white pine seedlings when exposed to a simulated acid mist

comprised of sulfuric and nitric acid. It was their belief that the increased NO_3 application was responsible for the growth increases. A positive effect on field grown soybeans was attributed to the application of an acidic mist (Irving and Miller, 1978). The increased growth was attributed to the fertilizing effect of the acid mist which apparently extended the pod filling stage. No visible injury symptoms were observed, but a histological study revealed a number of dead mesophyll cells.

Simulated acidic precipitation was found to increase the growth of Scots pine seedlings by Abrahamsen and Dollard (1978). It was observed that applications of acid rain with pH values of 3.0, 2.5, and 2.0 to seedlings resulted in greater growth than found in control plots. The increased growth rates were thought to be a function of increased nitrogen uptake.

A number of acid rain effects on vegetation have been reported, including foliar damage, cuticular erosion, altered response to pathogens, symbionts and saphrophytes, affect germination of conifer and deciduous seeds, affect establishment of seedlings, premature leaf abscission, abnormal development of pine needles, leaching of nutrients from leaves, and reduced growth rates. These results were largely obtained from studies in which simulated acid rain or mist was used on a short-term basis under controlled laboratory conditions. The effects noted above have not been observed to any great extent under field conditions and such effects under naturally occurring conditions are largely unknown. Some beneficial effects have been observed but, again under experimental conditions.

L.5.3 Wildlife

Acid precipitation is not thought to directly affect terrestrial vertebrates because of the protection afforded the body surface by scales, feathers or hair (U.S. Fish and Wildlife Service, National Power Plant Team, 1978). Indirect impacts to wildlife are, however, possible through significant habitat modifications.

As indicated by the foregoing discussion, the following statement from Florida Department of Environmental Regulation (1980) seems to be accurate: "In spite of a rather extensive literature review and discussions with area specialists, we are unable to ascertain the physiological effects of acid precipitation on Florida agricultural crops, forestry crops or, in general, the terrestrial flora of the state". With this in mind, it is impossible at this time to predict the direct or indirect impacts to local terrestrial ecosystems associated with acid precipitation.

L.6 EFFECTS OF ACID RAIN ON AQUATIC ECOSYSTEMS

L.6.1 Effects on Water Chemistry and Fish

It has been argued that rainfall acidity may have potentially significant effects on aquatic systems as they relate to terrestrial ecosystems. Relationships between these respective systems are complex and difficult to quantify. They depend, primarily upon interactions between sediment and aquatic systems which are incompletely understood. Certain aspects of these relationships have, however, been characterized and provide insight into possible chemical relationships.

The potential impact of acid rain on a given aquatic ecosystem depends in large measure on the type of soil or sediments underlying the region. Acid precipitation may interact with soils in the following ways:

1. be neutralized by bases (calcium carbonates and sodium carbonates)

2. pass through acidic or saturated soils into ground water

3. enter into ion exchange reactions with ions present in the soil.

The neutralizing capacity of a given soil will depend on the particular soil composition although, in general, most soils are quite resistent to pH changes. McFee et al. (1976) have used empirical calculations to suggest that depending on precipitation pH, top soils (upper 20 cm) might actively neutralize percolating water for long time periods (ten to several hundred years). In contrast, igneous and metamorphic bedrocks are quite resistent to weathering and are likely to have little buffering effect on percolating water pH levels (Almer et al., 1978). Thus areas of shallow soils with low cation exchange capacity and exposed bedrock are likely to have lakes and streams that are susceptible to acidic rainfall effects. The problem tends to be amplified by the fact

that surface waters in such regions are often soft (low Ca and Mg concentrations). These waters are prone to acidification as they have a limited buffering capacity.

Evidence has been presented to support the contention that rainfall acidity may in fact be affecting fresh water body pH levels. Studies in both North America and Europe indicate that in many regions lake water pH reductions have occurred over the last thirty years. As early as 1926, reports of the acidification of freshwaters in Sweden showed declines and disappearances of commercial fish populations (Wright et al., 1975).

Schofield (1978) in a survey of the Adirondack area of New York found that 51 percent of 217 lakes in the region had pH levels less than 5, whereas in 1935 only 4 percent registered pH less than 5. Kramer (1978) has suggested that this sharp reduction in lakewater pH values might be a reflection of a loss of buffering capacity in regional watersheds. As previously discussed, it has been suggested by several authors (Likens, 1976; Frink and Voight, 1976) that rainfall in the Northeast has been acidic since at least 1900. If so then certain soils may have undergone a slow loss of buffer capacity, as would be predicted by McFee et al. (1976). The shallow soils of watersheds such as those in Adirondacks would be particularly sensitive to such effects.

Chemical analyses have been used to suggest that the prime cause of lowered fresh water pH levels are increased sulfate loadings, coupled with decreased bicarbonate concentrations (Beamish, 1976). As evidenced by Figure L-5, lake water pH levels in Sweden appear to closely reflect sulfate inputs, suggesting that increased sulfate loadings may reduce pH.

Low cation exchange capacity of many sandy Florida soils may provide little buffer capacity, thus rendering many lakes susceptible of pH changes. In a consideration of potential aquatic chemical effects, Brezonik et al. (1980) noted apparent reductions in pH of some of the soft water lakes located in sandy regions of central and northern Florida,

suggesting pH levels may be 0.3-0.9 units lower now than approximately 20 years ago. Decreases have not been reported for similar lakes in southern Florida. A few researchers have contested the conclusion that lakewater pH changes are the result of precipitation acidity. Rovenquist (1978) has argued that lake acidification in areas of Norway can be explained by ion exchange processes resulting from human alterations (farming, forestry etc.) on watershed regions. In addition, a substantial body of data suggests that if precipitation pH affects streamwater pH, the relationship is a long term and apparently indirect one. Data from Likens et al. (1980) indicate that stream water pH levels do not reflect short term (yearly) variations in the precipitation hydrogen ion concentrations. Furthermore, results indicate that over cycles of up to a year, stream water hydrogen ion concentrations do not demonstrate the variations in concentration which have been observed in precipitation fluxes into the watershed (Figure L-6). These results have been interpreted as evidence that such watersheds possess a substantial capacity to neutralize precipitation effects.

From a chemical standpoint, long term variations in soil-water system pH levels may cause changes in the concentrations, speciation and availability of a variety of dissolved chemical constituents. It is well known that many limnological chemical reactions are pH dependent and that even small pH changes (less than 0.5 units) may significantly affect chemical equilibria (Wetzel, 1975). Kramer (1978), in a review of acid effects on soil-water systems, has indicated the following reactions to be among the more important pH mediated processes:

1. dissolution of calcareous minerals (calcite, dolomite)

2. dissolution of Fe, Mn and Al oxides

3. dissolution of cation aluminosilicates

4. adsorption on oxides, silicates and organics (particularly trace metals)

5. effects on photosynthetic processes.

The chemical reactions related to these processes are outlined in Table L-7.

Studies involving both northeastern U.S. (Cronan and Schofield, 1979) and Scandinavian lakes (Gjessing et al., 1976) have reported increased aluminum leaching in certain areas receiving acidic precipitation. Increased aluminum levels have been suggested as being potentially capable of decreasing aqueous humic concentrations through flocculation. Decreased humic levels may in turn result in increased aqueous trace metals concentrations since these metals are scavenged by humic material. Increased trace metal concentrations have, in fact, been reported for a number of species including mercury, manganese, lead and zinc (Dickson, 1975).

L.6.2 Effects on Freshwater Trophic Levels

The biotic effects of increasing acidity in surface freshwaters are very complex. Short term (acute) effects may cause massive fish mortalities while subtle long term effects can alter the abundance of select aquatic organisms as well as the total amount of life supported in an aquatic community. Declining total aquatic life (biomass) is an event referred to as "oligotrophication". This process usually occurs from decreasing concentrations of available nutrients which support the aquatic community. Nutrient abatements may arise from either an external (allochthonous) or internal (autochthorus) source or a combination of both. External nutrient sources usually enter a lake with surface water runoff. Autochthonus nutrients come from the decomposition of aquatic life and nutrient exchange between bottom sediments and overlying waters. An excellent review of oligotrophication concepts as a response to increasing

acidity are presented in Hendry et al., 1976 and Grahn et al., 1974. Very often, these effects are latent, taking between 5 and 10 years before fishery declines and gross changes in water quality are obvious.

The response of an aquatic ecosystem to increasing acidity ultimately involves all trophic levels. Subsequent inter and intraspecific interactions between and among life forms can produce a lake with an entirely different fish and plant community.

The typical food web of lakes and the interdependence of different trophic levels are illustrated in Figure L-7. Subsequent discussion of acidic precipitation will address each trophic level from the decomposers at the bottom to the fish at the top of the food chain. Discussion of the decomposer community will show how this trophic level affects other communities. Similar interdependences occur in primary and secondary producing communities.

L.6.2.1 Decomposers

Bacteria found in lacustrine sediments and associated with particulate matter in the water column perform an important role as decomposers. Through their metabolic processes complex organic matter is transformed into simple organic compounds that can be readily assimilated by primary producers (i.e., algae and higher plants). In addition to their transformation functions, bacteria assimilate nutrients and provide a nutrient rich source of food for higher life forms such as protozoans, zooplankton, and benthic invertebrates. In acidified lakes where the pH is below 5.0, bacteria communities are displaced by fungi and filamentous algae. These decomposers breakdown organic compounds at a slower rate than bacteria (Hendry et al., 1976; Wright et al., 1975), which result in lower nutrient release rates and an increase in detrital material.

Subsequent shifts in the decomposer community from bacteria to fungi have additional effects on other trophic levels. Thick "felt-like" mats of fungus hyphae and filamentous algae cover the lake sediments and

effectively reduce nutrient exchange between sediment and overlying water (Hendry et al., 1976) and limit the growth and abundance of other primary producers. Formation of fungal mats change the benthic substrate such that benthic invertebrate who depend upon bottom substrate for food (bacterial aggregates) and shelter are replaced by invertebrates more suited to the new habitat. The net effect is a shift from a benthic invertebrate community that processes sediment and releases nutrients to a carnivorous benthic invertebrate community who prey upon each other as well as on small vertebrates (Grahn et al., 1974).

L.6.2.2 Primary Producers

Photosynthetic organisms which assimilate inorganic nutrients make up the trophic level called primary producers. Phytoplankton (floating microscopic plants) are a source of food for herbivorous zooplankton (Daphnia spp.) and fish. Emergent and submerged aquatic plants (macrophytes) provide shelter as well as food habitats for benthic invertebrates and fish. Lowering the water's pH selects against acid sensitive submerged and emergent macrophytes as well as phytoplankton (Almer et al., 1974; Grahn et al., 1974; Hendry et al., 1976). Shifts in these communities alter decomposition rates (Grahn et al., 1974) as well as the structure of foraging communities (i.e., zooplankton and planktivorous fish). In some Swedish lakes where pH is approximately 4.8 emergent aquatic plants such as Lobelia and Iosetes spp. have been replaced by the acidophilic moss Sphagnum. The Sphagnum decomposes slower than the plants it displaced and increases the amount of organic detrius.

L.6.2.3 Secondary Producers

Organisms which feed on other organisms to assimilate nutrients are called secondary producers. In aquatic systems, these organisms are represented by zooplankton, benthic invertebrates, and fish. As a result the acidification of Swedish lakes, zooplankton communities were found to shift to omnivorous feeders (copepods) while filtering feeding Daphniids

disappeared (Almer et al., 1974). Molluscs with calcareous shells such as snails and clams were also notably absent in Swedish lakes when water pH dropped below 5.2 (Grahn et al., 1974). At these low pH levels, the solubility of calcium carbonate increases. Low calcium concentrations in the lake water along with increased dissolution of calcium carbonate limit the development of molluses with calcium carbonate shells. In Canadian shield lakes where increasing acidity has been noted, several species of fish disappeared due to their inability to spawn successfully (Beamish and Harvey, 1972). In Sweden, growth rates in sea trout were changed when acidic water formed by snow and ice melts caused these fish to stop feeding (Hultberg, 1976). Salmon disappeared from nine rivers in Sweden as their spawning functions ceased (Wright et al., 1975) and the fish Leuciscus rutilis disappeared from ten Swedish lakes (Almer et al., 1974) when the pH values dropped below 5.5.

L.6.3 Indirect Chemical Effects

In addition to perturbations in the aquatic food chain and habitats, soil leachates from acid rain can have direct effects on fish populations. Aluminum toxicity from dissolution of aluminum silicates in the watershed has been reported by Schofield (1978) while dissolved iron and manganese from dissolution of their oxides have been linked with declines in fish health (Grizzle, 1978). Concentration of aluminum between 0.25 and 1.0 mg/l coupled with pH values below 5.0 resulted in serious gill damage to adult trout while their fry suspended feeding activities (Office of Water Research and Technology, 1977).

To summarize, in situ effects on aquatic ecosystems due to acid precipitation have been well documented in the United States and European countries, and the degree of impact appears to relate to the following three criteria:

1. The amount and duration of sulfate and nitrate loading within the watershed.

2. The neutralizing capacity of the soils within the watershed.

3. The buffering capacity of the receiving body of water.

With the exception of acid water influx from snow and ice water, review of the literature on acid rain suggests it generally takes between 10 and 20 years before the water quality and aquatic life in a "susceptible" lake are changed. From this literature review, it is obvious that deleterious changes can and do occur in isolated aquatic ecosystems as a response to increased acidity. However, it is important to note that not all surface waters have the potential to be affected by acid rain. Studies in Florida note that while subtle differences were found in benthic invertebrate and zooplankton communities in soft water lakes which had pH levels of 4.6-4.7, there was no evidence that major impacts had occurred to the fisheries component of the aquatic community. In comparison, small mouth bass (Micropterus dolomieui) were found to be unable to successfully reproduce in Canadian lakes which had higher pH values (5.5-6.0) than those found in the Florida lakes. These findings suggest that the aquatic communities in subtropical lakes may be more tolerant to acidification than northern temperate communities.

L.7 ACID RAIN CHEMISTRY IN FLORIDA

While the southeastern U.S. has received somewhat less attention from acid rain researchers than have other areas of the country, recent studies have characterized precipitation chemistry over the Florida peninsula. In an assessment of current rainfall pH levels Brezonik et al. (1980) have constructed rainfall isopleths (Figure L-8) based on state wide sampling over a one year period (1977-1978). As indicated by the isopleths, substantial fractions of the central and northern portions of the state typically receive precipitation of less than pH 4.7. Average pH levels appear to increase toward the southern end of the state. These researchers indicated that the observed isopleths may reflect in part the influence of dry deposition and apparent neutralization within rainfall collectors. In the absence of dry fall, even samples from the Florida Keys displayed acidities as great as those observed in the northern part of the state.

Detailed observations at Gainsville (Figure L-9) suggest that individual storm events may display considerable variability in rainfall pH, with levels ranging from pH 3.8 - pH 5.8 for "wet only" storms. In addition studies suggest that rainfall pH levels display seasonal variations. Rainfall acidities appear to be highest during the summer months. It is suggested that this trend may be attributable to thunderstorms contributing a larger percentage of the total rainfall during the summer. Such storms could affect rainfall pH levels through increased nitric acid formation from lightning, catalyzed oxidation of nitrogen oxides or greater washout from increased atmospheric turbulence. Alternatively, it is suggested, but not substantiated, that rainfall pH levels might be related to increased summer power production by utilities.

Based on a comparison to the work of Cogbill and Likens (1974) and Junge and Werby (1958), Brezonik et al. (1980) argue that rainfall over Florida has become increasingly acidic over the last 25 years. As has been previously indicated, such comparisons must be viewed with considerable caution. On the basis of mass balance computations it is estimated (Hendry

and Brezonik, 1980) that acidity in Florida precipitation results primarily from the presence of H_2SO_4. This chemical species is suggested to contribute approximately 69 percent of the average rainfall acidity, HNO_3 approximately 23 percent and HCl perhaps 8 percent. The authors indicate, however, that excess atmospheric sulfate and nitrate concentrations (corrected for sea salt contributions) show a poor correlation with wet precipitation pH measurements. It is suggested that this poor correlation may be due in part to neutralization from washout of terrestrially derived Ca and Mg ions.

Overall, it appears that rainfall over the Florida peninsula is rather acidic (pH less than 5) and studies suggest that pH levels have decreased over the last 30-40 years. There exists some evidence to suggest that lake water pH levels in areas of northern Florida have been affected (Florida DER, 1980). Currently atmospheric sulfate levels appear to be the predominant contributors to rainfall acidity. However, evidence suggests that any recent changes in acidity may be the result of increases in atmospheric nitrogen oxide levels (Liljestrand and Morgan, 1978; Marsh, 1978; Brezonik *et al.*, 1980). Since utility contributions constitute a significantly smaller percentage to total nitrogen oxide emissions than to SO_2 emissions, anthropogenic sources other than power plants may be increasingly affecting rainfall acidity.

L.8 RECENT AND ONGOING RESEARCH PROJECTS

L.8.1 Atmospheric

There are presently several ongoing projects in the U.S., Canada and Europe directed to investigating the behavior and the effects of energy related atmospheric pollutants. Among these studies are the Organization for Economic Cooperation and Development (OECD) on Long-Range Transport, the Multi-State Atmospheric Power Production Pollution Study (MAP3S), the Sulfate Regional Experiment (SURE), Midwest Interstate Sulfur Transformation and Transport (MISTT) project, and the Sulfur Transport and Transformation in the Environment (STATE) project.

Results from the OECD study on Long-Range Transport concerning transport and deposition of sulfur compounds, and the acidification of precipitation, are summarized by Ottar (1978). The study indicated that considerable quantities of sulfur dioxide produced by burning of fossil fuels are transferred from the major source areas to remote regions. Further, the study indicated that emission data together with atmospheric dispersion models and wind trajectories can be used to estimate the movement of pollutants over a large region containing major emission source areas. The transmission of the pollutants was calculated by estimating sulfur dioxide concentrations in air parcels which moved with the wind along air trajectories passing over grid elements of 127 x 127 km. Assuming that the main transport took place in the lowest 2 km of the atmosphere, the dry deposition of sulfate and the wet deposition of sulfate for each grid element were about 10 percent of the sulfur dioxide concentration). The most pronounced maxima appeared in areas exposed to a combination of polluted air masses and heavy precipitation; the maxima amounted to about 4 g/m^2 of sulfur in the southernmost regions of Scandanavia and northern Europe.

Included in the field program of Project MISTT was aircraft plume sampling of a coal-fired power plant near St. Louis. The plumes were sampled over a range of 300 km and measurements were made of SO_2, particulates and NO_2. Included in the findings were: (1) SO_2 to $SO_4^=$ conversion rates are low near power plant plumes, gas to particle conversion of sulfur occured mostly during daylight hours and are linearly related to total solar radiation; (2) tall stacks reduced the total dry deposition of SO_2; (3) the rate of sulfur conversion increased with the addition of ambient air to the plume to a maximum of about 3-4 percent per hour. In addition, from 30-45 percent of SO_2 can be expected to be converted to particulate sulfur, half within the first day. While the maximum transformation and removal of sulfur occurs during daylight hours, the transport is fastest at night. Wilson's report (1977) describes a typical 24-hour scenario of a power plant plume budget. ".... in short, after a hard day of convection, reaction and deposition the lower atmosphere relaxes at dusk while the plume takes off overnight via the midwestern jetstream and begins the next day's work 300-400 km from the stack..."

The Electric Power Research Institute (EPRI) funded the three year six million dollar SURE program to define the relationship between the emitted SO_2 products and the regional concentrations of sulfate. The SURE program comprised four main elements: (1) a ground monitoring network of 54 randomly distributed stations throughout the northeastern United States; (2) a program of aircraft air quality monitoring; (3) a detailed emissions inventory; and (4) a modelling program which will predict regional concentrations of primary and secondary pollutants in terms of meteorological parameters (temperature, humidity), multiple sources and pollutant transport and chemical reaction. Among the principal findings of the study were:

- The region of $SO_4^=$ conversion and maximum ground level exposure appears to extend over a distance confined to 300 km from major sulfur oxide sources. The zone of influence of an individual source

on the concentration values of the sulfur oxide particulate complex (SPC) appears to be 200 to 300 km weighted toward the downwind direction.

- No useful relationship has been established between the existing sulfate data and local (up to 100 km) sulfur oxide emissions (elevated or surface).

- Of the five aerometric variables measured (dew point, relative humidity, temperature, SO_2 concentration, and particulate concentration) temperature and dew point are the most strongly correlated with concentrations of $SO_4^=$.

- Twenty-four hour averaged samples provide inadequate resolution for evaluating the coversion of sulfur oxide emissions into $SO_4^=$ as a function of meteorological events. Shorter sampling periods (two hours) appear desirable.

- Existing data are not adequate to describe fully the chemical conversion from SO_2 to sulfates and the removal processes of sulfur oxides. There still is a great need for time-dependent three-dimensional measurements of many aerometric quantities to characterize the evolution and fate of the atmospheric sulfur oxides.

The MAP3S project is a major atmospheric research program sponsored by the U.S. Energy Research and Development Administration which is now encompassed in the Department of Energy. The study area is the high population energy intensive northeastern U.S. The major thrust of the program is to develop an improved and verifiable capability to simulate present and future changes in pollutant concentrations, atmospheric behavior, and precipitation chemistry, so that guidance can be provided to the agencies charged with assessing strategic energy alternative and protecting the natural environment. Numerous modelling activities are underway through the study at several Department of Energy laboratories.

Data for the various modelling activities being undertaken have been provided by the MAP3S monitoring network as well as various other monitoring networks such as SURE.

The Environmental Sciences Research Laboratory is undertaking the STATE program. This program was initiated in 1978 to quantify the impact of various regional air pollution sources on air quality. The first major field effort focused on tracer studies of the TVA Cumberland power plant in Tennessee to obtain measurements of plume dispersion and chemical transformation over a large range of meteorological conditions. The next major effort of the STATE program began this year in the area of the Ohio River Basin. The results of some of these experiments indicate sulfates of more recent origin are more acidic than older sulfates, and the amount of ammonia available in the atmosphere appears to determine the extent to which sulfuric acid and nitric acid can be chemically neutralized.

L.8.2 Ecological

The USEPA is conducting a program to identify those lakes in the eastern and western U.S. that are sensitive to acid deposition. Lakes suitable for long term study are being selected for determination of such factors that influence lake acidity as buffering capacity, precipitation quantity, and chemical composition of acid entering the water body. Physical and chemical models of aquatic systems are also being developed to aid in identifying the link between ecological effects and levels of acidity.

EPA programs dealing with terrestrial ecosystems include soils, forest productivity and crop productivity. The effects of acid deposition on the leaching of nutrients from various soils is being conducted by the Corvallis Environmental Research Laboratory. A soil water chemistry computer simulation model is being used to evaluate nutrient leaching from soils of varying chemical composition, organic content, alkalinity, and acidity. Other soil experiments currently underway are designed to measure

changes in litter decomposition rates as well as effects on microbial populations. Results from these studies coupled with the modelling studies and nutrient leaching will help in determining the long-term effects on soil fertility.

Model forest ecosystems containing simulated forest soil and litter layers, sugar maples, red alder seedlings, and other ecosystem components are being used to determine the effects of simulated acid rain at varying pH's. Adverse effects will be determined by monitoring such biological processes as tree growth, leaf production, nutrient uptake, and litter decomposition.

Future research is planned to document the effects of acid rain on ecosystems representative of the northeastern U.S., to study the historical and potentially adverse impacts on various types of soil, and to develop models to be used to forecast the ecological effects of acid deposition. Various management strategies to counteract the adverse effects of acid rain will also be evaluated in future research studies.

The Oak Ridge National Laboratory (ORNL) is also involved in acid rain research. Laboratory, greenhouse, and field studies are being conducted to relate concentrations of acid rain, SO_2 and O_3 to responses of individual plants and plant ecosystems. The effects of acid rain and individual atmospheric pollutants on yellow poplar, white and black oak, and black cherry are also being identified. The long-term effects of acid rain on forest ecosystems are being evaluated using a forest growth simulation model.

The effects of simulated acid rain on various terrestrial ecosystems are also being examined by the Brookhaven National Laboratory. Through their research, threshold limits for injury or biological change to crops and organisms within the soil are being determined. Their approach employs the exposure of plants to simulated acid mists under laboratory or field conditions. Mathematical models are being utilized in analyzing the data obtained from these studies.

The EPA has recently completed a preliminary study on crops. The prime objective of this study was the determination of injury threshold limits based upon exposure to simulated acid rain in a laboratory environment. Future research on crops will center on the determination of acid rain on growth, yield, and quality of economically important crops.

L.9 CONCLUSIONS

There is sufficient evidence contained within the literature to support the contention that the acidity of precipitation, particularly in the northeast, is increasing. However, there does seem to be many conflicts and contradictions regarding the comparision of existing conditions with historical data. This precludes the drawing of any conclusions regarding long term trends in precipitation acidity.

Sulfur dioxide can be oxidized to sulfate in gas phase, liquid phase and solid surface reactions. The most current evidence suggests that photochemical oxidation in the gas phase may be the most important oxidation mechanism of NO_x and SO_2. The rates of oxidation mechanism appear to be governed by the presence of a variety of atmospheric contaminants.

Sulfur dioxide, sulfates, and other pollutants are removed from the atmosphere by wet deposition (precipitation) and by dry deposition (direct transfer in the absence of precipitation). Evidence suggests that wet and dry deposition account equally (50 percent) for all sulfur removed from the atmosphere. Wet removal of sulfur compounds may involve incorporation into cloud droplets (rainout) or removal through falling precipitation (washout). Rainout appears to be of more importance than washout due to the fact that the prime contribution of sulfate to rainwater appears to result from rainout of condensation nuclei.

It would also appear from the analyses reported in the literature that a small percentage (3-10 percent) of measured SO_2 concentrations may be removed within 50 km of a plume origin. These results suggest that measurements of SO_2 concentration at a given location may not show good correlation with rainfall pH levels and that SO_2 emissions from a individual power plant may have relatively little effect on rainfall acidity in areas directly adjacent to such a plant.

The long range transport of sulfur dioxide and its related compounds from a given source is controlled by three main processes: dispersion, transformation, and removal. The most common approach for studying these processes is by measurements in the atmosphere or laboratory or by theoretical calculations using mass conservation or "budget" calculations to estimate space and time averages of such processes. A number of models have been developed, as well as a variety of other simpler approaches. However, all have shortcomings such as their failure to incorporate functions pertaining to vertical shear and transport, or vertical pollutant gradients. At the present time, realistic acid rain modelling remains a formidable goal rather than a reality.

There is common agreement that sulfates and nitrates are precursors of acid rain. However, there is some disagreement as to the sources of these precursors or to the percent contribution of a certain precursors from a particular source. The Florida Department of Environmental Regulation (1979) reports that nearly all the sulfur dioxide and nitrogen dioxide emission in the State of Florida for 1975 were attributed to fossil fuel burning with little or no emissions from natural sources. They estimate that about 67 percent of SO_2 emissions come from the electric utility industry, 25 percent from other industries, and 7 percent from mobile sources. Mobile sources accounted for approximately 60 percent of Florida's NO_x emissions for 1975, with the electric utility industry accounting for 25 percent and the remaining 15 percent from other industries. Varshney and Dochinger (1979) attribute the main sources of SO_2 to thermoelectric power plants; copper, lead, and zinc smelters; and urban and rural areas where fossil fuels are burned. The major contributors of NO_x are power plants, auto exhaust, smelting operations and space heaters. In contract, the National Coal Association reports that a number of natural sources of sulfur dioxide and nitrogen dioxide as well as the man-made sources contribute to acid rain. The natural sources include: ligthning, volcanoes, seaspray, and the organic decay of vegetation. Clearly, there are two viewpoints which will require further investigation to clarify the situation.

The actual effects of acid rain on vegetation and soils have not been documented. Most of the studies reported in the literature have been conducted under controlled environmental conditions using a simulated or artificial acid mist or rain. The results from such studies are important because they are indicative of potential natural effects. There are some basic generalizations which can be drawn from the data reported in the literature. In terms of effects on vegetation, responses have been elicited from short-term exposures to relatively high precipitation acidity levels. The implication, then, is that short-term exposures (low pH) have a greater effect than long-term exposures to near neutral pH. Unfortunately, the lack of long-term studies precludes the confirmation of this implication. It is true that the effects observed in the short-term studies have not been observed in the field. It may be that the effects are occurring in the field, but are not as pronounced as they are under laboratory conditions. Given the current state-of-the-art, it is difficult, if not impossible, to predict whether short-term exposures are more significant than long-term exposures.

There is some evidence which would support the suggestion that acid rain effects are more significant at one time of the year than another. Investigators have reported that the age of tree seedlings, as well as the stage of leaf development, are two factors which determine the susceptibility to acid rain. For these few species, then, the early part of the growing season would appear to be more significant, in terms of susceptibility, than other seasons. Intuitively, injury to a crop during the period when the yield could be affected, such as the pod filling stage of soybeans, is more significant than other periods when the affected leaves could be replaced by new growth. This occurrence has not been observed under field conditions, and as such its significance is not known at this time. At best, there is some evidence which suggests that plants are more susceptible to acidic precipitation in some seasons than others.

The variations in sensitivity of soil regions found within the eastern United States is indicative of the spatial nature of acid rain effects. In a recent study, McFee (1980) ranked the sensitivity of soil regions in the

eastern U.S. to acid precipitation on the basis of cation exchange capacity (buffering capability) and presence or absence of carbonate in the top 25 cm of the soil. The areas of potentially sensitive soils were found to be concentrated in the southeastern United States on highly weathered soils, on the shallow and steep soils of the Appalachian Highland regions, in the Adirondack Mountains, and on the coarse, non-basic tills of New England (McFee, 1980). The sensitivities of various types of vegetation have not been determined to date, and as a result, the significance of an acid rain effect on one area versus another cannot be defined.

The acidification of lakes in Scandinavia over the past 20-25 years and more recently in the northeastern U.S. and eastern Canada has been attributed to acid rain. However, the lack of definitive long-term data has made these conclusions somewhat uncertain. A number of effects due to acidified lake ecosystems have been observed. The effects on fish, namely their disappearance from lakes and streams, has been observed to follow two generalized patterns. One pattern results from long-term pH decrease and the other to short-term changes in pH (Hendry and Wright, 1976). Acid shock, a sudden short-term change in pH, can cause severe physiological stress that may cause fish kills, at pH levels above those considered toxic to fish (Schofield, 1976; Wright et al., 1976; Hendry and Wright, 1976). These sudden decreases have been observed in early spring when acidic components which accumulated in snow during the winter are released. It would appear from the data that, in aquatic systems, both short-term and long-term accumulations can have a significant effect.

The sensitivity of certain lakes to acidity as opposed to other lakes is determined by a number of factors including: the acidity of both wet and dry deposition, hydrology of the lake, the soil system, the surface water and the bedrock. The capability of a lake and its drainage basin to neutralize acidic contributions as well as the mineral composition of the surface water is largely governed by the composition of the lake bedrock (Wetzel, 1975; Wright and Gjessing, 1976; Wright and Henriksen,1978). Bedrock varies from location to location and as a result, the buffering

capability of lakes varies accordingly. The lakes with low buffering capability are found in regions where the bedrock is igneous or metamorphic in origin (Galloway and Cowling, 1978). These rock types are highly resistant to weathering with the result that surface waters contain low ion concentrations from weathering. Characteristically, these waters have a low buffering capability. Buffering capability is high in those lakes occurring on calcareous or sedimentary bedrock. This data suggests that the effects of acid rain is likely to vary in significance from one area to another.

From this review, it is obvious that very few questions relating to acid rain have been adequately answered in the literature. Extensive research is needed to identify the effects and determine the magnitude of acidification on terrestrial and aquatic systems. Both short-term and long-term studies are needed with the orientation shifted from the laboratory to the field. The budgeted expenditures of more than $50 million by governmental, institutional, and industrial groups over the next few years will hopefully initiate the necessary investigation.

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Table L-1

ANNUAL MEAN CONCENTRATIONS (WEIGHTED FOR VOLUME) OF DISSOLVED SUBSTANCES IN BULK PRECIPITATION IN HUBBARD BROOK EXPERIMENTAL FOREST (1964-1977)

Substance	Concentration (mg/l)	Substance	Concentration (mg/l)
H^+	.070	$SO_4^=$	2.74
NH_4^+	.19	NO_3^-	1.46
Ca^{++}	.14	Cl^-	0.42
Na^+	.11	$PO_4^=$	0.008
Mg^{++}	.04	HCO_3^-	0.006
K^+	.06	Dissolved Silica	0.02
Al^{+++}	-	Dissolved Organic Carbon	2.4
pH	4.15		

Source: Likens et al., 1980

Table L-2

REPRESENTATIVE SO_2 OXIDATION RATE MEASUREMENTS
FOR COAL FIRED POWER PLANTS

	INVESTIGATOR	OBSERVED RATE (% hr^{-1})	SPATIAL SCALE (km)	COMMENTS
1.	Hegg et al. Four Corners, N.M.	0.3	1-6	Relative humidity 40-80%
2.	Pueschel & Van Valin Four Corners, N.M.	2.8	8-80	Relative humidity 20%
3.	Cantrell & Whitby Labadie, Mo.	0.4-5	8-50	--
4.	Forrest & Newman 4 Different Plants	1	2-70	Rapid near source of conversion (1-2% within 2 km)
5.	Meagher et al. (Cumberland)	0.2	5-100	Rapid near source of conversion (0.9% within 5 km)
6.	Smith and Jeffery (general emission, U.K.)	1-10	100-200	Greatest conversion near source

Source: Larsen, 1980

Table L-3

MECHANISMS OF SULFUR DIOXIDE CONVERSION TO AEROSOL SULFATES

Mechanism	Reaction	Important Variables
1. Direct photo-oxidation	$SO_2 \xrightarrow[\text{water}]{\text{light oxygen}} H_2SO_4$	Sulfur dioxide concentration, sunlight intensity.
2. Indirect photo-oxidation	$SO_2 \xrightarrow[\text{organic oxidants}]{\text{smog, water, } NO_x} H_2SO_4$	Sulfur dioxide concentration, organic oxidant concentration.
3. Air oxidation in liquid droplets	$SO_2 \xrightarrow{\text{liquid water}} H_2SO_3$ $NH_3 + H_2SO_3 \rightleftharpoons NH_4^+ + SO_4^=$	Ammonia concentration.
4. Catalyzed oxidation in liquid droplets	$SO_2 \xrightarrow[\text{heavy metal ions}]{\text{oxygen, liquid water}} SO_4^=$	Concentration of heavy metal ions.
5. Catalyzed oxidation on dry surfaces	$SO_2 \xrightarrow[\text{carbon particle}]{\text{oxygen, water}} H_2SO_4$	Carbon-particle concentration.

Source: Wilson, 1977

Table L-4

MAJOR GAS PHASE REACTIONS THOUGHT TO BE INVOLVED IN SO_2 OXIDATION

	Reaction		Estimated Oxidation Rates (% hr^{-1})		
			Polluted Atmosphere	Clean Atmosphere	Stack Gas
1.	$SO_2 + OH\ (+M)$	$HOSO_2\ (+M)$	2.7	0.4	1.2
2.	$SO_2 + HO_2\ (+M)$	$HO_2SO_2\ (+M)$	1.9	0.2	-
3. a	$CH_3O_2 + SO_2$	CH_3O	2	0.01	-
b	$CH_3O_2 + SO_2$	$CH_3O_2SO_2$	-[a]	-[a]	-[a]
4.	$CH_3CHOO + SO_2$	$CH_3CHO + SO_3$	0.2	-	-
5.	$O + SO_2 + M$	$SO_3 + M$	-	-	1.4

(M = catalyst)

Source: Calvert, 1978

[a] Data not available

Table L-5

MECHANISMS OF SULFUR INCORPORATION IN RAINWATER[a]

Mechanism	Suggested Pollutant Lifetime in Rain (hr.)		Sulfate Concentration in Rainwater (mg/l)	
	80% Submicron Particles[b]	20% Larger Particles[c]	80% Submicron Particles[b]	20% Larger Particles[c]
Diffusophoresis	-	-	10^{-2}	10^{-3}
Brownian diffusion to cloud droplets	100	400	0.2	3×10^{-3}
Brownian diffusion to raindrops	10^4	2×10^5	10^{-3}	2×10^{-5}
Impaction and interception by raindrops	400	1	0.02	1.2
Rainout of condensation nuclei			3-10	
SO_2				
Solution and oxidation in cloud droplets		3		
Uptake by falling raindrops	10	1		

[a] Calculations assume
(1) 10 mg/m^3 of sulfate composed of:
80% submicron particles of typical diameter 0.2 um and
20% larger particles of typically 4 um diameter
(2) 10 mg/m^3 of SO_2
(3) rain falling at 1 mm h^{-1} from a cloud containing 100 drops cm^3 at 10 mm radius

[b] Typical diameter 0.2 um

[c] Typical diameter 4 um

Source: Garland, 1978

Table L-6

PARAMETERS USED IN A SELECTION OF CURRENT NUMERICAL MODELS

Model	Fractional $SO_4^=$ Emission	Mixing Height (m)	Hourly SO_2 to $SO_4^=$ Transformation Rate (hr^{-1})	Dry Deposition Velocity (cm sec^{-1}) SO_2	Dry Deposition Velocity (cm sec^{-1}) $SO_4^=$	$SO_4^=$ Nonspecific Loss Rate (hr^{-1})	Washout Coefficient (mm^{-1}) SO_2	Washout Coefficient (mm^{-1}) $SO_4^=$	Precipitation Averaging Period
LRTP	0.05	1000	0.0126	0.65	-	0.014	0.070[a]	-	6-12 hr
	0.05	1000	0.0072	0.8	0.2	-	0.070[a]	-	6-12 hr
EURMAP	-	1000	0.01	0.8	0.2	-	0.216	0.070	3 hr
ANL	-	2000	0.036	10	0.1	0.0036	-	-	-
BNL	0.02	100	0.005	3.0	0.3	-	0.0[b]	0.0[b]	-
Prahm and Christensen	0.05	1000	0.01	1.0	-	0.02	-	-	-
PNL	-	1000	0.05	1.0	0.1	-	0.500	0.050	1 hr
PNL	-	Variable	0.02	1.0	0.1	-	0.005	0.250	1 hr

[a] It is assumed that dry deposition continues during periods of wet scavenging and wet scavenging occurs only when it is raining. This conversion assumes a rainfall rate of 2 mm/hr; the LRTAP model actually adds a removal rate of 3×10^{-6} sec^{-1} for SO_2 independent of rainfall rate.

[b] Early versions have assumed that use of higher dry deposition values than are observed will account for wet scavenging.

Source: McCraken, 1979

Table L-7

REPRESENTATIVE pH DEPENDENT SOIL REACTIONS

1) Calcareous minerals

$$CaCO_3 + H^+ = Ca^{++} + HCO_3$$

2) Oxides

$$FeOOH + H^+ = Fe(OH)_2^+ + \text{etc.}^a$$

$$Al(OH)_3 + H^+ = Al(OH)_2^+ + H_2O$$

$$Mn(OH)_2 + H^+ = MnOH^+ + H_2O$$

3) Aluminosilicates

$$(Na, K, Ca, Mg)\ Al\ \text{silicate} + nH^+$$

$$= \text{clay} + Na^+, K^+, Ca^{++}, Mg^{++} + H_4SiO_4$$

4) Adsorption

$$Me - \text{substrate} + H^+ = Me^{++} + H^+ - \text{substrate}$$

5) Photosynthesis

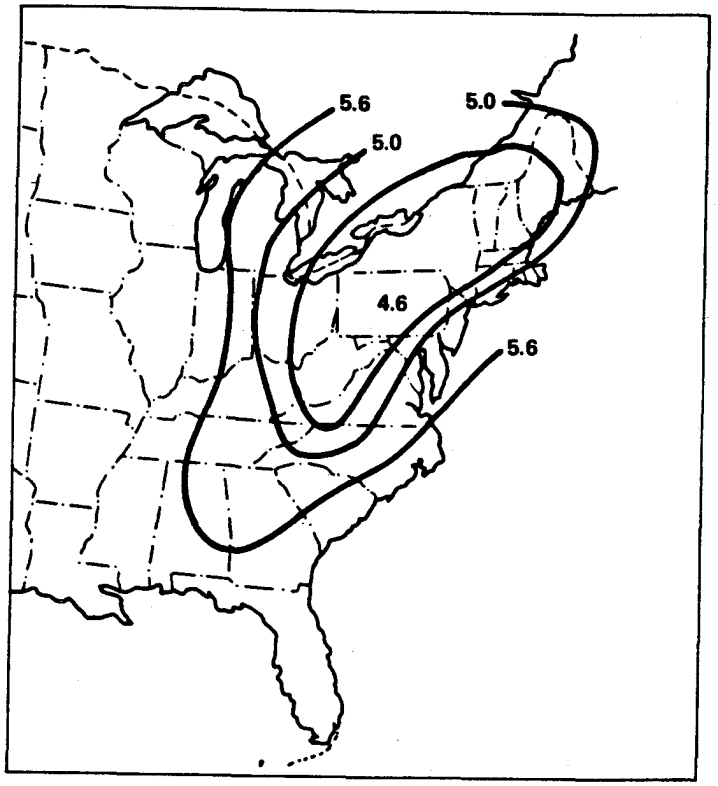
$$106CO_2 + 16NO_3 + HPO_4^{=} + 122H_2O + 18H^+$$

$$= C_{106}H_{263}O_{110}N_{16}P$$

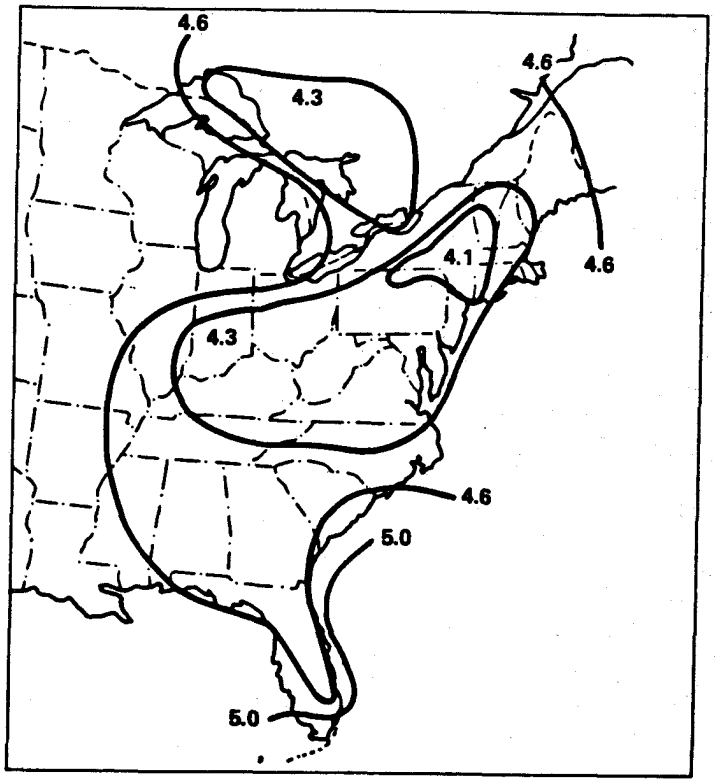
---

[a] Denotes the existence of a variety of iron oxide reactant species

Source: Kramer, 1978



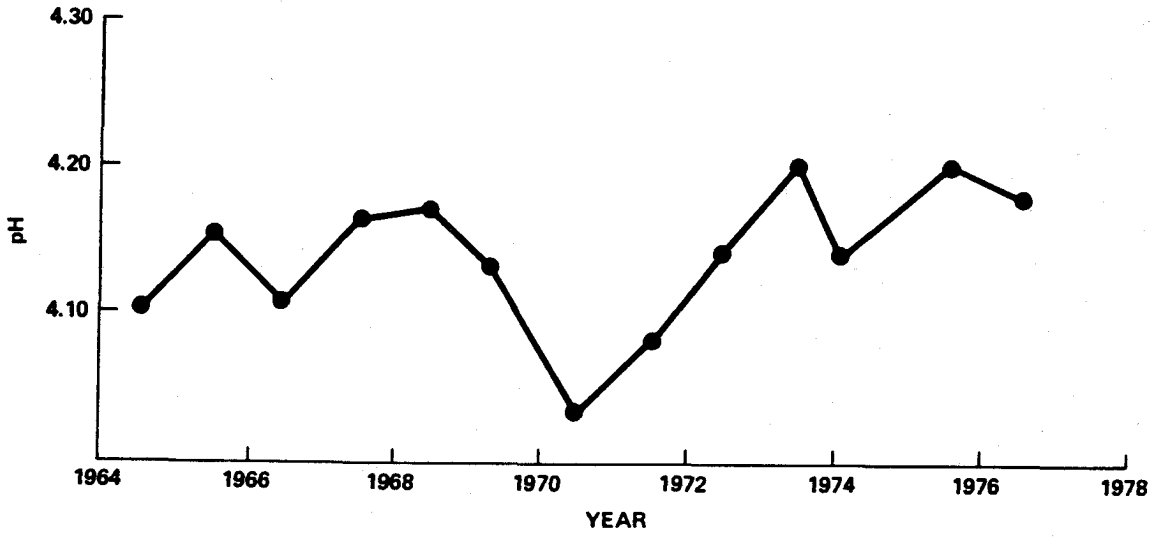
1955-56



1975-76

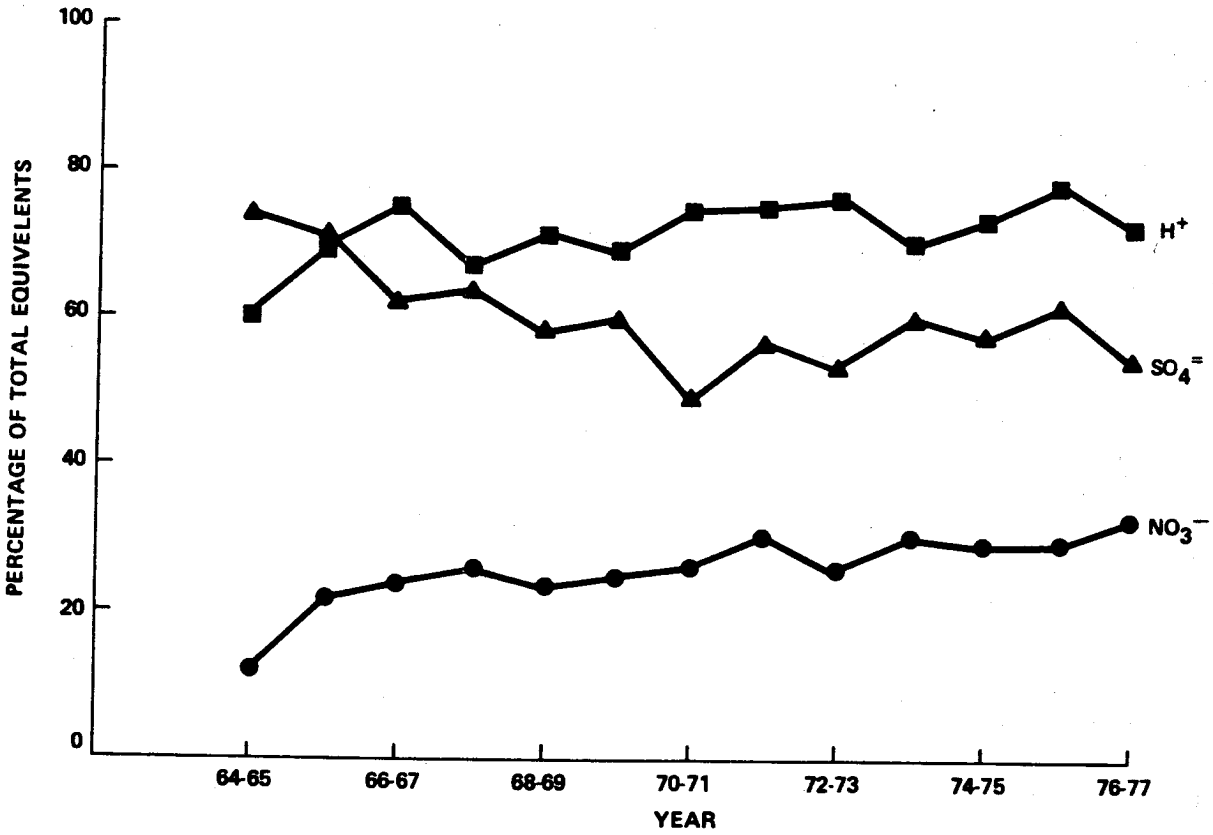
(LIKENS ET. AL., 1977)

Figure L-1 Isopleths Showing Annual Average pH for Precipitation in Eastern North America



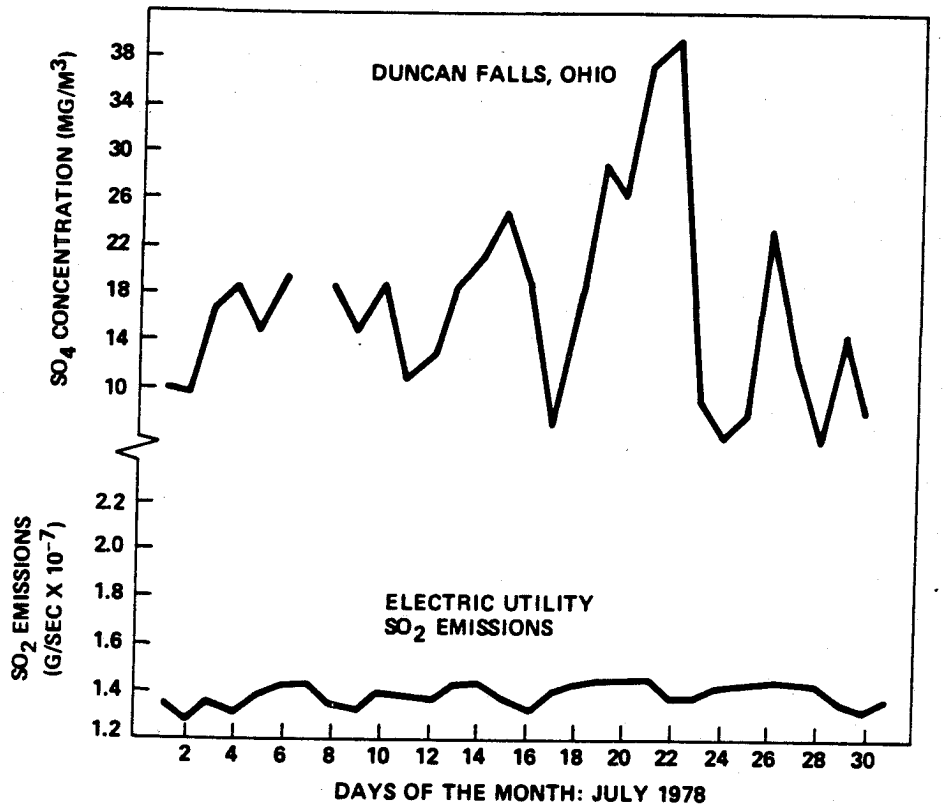
(LIKENS ET. AL., 1980)

Figure L-2 **Annual pH of Precipitation (weighted for volume) at the Hubbard Brook Experimental Forest**



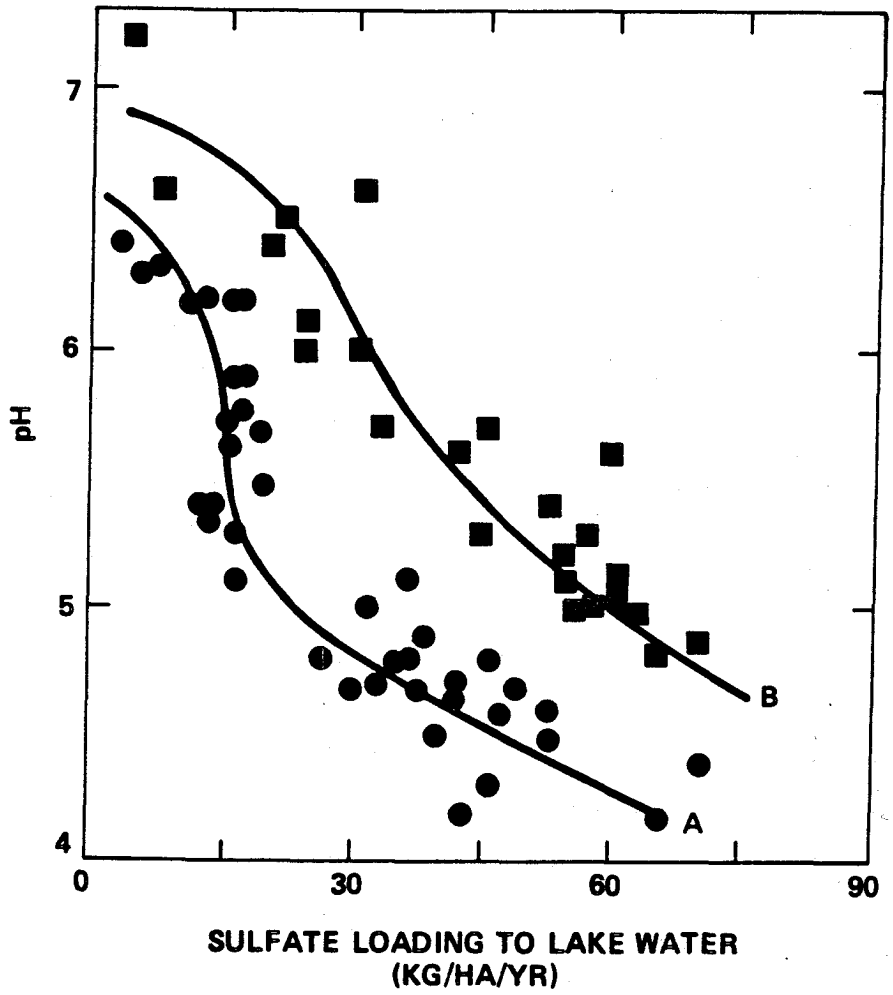
(LIKENS ET. AL., 1980)

Figure L-3 Percentage of Ionic Composition for the Hubbard Brook Forest (1964-1977)



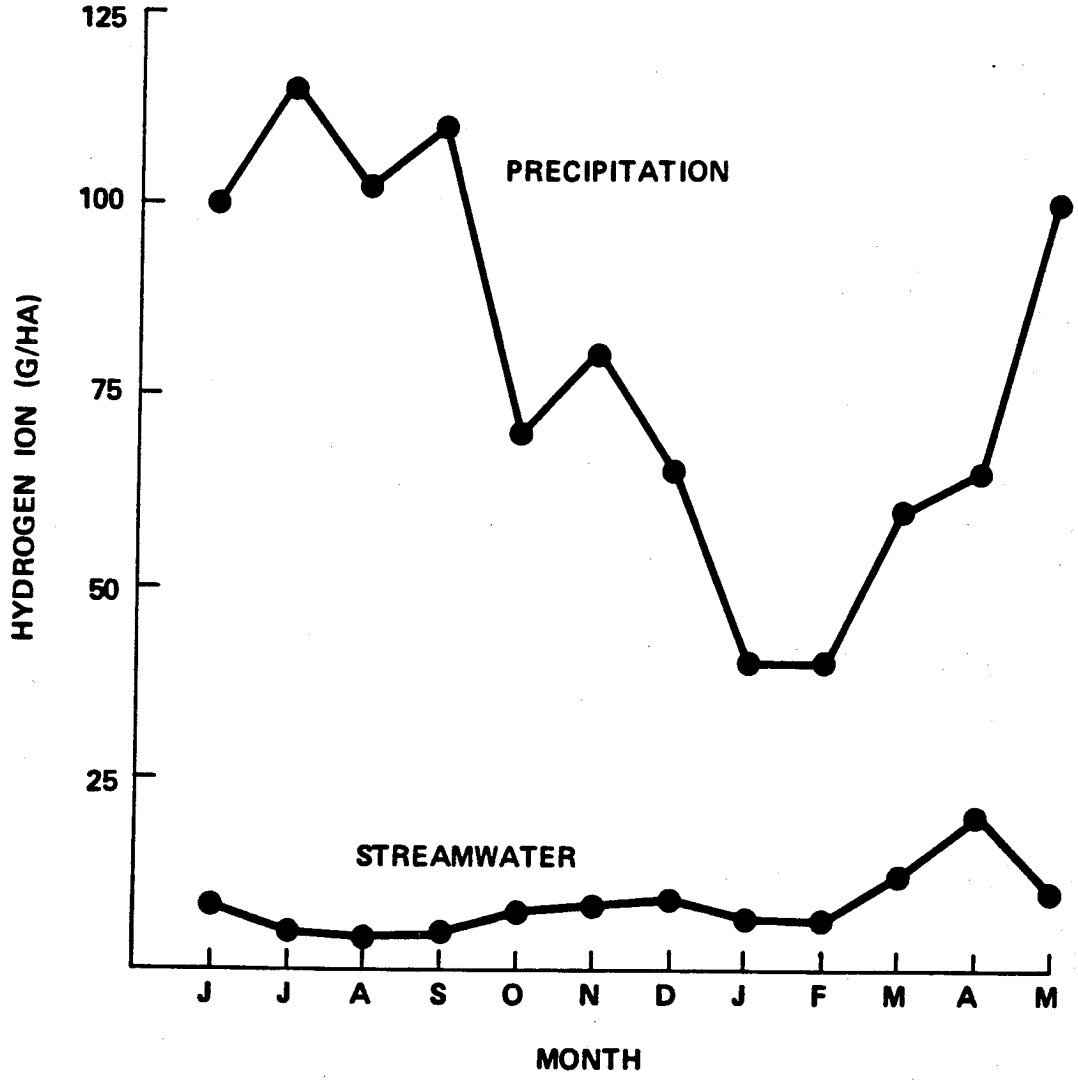
(PERHAC, 1980)

Figure L-4 SO_2 Emissions and Ambient SO_4 Concentrations



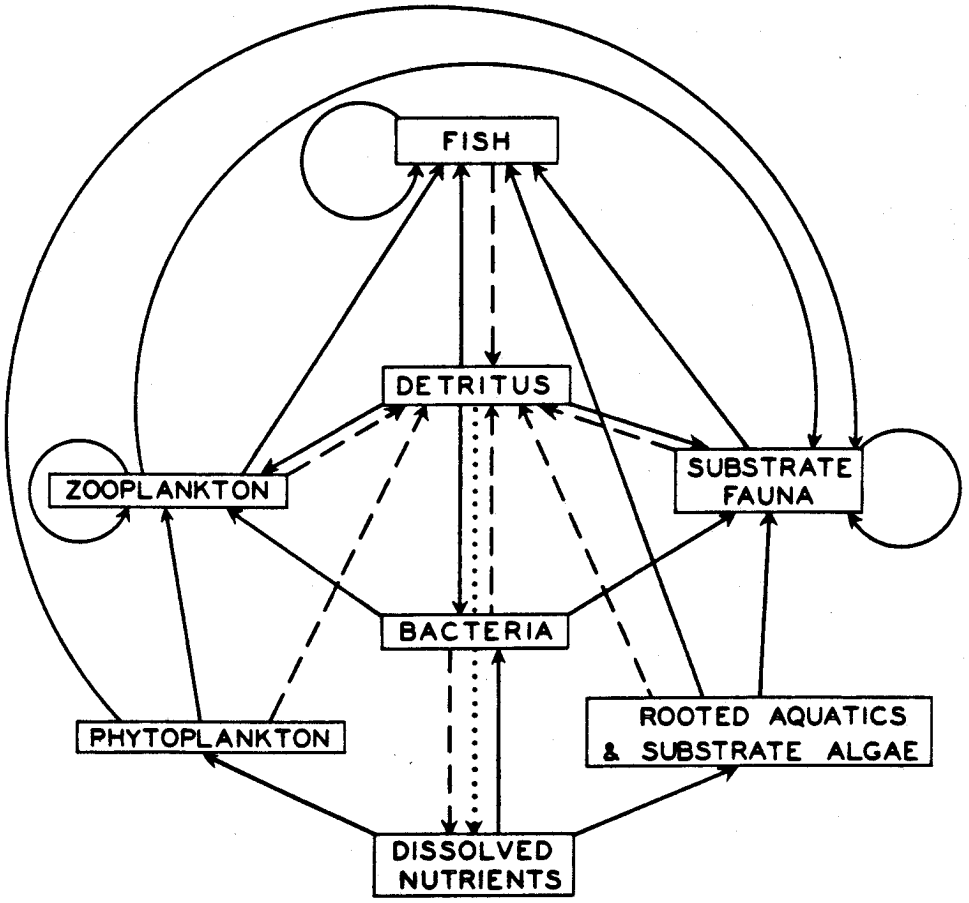
(EPA, 1979)

Figure L-5 Relationship of Swedish Lake Water Sulfate Loadings and pH for (A) Very Sensitive and (B) Less Sensitive Water-Sheds



(LIKENS ET. AL., 1980)

Figure L-6 Monthly Flux of Hydrogen Ions in Hubbard Brook Ecosystem During 1977



Pennak (1978)

Figure L-7 Basic Features of Aquatic Food Webs

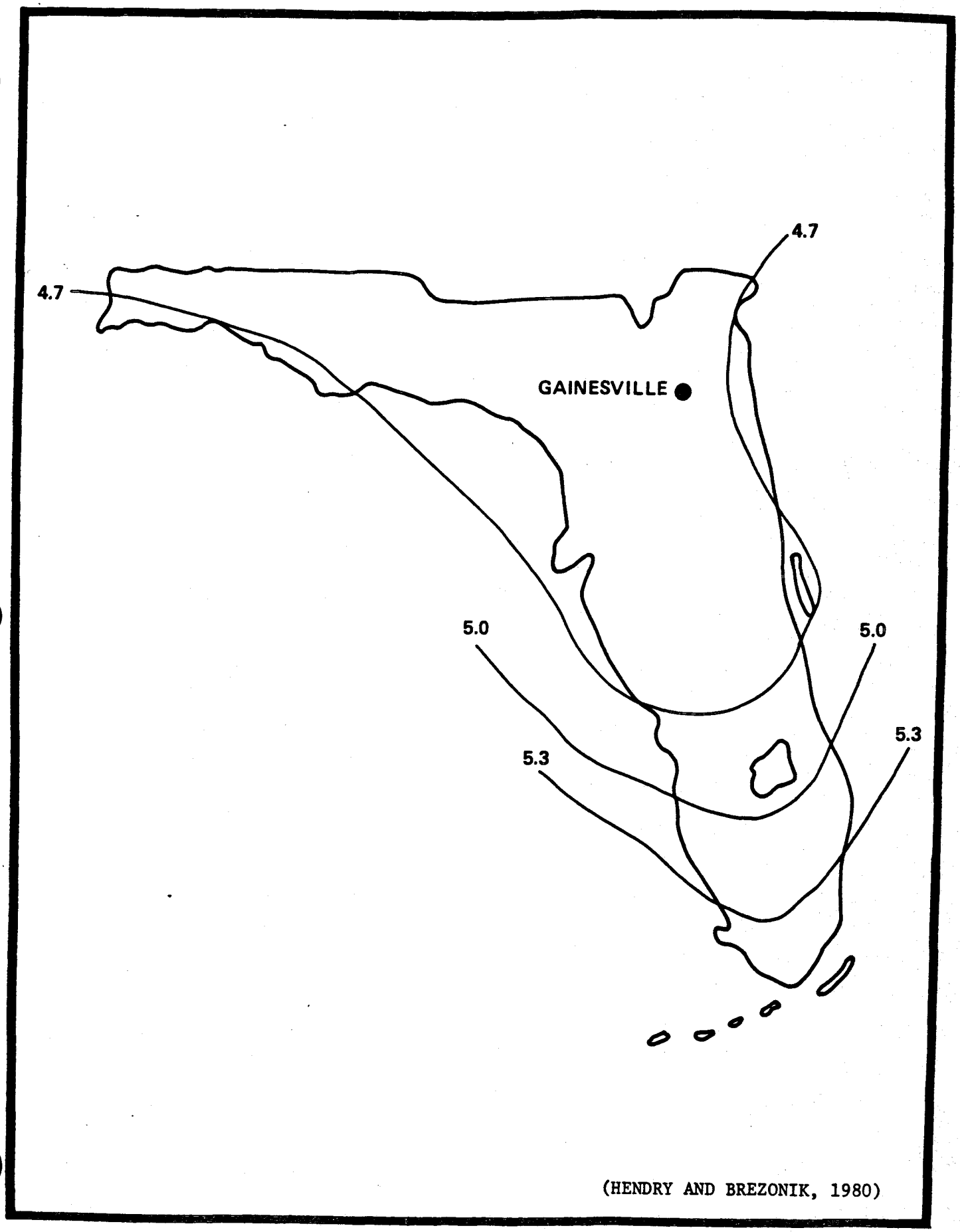
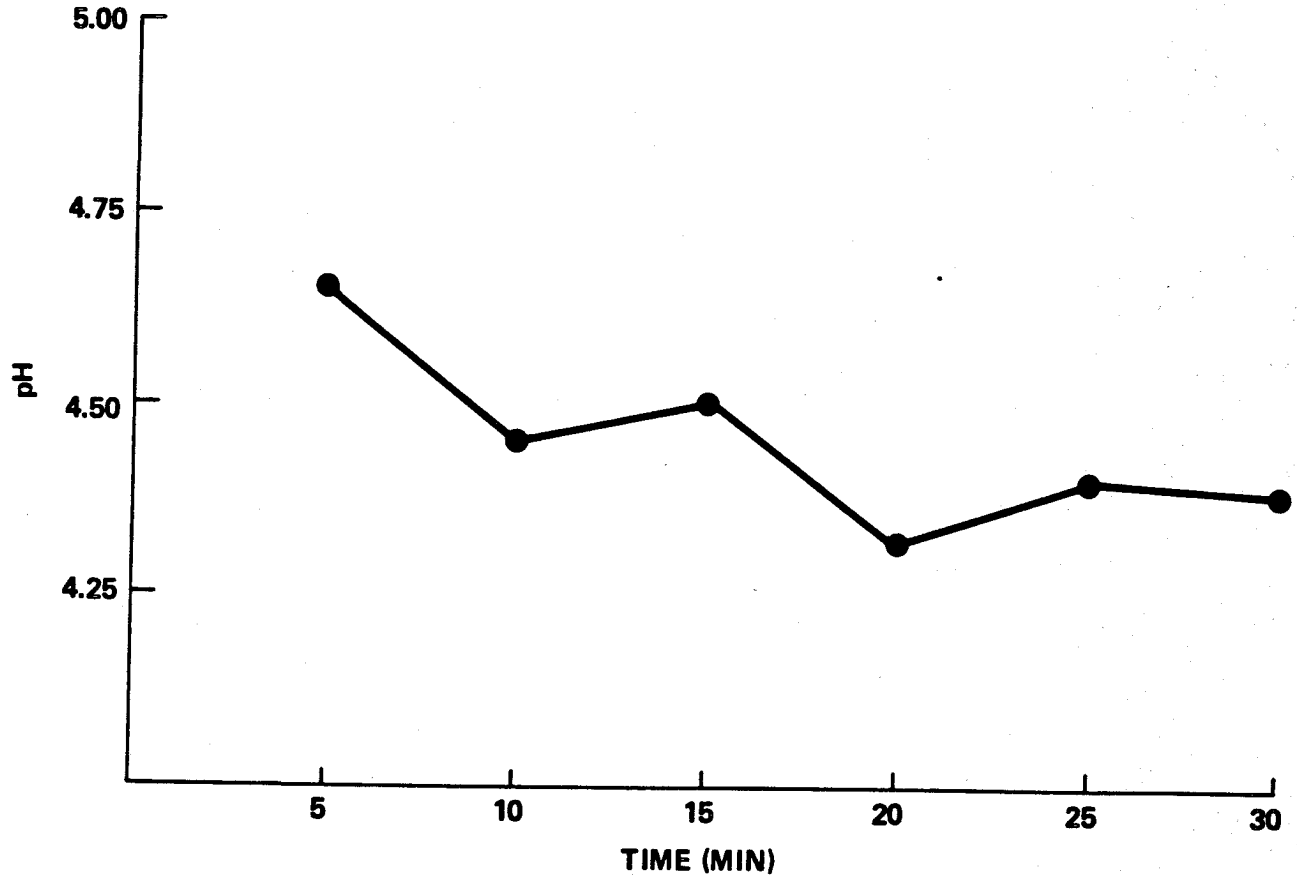
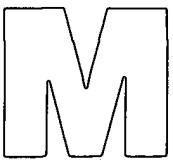


Figure L-8 Isopleths for the pH of Florida Rainfall over the Period May 1978-April 1979



(HENDRY AND BREZONIK, 1980)

Figure L-9 Variation in Rainfall pH for a Single Storm Event at Gainesville, Florida, October 1976



NEED FOR POWER

APPENDIX M

NEED FOR POWER

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NEED FOR POWER

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APPENDIX M

NEED FOR POWER

M.1 JACKSONVILLE ELECTRIC AUTHORITY LOAD AND ENERGY FORECAST

Jacksonville Electric Authority (JEA) contracted with Gilbert Associates, Inc. in 1980 to develop a forecast of energy and peak demand requirements for JEA for the period 1980 through 2000.

This forecast was developed by members of the professional staff of Gilbert Associates, Inc. and Wharton Econometric Forecasting Associates, Inc. with assistance from the JEA System Planning Staff.

The 20 year forecast of energy and demand requirements for the JEA system was produced from a system of economic, demographic, and electric energy and peak load models which were developed specifically for the JEA service territory by means of econometric analysis of regional data. The essential features of the methodology employed and a summary of key forecast results are presented below.

Forecast Methodology

Analysis was performed at the highest level of disaggregation possible consistent with the available data. Specifically, the net energy for load forecast for the JEA system was developed by forecasting energy use in each of the following JEA sales and energy classifications:

Rate 10	-	Residential Service
Rate 20	-	Small General Service
Rate 30	-	Large General Service
Rate 40	-	Industrial
Rate 45	-	Other Public Utilities
Rates 50-90	-	Street Lighting
		Losses and Adjustments

Total system peak load requirements were forecast for the 1st and 3rd quarters of each year throughout the forecast period (1980-2000).

In order to produce the energy and demand forecasts, a system of long run forecasting models were constructed specific to the JEA service territory. The integrated forecasting system consisted of the following five component models:

1. Wharton Quarterly and Annual Macroeconomic Models of the U.S. economy

2. Regional Economic Model of the Jacksonville Standard Metropolitan Statistical Area (SMSA) of Baker, Clay, Duval, Nassau, and St. John Counties

3. Regional Demographic Model consisting of two submodels

   - Duval County

   - Jacksonville SMSA Less Duval County

4. Service Area Econometric Energy Model by class of service

5. Peak Load Model

Figure M-1 illustrates the relationships between the various component models. As can be seen, data produced by the Wharton Quarterly and Annual Macroeconomic Models of the U.S. economy is used in both the Regional Economic Model and the Regional Demographic Model. Data used in the Regional Economic and Demographic Models is also used in both the Service Area Econometric Energy Model and the Peak Load Model.

The methodology used to construct each component model (except for the demographic model) was that of econometric analysis. That is, regional economic, demographic, and electricity data were assembled and analyzed econometrically in order to estimate functional forms and parameters which fit the regional data. As an example, the price and income elasticities in the residential electricity consumption equations were estimated directly from regional data on these variables. The resulting functions identified and quantified the important economic and demographic variables affecting JEA electricity sales and demand.

Computerized data bases were constructed containing the economic, demographic, and electricity data required to estimate the various models contained within the forecasting system. While some data series were available starting in 1957, data for all variables was available starting in 1970. In order to provide sufficient data points for statistically significant econometric analysis, and also to provide seasonal analysis and forecasts of electricity sales, the models were estimated on a quarterly basis using quarterly data. The quarterly data base contains data on employment, manhours worked, wage rates, wage bills, personal income, labor force and unemployment for the Jacksonville SMSA as well as personal income data for Duval County. Population data by selected age groups for Duval County and the sum of the other counties contained within the Jacksonville SMSA are also included. The resulting data base provided a comprehensive picture of the Jacksonville economy as measured by employment, population and income flows, as well as electricity consumption, customers, and peak demand for the JEA service area.

The electricity data was supplied by JEA and the other necessary regional data were obtained from standard sources such as the U.S. Bureau of Economic Analysis, the Bureau of the Census, and the Bureau of Labor Statistics. National data was obtained from the Wharton Econometric Forecasting Associates (WEFA) macroeconomic data bases.

In a number of cases the published data for the regional area was available only on an annual basis; consequently, the quarterly data had to be developed using interpolation procedures to transform annual data into quarterly equivalents. The data sources and methods employed are described in the following sections.

The quarterly economic data base was constructed to support the econometric analysis of the Jacksonville economy. This data base contained comprehensive data on employment, wage rates, wage bills (total compensation) and personal income by component for the Jacksonville SMSA, as well as personal income for Duval County. This data base also reconciled the Bureau of Labor Statistics 790 series employment data, which covers non-agricultural wage and salary employment, with the Bureau of Economic Analysis concept of total employment and personal income by residence. This reconciliation was necessary to insure that the income and employment data were completely consistent. In general, the data was disaggregated by one digit Standard Industrial Code (SIC) in order to provide for the analysis of the various factors affecting different sectors of the economy.

The population data by age group was estimated by means of the population model. In constructing this data base, military population was first removed from the total population, in order to obtain the civilian population. The resulting civilian population was computed by age, race and sex using the 1970 census data to establish the base for the population model. Using regional data on births and deaths, the surviving population was computed for the first post-censal year. The intercensal estimate of total population in that year (as updated in current population reports series P-25), less an estimate of the military population, was then used to compute total migration. Total migration was determined as the difference between the surviving population and the intercensal estimate. The distribution of migration by cohort (a group of individuals having a statistical factor in common), as reported in the 1970 census for the period 1965-70, was then applied to the estimated total migration to

compute migration by cohort. Net migration by cohort was then added to each cohort of the surviving population so that the total population equaled the intercensal estimate. This procedure was repeated for each intercensal year. The computations were done on an annual basis. The quarterly population data for a selected set of cohorts were then created by using a polynomial interpolation function. The military population was then added to the civilian population to produce total population. It was assumed that the military population living in barracks retained the age distribution given in the 1970 census.

A system of forecasting and simulation models was constructed to provide JEA with long run forecasts of system energy and demand requirements as well as the capability to simulate various alternative scenarios under different exogenous assumptions.

Presented below is a detailed discussion of the major characteristics of the models developed for JEA.

Regional Economic Model

The Jacksonville Regional Economic Model was designed to provide forecasts of the regional economic variables needed to forecast quarterly electric energy and demand requirements for the JEA over a twenty year forecast horizon. The economic model therefore was constructed using quarterly data and incorporates both short and long term economic relationships. In order to provide adequate analysis of the factors affecting the different sectors of the regional economy, the Economic Model was disaggregated by one digit SIC code. The sectors considered include:

- Manufacturing
- Contract Construction
- Finance, Insurance and Real Estate
- Services and Mining

- Regulated Industries
- Government
- Agriculture
- Wholesale Trade
- Retail Trade

Due to the fact that output data (value added) for Jacksonville exists only in annual form for manufacturing and tends to have a large standard error, output was not modelled directly. Instead, manhours in manufacturing and employment in non-manufacturing were modelled directly as proxies for output. Reliable monthly estimates were available for both these measures from 1967 to the present.

The Jacksonville Economic Model is a modified export base type model. Industries which are significant exporters to areas outside of the Jacksonville SMSA are modelled as a function of national and regional activity and of regional wage rates relative to national wage rates. Industries which are primarily regional are modelled as a function of regional activity variables including: (1) employment in other regional industries, (2) real personal disposable income, and (3) population. Regional wage rates by industry are thus a function of national wage rates in the same industry, the regional price level relative to the national price level, and the tightness of the regional labor market relative to the national labor market as measured by ratios of employment to labor force. Total wages paid to area residents are determined by adding up the wage bills (wage rates times employment) for establishments located in the SMSA, and correcting for the net wages earned by commuters. The other components of personal income such as transfer payments, dividends, interest and rent, and supplements to wages are determined by combinations of regional and national variables.

Personal income and disposable (after tax) income by area of residence were then computed by adding the above components and subtracting federal income tax payments. Since regional disposable income also was used to determine non-manufacturing employment, the causal chain is thus completed between regional economic activity and the resultant income flows.

In the ideal case, economic activity is measured by output - either value added or gross output. However, as is the case with most regional areas the size of Jacksonville, adequate time series do not exist for these variables. Similar data also does not exist for non-manufacturing. For manufacturing, the Survey of Manufacturers does provide some data pertaining to value added and value of shipments (a proxy for gross output). However, most of this data was unusable for the task at hand because it exists only for a limited number of years and is subject to large measurement errors when applied at the SMSA level.

For the above reasons, manhours worked and employment were used as proxies for output in manufacturing and non-manufacturing respectively. Manhours worked were computed as the product of average weekly hours and employment. Both of these variables were available for manufacturing on a monthly basis from 1967 to the present and were measured with an acceptable degree of accuracy. Manhours in manufacturing was chosen over manufacturing employment because manhours tend to correspond more closely with output than does employment in the short run, and therefore captures quarterly and cyclical changes better than employment alone. The correspondence of manhours and output results from the fact that the manufacturing industries with hourly workers, employers tend to raise or lower the work levels in the short run before increasing or decreasing the number of employees.

In non-manufacturing, there are no regional data on average weekly hours, so for these industries, employment data, which exists on a monthly basis since 1967, can be estimated directly. In cases where an overall homogeneous measure of output is needed in terms of manhours the national data on the average work weeks in non-manufacturing were used to create a regional non-manufacturing manhours measure.

Regional Demographic Models

In order to identify and provide a detailed forecast of the population within the JEA service area (which essentially consists of Duval County), separate population models were constructed for Duval County and for the balance of the other counties contained within the Jacksonville SMSA. This approach was chosen as an alternative to the University of Florida population projections by County (Bulletin No.53). JEA feels this methodology has several distinct advantages:

- While University of Florida estimates for the State as a whole are based upon rigorous methodology and appear accurate, estimates by County are based on a simple ratio - share procedure.

- Since JEA's service area encompasses only a few counties, population estimates are very sensitive to small errors resulting from sharing of State projections to the County level.

- JEA methodology maximizes use of available data disaggregated to the County and SMSA level.

The population models employed are of the single year of age cohort (a group of individuals having a statistical factor in common) survival type and have the capability to generate population estimates by single year of age, race and sex. The models were started as of 1970 using the 1970 U.S. Census data for the counties currently comprising the Jacksonville SMSA. U.S. survivorship rates by single years of age were adjusted to reflect total regional mortality. National fertility rates by cohort were also adjusted to reflect total regional fertility. The regional mortality and fertility statistics were obtained from the intercensal population estimates reported in Current Population Reports Series P-25.

The models were used to estimate the surviving population, and the Series P-25 estimates were used as control population totals so that the difference between the surviving population and the intercensal estimates for each post 1970 Census year represented the estimated total net migration. The total migration estimate was then distributed across cohorts according to the distribution of cohort migration given in the 1965-1970 migration data. This procedure resulted in population estimates by age, race and sex over the historical period 1970-1979, which total to the series P-25 estimates of total population.

In the forecast period, the area adjusted survivorship (mortality) rates were forecast on the basis of the U.S. Census Series II fertility rates. Net migration rates were specified exogenously (a variable whose value is determined outside the system of equations is defined as an exogenous variable) to produce total population forecasts consistent with the employment forecasts of the Jacksonville Economic Model. The population models did not include the military population which was forecasted as an exogenous ratio, to total military employment. Total households for Duval County were forecasted by specifying exogenously the average household size and then applying this forecast of household size to the total county population.

Growth in residential customers depends upon the growth in households which in turn depends upon population growth. Since no estimates were available for the number of households in Duval County, the growth in customers on an annual basis was used to estimate the number of households, using the 1970 Census count of households as a starting point. The annual estimates of households were then interpolated to a quarterly basis for purposes of analysis. The rationale for using this procedure rests upon the fact that with the exception of single pointmetered multiple dwelling units, nearly every household is an electric customer and therefore a close correspondence should exist between growth in households and growth in residential customers. Residential customers were then estimated as a function of total households in Duval County.

Customer equations were estimated for large and small general service customers (Rate 30 and Rate 20). These customer variables do not feed back into the electricity consumption model, and were provided solely for the purpose of computing total customers for the JEA system. The Rate 30 and 20 customer equations estimate customers as a function of employment in the industries that were used to drive the energy sales equations for these rates. The only difference in structure is that in the Rate 20 equation the number of proprietors is made a separate variable because of the heavier concentration of proprietors on this rate. Large general customers were modelled as a function of total employment less military and proprietors. Small general customers were modelled as a function of total employment less military and proprietors, and non-agricultural proprietors. The equations were estimated in linear form. The elasticities indicate that large general customers grow faster than economic activity and small general customers grow slower, reflecting the general trend towards larger enterprises that has been occurring in the sample period.

Service Area Econometric Energy Model

The Service Area Econometric Energy Model forecasts electricity sales by class of service and is driven by the combined output of the Regional Economic and Demographic models. Driving variables for the energy model include manhours, employment, alternate energy prices including the JEA forecasted price of electricity, population, households, per capita income, and wage rates relative to the cost of capital. The energy model incorporates the effects of alternate fuel prices and labor-capital substitution on electricity demand. Historical weather conditions are explicitly included as well.

Peak Load Model

The JEA Peak Load Model consists of econometric equations for the first and third quarter system peak loads. This model is driven by regional electricity sales obtained from the Service Area Econometric

Energy Model, residential air conditioning saturation, and residential electric heat saturation. The combined effects of these saturation levels and weather variables are explicitly identified in the peak load equations.

Total system summer (third quarter) peak load was modelled as a function of (1) a residential cooling load variable which combined the influences of residential air conditioning load and weather, (2) residential base or non-weather sensitive energy, and (3) total third quarter energy requirements for all other classes, including Losses and Adjustments. It was assumed that second quarter residential sales would serve as a reasonable proxy for the residential base or non-weather sensitive energy. In the final form of the summer peak load model the residential second quarter energy sales and the total of all other third quarter non-residential energy requirements were combined into a single variable. The equation for third quarter peak load was estimated in linear form.

The form of this peak equation was based upon the observation that, during the historical period, the third quarter peak load tended to occur in late afternoon or very early evening, normally around 5 or 6 p.m. As a consequence, it was hypothesized that all classes contribute to the summer peak with the residential class and especially residential air conditioning load being of special importance. The results of the econometric analysis supported the above hypothesis and further verification was obtained from an independent end-use analysis in which it was estimated that in recent years, the residential class accounted for slightly over 50 percent of the total system summer peak load.

Total system winter (first quarter) peak load was modelled in a manner similar to the third quarter peak load model. First quarter peak load was specified as a function of (1) a residential heating load variable which combined the influences of residential electric heating load and weather, (2) residential base or non-weather sensitive energy, and (3) total first quarter energy requirements for all other classes, including Losses and Adjustments. It was again assumed that second quarter residential sales

would serve as a reasonable proxy for the residential base or non-weather sensitive energy. Likewise, in the final form of the winter peak equation, the residential second quarter energy sales and the total of all other third quarter non-residential energy requirements were combined into a single variable. The equation for the first quarter peak load was estimated in linear form.

The form of the first quarter peak equation was based upon the observation that during the historical period the first quarter peaking period occurred during the morning hours and over time has gradually been shifting toward the earlier morning hours of between 7 a.m. and 9 a.m. This phenomena is attributed to increased residential electric space heating. As a consequence, it was hypothesized that all classes would be contributors to the winter peak with the residential class, and especially residential electric heating load, being of special importance. The results of the econometric analysis supported this hypothesis.

Economic/Demographic Forecast

Table M-1 presents forecast results for key economic and demographic variables which underlie the forecasts of system energy and demand requirements. For comparative purposes, forecast results are presented for the Low, Most Probable, and High Growth Cases.

Most Probable Forecast - During the period 1979 through 2000, the total Jacksonville SMSA population in the Most Probable forecast is expected to grow at an annual rate of 0.9 percent, which is slightly above the expected national growth rate of 0.8 percent. This regional population growth rate was obtained by making exogenous assumptions which insured that population growth would be consistent with the economic forecast for the area. The major assumptions regarding population were:

- The current net migration rate of -1.1 percent per year experienced in Duval County would gradually be reduced to a -0.3 percent rate by 1995 and remain constant thereafter.

- The current net migration rate of 3.5 percent per year for the non-Duval County population within the Jacksonville SMSA would gradually slow to a 0.5 percent annual rate by 1995 and remain constant thereafter.

Using these population assumptions, the economic model produced a slightly rising labor force participation rate and a stable unemployment rate of about 5.5 percent. Per capita real personal disposable income rises from a level of about 2 percent below the current national level to equal the national level by the year 2000.

Total Jacksonville SMSA employment under the Most Probable forecast is expected to grow at an annual rate of about 1.0 percent through 2000. This growth rate is roughly comparable to the expected national growth rate of 1.1 percent over the same period. As in the case of the national forecast, manufacturing employment shows almost negligible growth while non-manufacturing employment, which includes the higher growth sector such as services, retail trade, and finance, insurance and real estate, grows at a rate of in excess of 1 percent.

When negative net migration is combined with positive growth in the net of births and deaths, the result is that the total population of Duval County is forecast to grow at a compound annual rate of 0.3 percent over the forecast period thus reaching a level of 587,840 people by the year 2000. This growth rate is slightly lower than the 0.5 percent rate experienced over the historical period 1970-1979. However, it should be noted that during this same period, the positive growth rates of the early 1970's turned to negative growth rates during the period 1975 through 1977. The Duval County population forecast thus represents a return to sustained positive growth.

High Growth Forecast - The higher growth alternative forecast is based on the higher growth national alternate forecast and also upon regional migration assumptions which produce higher regional population growth. The higher growth national forecast is based on assumptions concerning economic policies and domestic productivity growth which enable the economy to sustain a higher rate of expansion. In particular, it is assumed that Congress will enact a personal tax cut, by increasing the personal exemption from $1,000 to $1,250 and will increase the investment tax credit from 10 to 15 percent. It is also assumed that an exogenous increase will occur in labor productivity, raising its growth rate to 2.0 percent per year as against the 1.6 percent growth rate of the most probable forecast.

As a consequence of this higher national growth rate, total Jacksonville SMSA employment would be expected to grow at a compound annual rate of 1.4 percent. The regional population migration assumptions were modified to produce a population growth consistent with this forecast. This was done by assuming that:

- Net migration rate for Duval County would become zero by 1995
- Net migration rates for the other counties within the Jacksonville SMSA would reach 1.0 percent by 1995

These assumptions produced declining unemployment rates and a higher labor force participation rate. Under the high growth forecast assumptions, the population growth rate for Duval County during the period 1970-2000 is expected to be 0.5 percent.

Low Growth Forecast - The low growth alternative forecast was produced by using the lower growth alternate national forecast and lower regional population assumptions. The lower growth national forecast is based on the assumption that higher inflation rates will prevail and that monetary policy will remain tight as a consequence. Productivity growth will be

High Growth Forecast - The higher growth alternative forecast is based on the higher growth national alternate forecast and also upon regional migration assumptions which produce higher regional population growth. The higher growth national forecast is based on assumptions concerning economic policies and domestic productivity growth which enable the economy to sustain a higher rate of expansion. In particular, it is assumed that Congress will enact a personal tax cut, by increasing the personal exemption from $1,000 to $1,250 and will increase the investment tax credit from 10 to 15 percent. It is also assumed that an exogenous increase will occur in labor productivity, raising its growth rate to 2.0 percent per year as against the 1.6 percent growth rate of the Base Case forecast.

As a consequence of this higher national growth rate, total Jacksonville SMSA employment would be expected to grow at a compound annual rate of 1.4 percent. The regional population migration assumptions were modified to produce a population growth consistent with this forecast. This was done by assuming that:

- Net migration rate for Duval County would become zero by 1995

- Net migration rates for the other counties within the Jacksonville SMSA would reach 1.0 percent by 1995

These assumptions produced declining unemployment rates and a higher labor force participation rate. Under the high growth forecast assumptions, the population growth rate for Duval County during the period 1970-2000 is expected to be 0.5 percent.

Low Growth Forecast - The low growth alternative forecast was produced by using the lower growth alternate national forecast and lower regional population assumptions. The lower growth national forecast is based on the assumption that higher inflation rates will prevail and that monetary policy will remain tight as a consequence. Productivity growth will be

also lower than in the most probable forecast. This alternate forecast produces an annual growth rate of 0.8 percent in total Jacksonville SMSA employment during the period 1979-2000. Corresponding assumptions were, therefore, made in the regional population forecasts. These lower growth population assumptions were:

- Net migration rate for Duval County would reach -0.7 percent by 1995

- Net migration rate for the rest of the Jacksonville SMSA would reach 0.5 percent 1995

These assumptions resulted in an overall Jacksonville SMSA population rate of 0.7 percent and a population growth rate for Duval County of only 0.1 percent. As a result of these population growth rates, the labor force participation rate declines slightly and the unemployment rate rises during the forecast period.

Forecast Results

Energy and Demand Requirements

Three separate forecasts of JEA system energy and demand requirements were developed using the integrated forecasting system described above. These three forecasts are identified as the Most Probable, Low Growth Case, and High Growth Case. The Low and High Growth forecasts were developed to illustrate the possible range of energy and demand requirements which would result from alternate regional and national economic forecasts and alternate local demographic forecasts.

Most Probable Forecast - Tables M-2, M-3, and M-4 present the results of the Most Probable energy and peak load forecast. This forecast yielded a long term (1979-2000) compound annual growth rate of 2.8 percent in net energy for load and a compound annual growth rate of 3.4 percent in annual system peak load. Beginning in 1985, the JEA system is expected to switch

from a summer (third quarter) peaking system to a winter (first quarter) peaking system. This conversion to a winter peaking system results from the expectation that residential electric heat saturation will grow rapidly from its present level of approximately 30 percent to a saturation level of 95 percent by the year 2000. At the same time, air conditioning saturation, which already is at about 86 percent, cannot be expected to contribute to similar strong growth rates in summer (third quarter) system peak load despite the forecast of increases in the saturation level of central air conditioning systems.

The expected growth in electric space heating is induced by large increases in the price of alternate heating fuels (oil and natural gas) relative to the average price of electricity. A major assumption upon which the above conclusions rest is that JEA will be able to essentially remove the current large positive differential in JEA's average electricity rate versus the national average price. Inherent in this assumption is the expectation that JEA will realize a rapid switchover from the current 100 percent reliance upon oil-fired generation to 90 percent non-oil-fired generation by the year 2000. The result of such a generation fuel switchover would be a 6.6 percent compound annual growth in electricity price, which is substantially below the 8.0 percent growth rate expected for the national average electric price.

As previously stated, the overall JEA electricity sales forecast was produced by forecasting sales separately for each class. Rates 10, 20, 30 and 40 are forecast endogenously (a variable whose value is determined by the econometric equations within the model is defined as an endogenous variable; a variable whose value is determined outside the system of equations is defined as an exogenous variable) by means of econometric equations. Rates 45, 50-90, and Interchange were forecast exogenously by making assumptions concerning their growth rates. Table M-4 presents the most probable annual energy sales by customer class.

Sales to large industrial customers (Rate 40) are expected to grow at a compound annual rate of 3.5 percent over the forecast period. This growth in electric energy consumption is expected to occur despite the fact that local activity in consuming industries, as measured by manhours in manufacturing and military employment, remains constant during the forecast period after recovery from the current recession. Part of this growth is due to fuel substitution. While electricity prices are forecast to grow at an annual compound rate of 6.6 percent from 1980 to 2000, the price of industrial oil is expected to grow at 8.4 percent and the price of industrial gas at 12.7 percent as deregulation is implemented. The econometric analysis indicated that electricity consumption per manhour is sensitive to the price of electricity relative to these alternative fuels. The relative price elasticity was estimated to be -0.3 which implies that for each one percent differential in electricity price growth relative to the average growth rate of alternate fuels, a 0.3 percent increase in electricity consumption per manhour will occur. This effect, therefore, accounts for about 1.0 percent of the expected growth rate in Rate 40.

More importantly, productivity growth may be expected to increase the capital to labor ratio over the forecast horizon. Increased use of capital embodying electric energy inputs can, therefore, be expected. The motivation for this capital labor substitution lies in the expected growth of wage rates at an 8.0 to 9.0 percent rate, while the user cost (marginal price) of capital is expected to grow at about 5.0 percent. The econometric analysis indicated that the elasticity of electricity consumption per manhour with respect to the ratio of the wage rate to user cost of capital is about 0.77 percent. Applying this elasticity to the differential in wage rate versus capital price growth yields a growth in electricity consumption per manhour of about 2.5 percent. This factor substitution effect accounts for the balance of growth in industrial electricity consumption.

Sales on the large general rate (Rate 30) are also expected to grow at about 3.6 percent over the forecast horizon. In this forecast, activity, as measured by total manhours worked (less military and self-employed), is expected to grow at about 1.0 percent per year. The econometric analysis indicated that here the relative fuel price elasticity is much smaller at -0.12, as would be expected where fuels are not so intensely used. The capital labor substitution elasticity of 0.72 is much the same as in the industrial rates, but the lower growth of wage rates in non-manufacturing reduces the substitution effect. These differences account for the lower growth rate in electricity per manhour shown between the large commercial and industrial rates.

Small general sales (Rate 20) shows a growth rate of only 1.8 percent during the forecast period. The basic reason for this forecast result is that consumption of electricity by this rate class has exhibited an elasticity of only about 0.7 with respect to the level of manhours minus military. Electricity sales, therefore, are expected to increase substantially slower than general economic activity. The elasticity of sales with respect to the ratio of wage rate to capital price was estimated to be small at 0.2, and therefore, labor substitution has little effect on electricity sales, as might be expected. However, electric heat saturation is a significant factor in first quarter sales and causes somewhat faster growth in that quarter relative to the other quarters. The electric heat saturation forecast used for Rate 20 is the same as that used in the residential forecast.

Residential sales (Rate 10) are forecast to grow at a compound annual rate of 2.8 percent. This growth rate in total Rate 10 electricity sales may be separated into a customer growth at a 1.1 percent rate and a growth rate of 1.7 percent in average consumption per customer. The customer growth rate is the same as the projected growth in households. Households are expected to grow faster than total population as the trend towards decreasing family size continues. The rate of decline in household size is, however, expected to decrease throughout the forecast period. Average

consumption per customer is strongly affected in the first and fourth quarters by the rapid increase of electric heating saturation. Electric heat saturation is expected to grow quickly as the price of alternate fuels rises faster than the price of electricity. As the electricity price begins to show lower growth rates than the consumer price index early in the forecast period, and as real per capita disposable income recovers from the low and negative growth rates in 1979, 1980, and 1981, average consumption will recover from negative growth rates in 1979-1980 to an annual rate of about 2.0 percent.

High and Low Growth Cases - Table M-5 presents comparative annual forecast results for the Low, Most Probable and High Growth Cases. The higher and lower forecast cases are based upon higher and lower alternative national economic forecasts which in turn led to higher and lower regional economic and demographic forecasts. During the period 1979 through 2000, the lower forecast assumptions yield a compound annual growth rate of 2.3 percent in net energy for load and 3.0 percent in annual system peak load. During the same forecast period, the higher growth assumptions yield a compound annual growth rate of 3.2 percent in net energy for load and 3.7 percent in annual system peak load. As with the Most Probable forecast, the Low and High Growth Cases also forecast that the JEA system will convert to a winter peaking system by about 1985. Additionally, annual system load factor in the Most Probable forecast is expected to be about 51 percent in the year 2000 while for the Low and High Growth Cases annual system load factor in the year 2000 are forecast to be 49 percent and 52 percent, respectively. Figures M-2 and M-3 present in graphic form, the Low, Most Probable and High Growth forecasts of net energy for load and annual system peak load, respectively.

Conservation Scenario

An effort was made to estimate the potential impact upon the Most Probable forecast of the introduction of residential appliances of improved efficiency ratings and also of the potential impact of various load management strategies. The Conservation Scenario is intended to provide a

quantitative estimate of the potential impact upon the Most Probable Forecast of the introduction of residential appliances which conform to the Department of Energy (DOE) efficiency improvement targets and also the potential impact of load control of water heaters, electric space heating and, to a limited extent, central air conditioners. The conservation adjustments were aimed exclusively at the residential class and were determined only for specific points in time - 1985, 1990, 1995 and 2000. The energy sale forecasts and the coincident peak demand contributions for all other customer classes were not adjusted for the above considerations and remain the same as in the unadjusted Most Probable Forecast.

In order to estimate the potential conservation adjustments, it was necessary to consider total residential electric energy consumption in terms of the major end-use appliances owned and operated by JEA's residential customers. Specific end-use appliances considered were:

Electric Heating
  Heat Pumps
  Non Heat Pumps
Air Conditioning
  Heat Pumps
  Non Heat Pumps (central)
  Room Air Units
Electric Range
Water Heaters
Refrigerators
  Frost free
  Non frost free
Television
  Color
  Black and White
Freezers
Dishwashers
Washing Machines
Miscellaneous and Lighting

For each of the above major end-use appliances it was first necessary to forecast the respective saturation levels, which, when applied to average annual residential customers, would allow one to compute total number of units on line in 1985, 1990, 1995 and 2000. Table M-6 presents historical and forecast saturation levels by appliance type. The saturation level of electric space heating was explicity modelled as a function of the relative prices of electricity and alternative fuels (oil and natural gas). The future saturation levels of all other appliances were forecast based upon historical trends as observed from the JEA annual Residential Customer Surveys and the 1970 Census data.

In addition to appliance saturation levels, it was necessary to consider the following appliance operating characteristics:

- Annual per unit kWh consumption levels unadjusted for appliance efficiency improvements.

- Average per unit diversified demand (kW/unit) at the time of the system summer and winter peak load - unadjusted for appliance efficiency improvements.

- Average operating life by appliance type.

- DOE appliance efficiency improvement targets.

Annual per unit kWh consumption levels for each of the major appliances considered were estimated using actual JEA residential sales data and published industry estimates. Annual kWh per customer associated with the use of electric heating and air conditioning were estimated for the historical period 1970 through 1979 by disaggregating total monthly residential kWh sales per customer into its base (non-weather sensitive), heating, and cooling components. Annual kWh consumption for all other appliances were estimated for the historical period 1970 to 1979 by applying published industry per unit usage estimates by appliance type to the historical number of appliances on line to arrive at total kWh usage by

appliance type. The sum of the annual energy consumed by all appliances (excluding electric heat and air conditioning) was then compared to the total actual base kWh and, where necessary, the per unit usage levels were uniformly adjusted upward or downward to ensure that the total energy estimated for base kWh conformed to the actual observed base kWh. The initial values for per unit kWh consumption levels by appliance type were obtained from estimates published by the Edison Electric Institute (EEI) and the Electric Power Research Institute (EPRI). The resultant average kWh per unit consumption levels, to which appliance efficiency improvement targets were applied, are presented in the Table M-7.

Values for average per unit diversified demand (kW/unit) at the time of the system summer and winter peak load were obtained from published industry estimates and are presented in Table M-7. More specifically, these estimates were obtained from load research data published by the Association of Edison Illuminating Companies (AEIC), and estimates presented in the Volume I, Long Range Plan, 1980 Report of Member Electric Systems of the New York Power Pool, dated April 1, 1980. It should be noted that no diversified demand data was available specific to the JEA system. JEA is currently in the process of evaluating data from its own residential load research program; however, the results of this study were not available for purposes of this forecast.

The DOE appliance efficiency improvement targets which were used in this scenario were in accordance with the targets published in the Federal Register, Vol. 43, No. 70, April 11, 1978 and Vol. 43, No. 198, October 12, 1978. These targets are presented in the Table M-7. Estimates of energy and peak load reductions due to appliance efficiency improvements were then computed by assuming that all appliances coming on line subsequent to 1977 would operate in accordance with the DOE efficiency improvement targets. Table M-8 presents, for each appliance type, the percentage of the total stock which will be operating at the DOE targeted appliance efficiency standards.

The summer and winter kW load reductions by appliance type were then summed over all appliances to arrive at the total residential summer and winter peak load reductions resulting from improved appliance efficiencies.

Load Control Reductions

The total impact of residential load control on winter system peak was computed by assuming that some form of control would be applied to water heaters and electric space heating. For each of the years 1985, 1990, 1995 and 2000, the total winter peak load reduction due to load control was estimated as the sum of the water heater and electric space heating load reduction.

The impact of residential load control on summer system peak was determined only for 1985 due to the fact that subsequent to that time it is expected that the winter peak will dominate and reductions to summer peak will not be required. For 1985, the total summer peak reduction was estimated by computing the load reductions resulting from control of water heaters and central air units.

Table M-9 presents the estimated reductions in annual residential energy sales (GWh) and residential coincident demand (MW) contributions to the system winter and summer peak loads. Regarding these results, the following observations are noteworthy.

- Appliance efficiency improvements were estimated to cause a reduction in both annual residential energy sales (kWh) and also the residential class coincident demand contributions to the winter and summer system peak loads. By 1985, appliance efficiency improvements was estimated to cause an 11.5 percent reduction in Most Probable residential energy sales. By the year 2000, when essentially the total appliance stock will have been upgraded to meet the DOE efficiency targets, the reduction in residential sales was estimated to amount to 14.3 percent.

- Appliance efficiency improvements were estimated to reduce system winter peak load by 108 MW in 1985 and 220 MW by the year 2000. Similarly, appliance efficiency improvements were estimated to reduce the 1985 summer peak load by 99 MW. By the year 2000, the summer peak load reduction was estimated to total 152 MW.

- The residential load control program was assumed to impact only the summer and winter peak load, with annual energy consumption being unaffected. In the year 1985, it was estimated that control of water heaters and electric space heating would result in a reduction of 123 MW from the system's winter peak load. It was further estimated that control of electric water heaters and central air conditioning systems could reduce the 1985 summer peak load by 78 MW. By the year 2000, control of electric water heaters and electric space heating would result in a winter peak load reduction of 202 MW. No control of end-use appliances affecting the summer peak was calculated for the years 1990, 1995 and 2000 due to the fact that JEA will have become a firm winter peaking system by 1985.

- Table M-10 presents the adjusted Most Probable Forecast. This adjusted forecast was developed by applying the energy sales and peak load reductions presented in Table M-9 to the unadjusted Most Probable Forecast. Comparison of the unadjusted Most Probable Forecast with the adjusted Most Probable Forecast reveals a reduction in the annual growth rate in Net Energy for Load requirements from 2.8 percent to 2.5 percent. Annual system peak load is likewise reduced from an annual growth rate of 3.4 percent in the unadjusted Most Probable to 2.5 percent in the adjusted Most Probable. As a final point, it should be noted that for each of the years 1985, 1990, 1995 and 2000, the adjusted Most Probable Forecast results in improved annual system load factors compared to the unadjusted Most Probable. As an example, the annual system load factor in the year 2000 is computed to be 57.6 percent in the adjusted Most Probable Forecast versus 50.5 percent in the unadjusted Most Probable Forecast.

M.2 FLORIDA POWER & LIGHT COMPANY LOAD AND ENERGY FORECAST

Florida Power & Light (FPL) forecasts customers, sales (energy), peak demand and load factor using both econometric and engineering models where appropriate. An econometric model is based upon the relationships between the variables to be forecasted and the economic and social environment, i.e., customers, sales and peak demand are estimated as a function of such local and national economic measures as real per capita personal income, population of the FPL service territory, Florida employment, and Gross National Product (GNP). An engineering model bases its forecast on the number of appliances and their consumption, projected improvements in appliance efficiency, and improvements in the thermal efficiency of buildings. FPL utilizes a combination of these two types of models and Monte Carlo simulation not only to project the forecast variables but also to determine the uncertainty surrounding the forecast of net energy and peak loads. Figure M-4 illustrates FPL's forecast model.

Forecast Methodology

The forecast is broken into three areas - customers, sales (energy), and peak load and each model is discussed separately.

Customer Forecasts

Customers are forecast using econometric models for the following six classes: residential, commercial, industrial, street and highway, resale and other. The basis for the customer forecasts are projections of FPL's service territory population.

Residential customers are forecast from population forecasts of the 21 major counties in the FPL service territory (see Figure M-5 for a list of the 21 counties) and estimated residential household size. The population of the FPL service area is derived from the University of Florida's and the National Planning Association's forecasts of population by county. The estimate of household size is derived from National Planning Association's

forecasts for Florida and SMSA's in FPL's service territory as well as FPL's own estimate. The residential customers forecast is derived by dividing the population forecast by the household size forecast.

Commercial customers are forecast by using FPL's residential customers from the previous year to account for the delay in the opening of such commercial ventures as shopping centers and restaurants following the occupancy of new residential homes. Industrial customers are forecast using GNP; since GNP is a measure of the nation's output of final goods and services, it tends to be highly correlated with FPL's industrial customers.

Street and highway and other public authority customers are forecast using population projections of the FPL service territory.

Resale customers are forecast as a function of the population of Florida.

Energy Forecast Model

The economy of FPL's service area is dominated by tourism, construction, agriculture, service industries, and light manufacturing. To adequately forecast the energy requirements for the area, this unique mix has to be recognized.

In order to more accurately evaluate and project the patterns of growth for the coming years, separate forecasting equations were developed for each of the major classes of users: residential, commercial, and industrial. The remainder of total sales is forecast by extrapolation of historical trends. These models are a combination of econometric and engineering methodologies.

The residential energy forecast begins with an estimate of the variables that influence the residential sector. Real per capita personal income in Florida, real price per residential kilowatt-hour (kWh), air conditioning saturation, electric heating saturation, and cooling and heating degree days are the variables selected to explain the trends in use per customer.

It is expected that residential conservation will have a pronounced effect on energy consumption in the future; therefore, FPL explicity accounts for seven types of conservation: appliance efficiency, Watt-Wise homes, solar water heating, home audit programs, the State Residential Building Energy Code, residential pool pump program and time of use (T-O-U) rates. The effect of each source of conservation on residential consumption is forecast separately.

The commercial sector in Florida is comprised primarily of tourist and service industries. After considerable study, a model was derived in which commercial sales per customer are a function of total non-agricultural employment in Florida and the real price per commercial kilowatt-hour. The total employment variable is used as a measure of the general economic conditions because it tracks the business cycle. The commercial sector's sales are further modified by the effects of T-O-U rates and an audit program described in FPL's Energy Management Plan for the 80's.

Industrial energy use represents about 7 percent of the total energy sales and is incorporated into the forecast by considering two factors. First, industrial sales are correlated with manufacturing employment in Florida. The industrial sector's sales are further modified by the effects of T-O-U rates and an audit program described in FPL's Energy Management Plan for the 80's.

Peak Load Model

Unpredictable variations in weather conditions can result in considerable variation in the use of air conditioning during the summer and electric heating during the winter. For analytical purposes, the summer peak load was separated into two components: non-weather sensitive and weather sensitive.

The non-weather sensitive component is defined as the minimum load during the hours when the summer peak usually occurs. This demand is predominantly determined by the economic environment and shows the load when weather sensitive appliances are at their minimal usage. This portion is forecast on a per customer basis by using real price of electricity and real per capita personal income in Florida.

The weather sensitive component is defined as the difference between the actual peak and the non-weather sensitive component for the period. It represents the load in excess of the base load and is primarily a function of weather conditions. The summer weather sensitive component is forecast on a per customer basis and is related to the minimum temperature on the peak day, the real price of electricity, and the saturation of air conditioners.

The winter peak forecast is based on the number of residential customers which have electric heat, the minimum temperature on the winter peak day, and the number of winter customers.

Regression analysis is used to develop the summer non-weather sensitive load, the summer weather sensitive load, and the winter peak load models. Having developed the regression equations, the relevant variables are then projected to determine the summer non-weather sensitive, summer weather sensitive, and winter peak load forecasts. Both the summer and winter peak load forecasts are then modified by the effects of certain types of conservation which are described below.

Conservation

The conservation models reflect the proposed programs to meet the FPSC rules establishing statewide energy conservation goals as required by the Florida Energy Efficiency and Conservation Act (FPSC Docket No. 800522-EG).

The regression techniques described previously are used to derive equations that forecast long term energy and peak demand. The coefficients derived are based on history and may not predict the effects of future changes in technology or consumer life-style. In order to have a realistic forecast, these future changes must be predicted and incorporated into the forecast separately from the regression equations. The changes must be identified, assumptions made about the significant parameters, and then the results must be incorporated into the forecast.

It is important to note that the total energy reduction attributed to conservation cannot necessarily be calculated by summing the energy reductions of each individual conservation program, and then subtracting this figure from the econometric models baseline forecast. The reasons why this cannot be done are as follows:

First, as explained above the econometric model's forecast is not a single number, but an entire band. Thus, the program results might vary depending upon where, in the banded econometric forecast, reference is being made.

The second problem involves the engineering models which were used to develop the program results. For example, if a program to insulate electric water heaters were proposed, a laboratory test could be designed to take a specific water heater, operate it under certain conditions and measure the kilowatt-hours used to establish a bench mark for comparison. The next step could be to place a blanket of insulation around the same water heater, operate it under the same conditions and possibly conclude that the blanket reduces kilowatt-hour usage by 10 percent. The potential

problem with this procedure is that a laboratory comparison of one situation to another is not necessarily a forecast. In order to properly forecast these results, there are several important questions which remain unanswered when using this engineering modelling approach. For example, was the water heater chosen for the test typical of those used by today's customers? Was the temperature setting of the water heater typical of the setting of most of the utility's customers?

The third problem area with respect to using engineering models involves the possibility of double counting of results or "would this have occurred anyway"? In other words, when the basic econometric forecast is made, it incorporates recent usage patterns, price effects, income effects, weather effects, and other effects as appropriate. An engineering model for an audit program might suggest a certain number of audits and a certain number of measures which, other things being equal, might reduce energy by perhaps 10 percent. The question is, how can it be ascertained whether the effects of those conservation measures have been accounted for in the basic econometric forecasting model through its structure and assumptions about the future price of electricity? It could be that virtually all effects have been taken into account since many measures have in fact already been taken by customers. If these measures have already been taken in response to the price of electricity, then subtracting these engineering results from the basic econometric forecast could result in significant double counting.

The fourth potential problem of engineering models is their failure to account for increased electricity use since customers' electric bills are lower after conservation measures are installed. This is a straight-forward situation. If a customer has an air conditioner with an Energy Efficiency Ratio (EER) of 6.0 and sets the thermostat at 78°F and replaces the air conditioner with a very efficient one with an EER of 12.0, energy usage (kWh) might drop by 50 percent. This is the conclusion an engineering model would produce. However, a 50 percent decrease in the

customer's electric bill might cause the customer to increase consumption (kWh) in response to the lower bill. For example, the customer could set the thermostat to perhaps 72°F.

The fifth potential problem area involving the use of engineering models is the difference between potential and probable results. Let's take a specific example to see how this problem might manifest itself. Consider a residential audit program where 100 audits are done assuming a 35 percent success rate and that each of those people, successfully doing something to conserve, adopt two measures which results in a 10 percent or 1,100 kWh reduction. A pure engineering approach would take 100 audits, multiply by the success rate, which would give 35 people doing something, times 1,100 kWh producing a potential conservation of 38,500 kWh. The question is, what is the probability of each of these steps occurring?

Assume we are very certain about each of those assumptions and felt there was an 80 percent chance of success at each of those levels. In other words, we were 80 percent certain we could do 100 audits, 80 percent certain we could accomplish a 35 percent success rate, 80 percent certain that two measures would be taken and 80 percent certain that a 10 percent energy savings would result. Now, we would still reach the same conclusion that 38,500 kWh could be saved; however, the probability of accomplishing this, producing a 38,500 kWh savings, is only 41 percent. Combine this with dozens of steps and dozens of different conservation programs and the result is obvious. The possibility of substantial energy savings is significantly different than the probability of substantial energy savings.

Therefore, care must be taken when evaluating the impact of conservation programs. In an attempt to avoid the double "counting" problems which arise when assessing conservation reductions, we insert multipliers in the equations of some of the individual conservation programs. This results in more realistic estimates of conservations energy reductions.

Eight changes have been identified as being significant and having a high probability of occurring. These are: (1) implementation and success of an energy efficient home building program (called the Watt-Wise home by FPL); (2) an increasing saturation of solar water heaters; (3) government mandated improvements in the efficiency of certain appliances; (4) home energy audit programs for the retrofit of existing homes with energy saving technologies; (5) the State Residential Building Energy Code; (6) a swimming pool pump audit program; (7) a commercial customer audit program; and (8) T-O-U rates. A more complete discussion of these programs can be found in FPL's Energy Management Plan for the 80's.

The Watt-Wise home program is designed to encourage energy efficiency through the design and construction of new single and multi-family homes. The primary emphasis is placed on structural improvements such as insulation and utilization of a rectangular floor plan. By definition, a home qualifying as a Watt-Wise home uses 25 to 35 percent less energy than a comparable "standard" home, for either single family or multi-family homes. There are separate models for each because the typical (average) single family home uses 14,000 kWh per year while the typical (average) multi-family home uses 8,400 kWh per year.

The number of single family homes that will be watt-wise is forecast. For each of these single family homes, 4,900 kWh is subtracted from the preliminary energy sales forecast. To determine the impact on peak demand, data from company studies is used and an amount is subtracted from the preliminary peak forecast for each Watt-Wise home. Uncertainty in this reduction is reflected by banding the variables using their probability distributions. A similar process is used for multi-family homes.

Solar water heating is an established technology as evidenced by the numerous manufacturers offering solar water heating systems. The only assumptions needed to assess its impact is the rate at which solar water heaters will penetrate the market and the electric energy savings realized by each solar water heater. The penetration rate is estimated by using a life-cycle curve and reinforced by a Delphi technique.

The DOE had originally mandated that by January 1, 1980, certain new appliances sold would meet specified efficiency improvement targets. The overall efficiency improvement target was set at approximately 20 percent over 1972 levels. To incorporate the effects of these regulations, FPL developed an appliance efficiency model. However, due to delays in implementation, FPL has modified its assumptions. Our assumption is that appliances sold after January 1, 1982, will average about 15 percent efficiency improvement over 1978 levels.

The appliance efficiency model is an end-use engineering model comprised of eleven submodels. There is one submodel for each 10 major appliances plus a miscellaneous appliance submodel. Input data includes the efficiency improvement target for each appliance, the energy consumption per appliance for 1979 (weather adjusted), the 1979 appliance saturations, the growth rates for these saturations, and the number of residential customers for each year. The appliance efficiency model is used in conjunction with the long term forecasting model. Its use enables us to assess the "conservation impact" that more efficient appliances have on energy use in our residential sector.

FPL is offering a program of energy audits to residential customers and industrial customers. The audits are designed to aid customers in identifying cost effective means of reducing energy consumption.

The Florida Model Energy Efficiency Code for Building Construction was enacted for the purpose of increasing the thermal efficiency of residential dwellings. All new residential construction will be subject to the state building code after October 1, 1980, except for mobile homes. The improvements made as a result of a new code are expected to reduce energy consumption by 15 percent compared to the non-code home.

Monte Carlo Simulation

While considerable effort is exerted to insure accuracy in the forecast, there is always uncertainty as to its ultimate accuracy. Hence in making a forecast, every decision maker would like to know to what extent events may alter the forecast, in order to assess the impacts that such changes may have on the planning process.

To achieve the flexibility to respond to uncertain future events, FPL has moved away from discrete forecasts. Plans made on the basis of a single set of forecast numbers do not have the flexibility necessary for unforeseen economic and technological growth.

Instead, FPL uses a simulation approach which is designed to allow: (1) the individual and/or simultaneous evaluation of a large number of alternatives, and (2) the internal development by the model of probabilities for these alternatives. Using this approach requires that a probability distribution be assigned to each independent (exogenous) variable. For example, a weather variable has been shown to be uniformly distributed through a range of values. The price variables might be described quite differently. Thus different forecasts for the independent variables may be evaluated by changing the distribution parameters or by utilizing a deterministic solution to the simulation model.

Using the forecasting model and the appropriate distributions for the independent variables, the dependent variables are arrived at by probabilistic simulation using a computer program based on Monte Carlo techniques which results in distributions of values for the forecasted dependent variables. These distributions are the result of the variation between the distributions of the independent variables.

The result of this simulation approach is a range of forecast values to be used instead of a single discrete forecast.

Principal Assumptions

In this section, the assumptions used in the preparation of the peak load and net energy forecasts are developed.

Sources for the population forecast have been drawn from federal, state, and local government; universities; and consulting services such as the National Planning Association. The University of Florida's population forecast is presently being used and is presented as a range. The Florida population growth projections for the next decade are average annual rates of 1.3 to 3.0 percent. This compares with the 3.4 percent average annual growth experienced from 1970 through 1980.

Historically, the number of FPL customers has grown at a rate faster than the population. From 1970 to 1980, customers increased at an average annual rate of 5.7 percent. Residential customers, which currently are about 90 percent of total customers, have accounted for most of this increase. In 1950, there were 4.2 people for every residential customer. By 1980, this ratio had dropped to 2.54, and is projected to be 2.34 by 1990.

The price forecast is prepared by the FPL Finance Department and is the result of the total planning effort at FPL.

Historically, the average real price per kilowatt-hour for FPL's customers fell at an average annual rate of 4.6 percent from 1965 through 1972. However, from 1972 through 1980, the real price increased at an average rate of 4.0 percent. This variation was caused by several coinciding unusual circumstances which caused the cost of operating an electric utility to increase at a rate faster than inflation. The real price of electricity is expected to increase between 0.0 to 3.0 percent per year over the next decade.

As mentioned previously, real per capita income and Florida employment were used in the appropriate models in order to adequately represent the impact on both the individual and the community. Through 1990, real per capita income is forecast to grow at an average annual rate in the range of 2.3 to 3.3 percent. The corresponding rates for employment are 2.0 to 4.5 percent.

Several basic areas of economic strength continue to characterize the state of Florida. One of these is the tourist sector. The increase in tourism can be largely attributed to new trends in the industry. First, there has been an increase in the number of second homes. These people are not counted in Florida's census when occupying their homes for only parts of the year; second, there is an increasing number of tourists who arrive by automobile which typically visit central Florida; third, the increase in the number of cruise passengers passing through Florida ports; and last, the increase in the number of Latin American tourists.

A second significant growth factor is the role of manufacturing in the state. While construction has been the dominant source of employment opportunities in Florida, it will be of lessening relative importance as growth in manufacturing industries increases. Another new development has been the increased movement to Florida of subsidiaries of some of America's largest corporations, specifically set up to conduct business outside the United States. These subsidiary corporations frequently characterized by the word "international" with the name of the parent company, are largely centered in the Miami area.

Other basic assumptions used in the forecast are:

Air Conditioning Saturation - The air conditioning saturation in the FPL territory is currently estimated at 85 percent. The saturation is expected to continue to increase to 90 percent by 1990.

Heating Saturation - The saturation of electric heat in 1990 is expected to be 82 percent.

Weather - The cooling degree days, heating degree days, summer peak day average temperature, and winter peak day average temperature are forecasted probabilistically on the basis of 30 years of data to include not only average but some of the variability of extremes.

The following conservation assumptions used in the forecast represent only the mid-points of the probability distributions for each variable:

Residential Building Energy Code - Each single family "code" home is estimated to reduce summer peak by 0.52 kW and winter peak by 0.55 kW. Each multi-family "code" home is estimated to reduce summer peak by 0.31 kW and winter peak by 0.33 kW. The annual energy savings for single-family and multi-family code homes are 2,100 kWh and 1,265 kWh, respectively.

Home Audit Program - Approximately 330,000 single and multi-family residential customers in years 1980 through 1990 will take advantage of programs with a 32.5 percent follow-up rate.

For the single family homes, the average reduction in energy is 1400 kWh per year. The summer peak reduction is estimated to be 0.35 kW and 0.37 kW for the winter peak reduction.

For multi-family homes, the average reduction in energy is 840 kWh per year. The summer peak reduction is estimated to be 0.21 kW and 0.22 kW for the winter peak reduction.

Solar Water Heating - Electric water heater average use is estimated at 212 kWh/month. Solar will supply 60 percent of domestic hot water requirements per year, and at the time of the summer system peak there will be no electric usage, while for the winter system peak there will

be 100 percent electric usage. Average savings per solar water heater are: annual energy = 1,975 kWh; summer peak = 0.27 kW; winter peak addition = 0.56 kW.

The projected number of solar water heaters is 136,400 in 1990.

Watt Wise Homes - By 1990, there will be a total of 353,730 Watt Wise Homes on the FPL system. Of these, each single family home will reduce energy consumption by 4,900 kWh and each multi-family home will reduce energy consumption by 2,950 kWh.

Each single family Watt Wise Home will reduce the summer peak by 1.21 kW and the winter peak by 1.28 kW. Each multi-family Watt Wise Home will reduce summer peak by 0.73 kW and winter peak by 0.77 kW.

Appliance Efficiency - The appliance efficiency model assumes that as of January 1, 1982, new appliances sold will, on the average, show a 15 percent efficiency improvement over 1978 levels. Individual use of an appliance will increase due to income and price effects and the average appliance life will be 10 years.

Load Management

Accurate forecasts of future electrical demand require careful consideration of the potential impact of conservation. The price of electricity is an important "conservation" variable since it affects the customer's decision to consume or conserve electricity. Economic activity also affects the consumption of electricity. Improved appliance efficiency, solar water heating, and the energy efficient homes would also tend to reduce the rate of growth of electricity. These variables are considered in the load forecast and were previously discussed.

In addition, FPL is currently looking into alternative load management measures that will help reduce the peak load while improving load factor. By improving load factor, existing facilities can be utilized to the

maximum extent possible. To achieve this, FPL initiated several test programs involving utility control of residential loads such as air conditioning and water heating. The results of these tests will be used in evaluating implementation techniques on a large scale basis. In addition, FPL will be implementing other load management programs such as time-of-use rates from both residential and commercial sectors, the previously discussed pool pump program, and curtailable rates for commercial and industrial customers.

In spite of these efforts, however, FPL needs the proposed plant from both a capacity and oil displacement standpoint. Were this new coal capacity to be deferred because of load management, the results may be an increase in oil consumption since the utilization of existing oil-fired capacity will be increased. Moreover, as with all new programs, there is a degree of uncertainty associated with these load management programs. This uncertainty is a result of the lag inherent in customer acceptance and response to these programs. Should customer acceptance be less than that expected by FPL, the company could find itself in the position of having insufficient time to react to this reduced response due to the long lead times required to build a power plant. This could lead to severe penalties being imposed on the public. FPL believes, however, that load management can be successful and will monitor customer response to these programs and adjust its plans as required to reflect their implementation and acceptance. Even if these programs are fully successful, the need for the capacity of this plant still exists, albeit with a slight delay. Until then, however, the need for the plant is fully justified and cost effective on an oil-reduction basis.

Summary

The use of a range (or distribution) of forecast values representing upper and lower bounds for each of the explanatory variables resulted in the development of banded peak load and energy forecasts. The forecast of summer peak load projects a compound annual growth rate in the 1980-1990

period ranging from 1.3 to 3.9 percent. The energy sales forecast has a low annual growth rate of 3.1 percent and a high annual growth rate of 5.1 percent. Figures M-6 and M-7 are a graphic representation of these bands. See Tables M-11 through M-27 for forecasted values and projected growth rates for peak, net energy, sales and customers.

M.3 JACKSONVILLE ELECTRIC AUTHORITY SYSTEM CAPACITY PLANNING PROCESS

It is JEA's practice to engage the services of consulting engineering firms to assist in conducting generation planning studies as needed. The objective is to lend an independent opinion to the process and to augment the experience of the JEA planning staff.

As a rule, members of the JEA System Planning Division actively participate in the study throughout, e.g., they expedite the collection of data, give advice and approval in the formulation of study criteria and assumptions, monitor the calculations, and comment upon the final report in draft. Care is taken that this shall not interfere with the consultant-client relationship. The consultant is never required to concur in any decision about which he may have reservations. However, it is the ultimate prerogative and responsibility of the JEA staff and the Authority to accept or reject the results.

New generation planning studies or the updating of prior studies are initiated by JEA staff. The System Planning Division has primary responsibility for monitoring internal and external developments which might affect the last complete study or its conclusions. Depending on the magnitude of change, JEA staff decides whether the circumstances require a completely new evaluation or an update of the prior study.

If a new study is deemed necessary, qualified firms are asked by open invitation to present their credentials and proposals for performing the study or update. The responses are evaluated and the consultant chosen, primarily on the basis of technical capability.

It is JEA's practice to define the scope of a typical generation planning study. Such a study includes the following steps:

- Quantify the need for new generation capacity between now and the horizon year of study (usually 20 years hence);

- Identify all reasonable alternatives for supplying this need in a reliable manner;

- Evaluate and compare the alternatives in all pertinent respects:

- Identify that course of action which will enable JEA to give reliable service at least cost, consistent with measures necessary to minimize environmental impact, conserve critical fuels, and satisfy any other constraints that may be identified.

These basic objectives are usually reinforced by certain premises, namely:

- All types, sizes and fuels or energy sources for new generating units or energy conversion devices will be considered, including emerging technologies and renewable energy sources;

- Past JEA generating supply practices set no precedent, rather each alternative is thoroughly re-evaluated;

- The purchase of bulk power from other utilities to defer or displace JEA generation, sale of bulk power to other utilities to hold reserve margins at the minimum possible level, and/or the sharing of large generating units with other utilities to achieve greater economy of scale are always options to be explored.

Below are the steps in the generation planning process which JEA normally requires, and which the consultant usually follows:

1. Examine the latest official JEA forecast and determine if it is sufficient for use as the basis for a new generation plan. If the environment has changed radically from that in which the forecast was conducted, request a forecast update prior to study commencement.

2. Confirm the net dependable capability of generating units and power purchases existing, under construction or committed to construction. Examine and identify the possibilities of increasing the capacity of such units or resources, or extending their useful life. Also examine and define the prospects for retirements or reductions in the capacity of such resources due to age, obsolescence, restricted or unreliable fuel supply, regulatory actions, or expiration of contracts.

3. Determine the annual amounts of installed reserve generation needed to the horizon year of study, using a loss-of-load probability type of analysis such as PROMOD.

4. Combine the results of the first three steps to determine JEA's minimum, most probable, and maximum need for new generating capacity to the horizon year of study.

5. Identify all reasonable types and sizes of generating units, energy sources, and energy conversion processes which can be used to satisfy the projected needs defined in the preceding step, including particularly emerging technologies, renewable energy sources, and measures for reshaping load characteristics to suppress peak demands.

6. Utilizing generation reserve margin criteria and reliability indices, compare and select those types and sizes of generating units or energy sources which are best in terms of reliability of on-time construction, reliability of operation and fuel supply, and relative efficiency and economy.

7. Identify potential sites for the selected options.

8. From the results of the last three steps, construct the alternative plans by which JEA may increase generating capacity, year by year, to meet the needs defined earlier. Identify for each alternative plan, unit size, type, fuel or energy source, tentative location, and sequence or timing of each increment of capacity.

9. Prepare conceptual descriptions of the alternative new generating units under study, including typical site plans and requirements, ratings and salient characteristics of major equipment components, definition of measures needed to protect the environment, typical construction schedule with allowance for the licensing process, and typical performance characteristics. This information is to show realism of concepts and provides a basis for cost estimating.

10. Define the transmission line and substation additions associated with each alternative generating scenario.

11. Estimate the capital costs of the alternative plans, including allowance for projected inflation.

12. Project and compare total system expenses for fuel, operation and maintenance in each year of the study for each alternative plan using a state-of-the-art computer model such as PROMOD. Calculate and add fixed charges on investment to show the life-cycle cost (i.e., present worth of comparative annual revenue requirements during the life of facilities under study) of each alternative scenario.

13. Make sensitivity analysis by repeating steps 11 and 12 considering varying rates of load growth, construction cost inflation, capital cost inflation, and cost of money.

14. Define the non-economic factors which might influence the choice between alternative plans, including relative reliability of electric service, probability of timely construction and dependable operation, and conservation of critical resources.

15. Interpret and present the findings, and recommend a course of action to JEA.

16. Document the study and findings in a comprehensive engineering report.

It might rightfully be deduced that the effort involved in making or even updating a study, as defined above, is considerable and complex. Extensive manpower and multidisciplinary expertise are needed, as well as advanced computer techniques. Such studies are, therefore, time consuming and costly. Through the use of this approach to generation planning, JEA believes it has applied the best available resources to the planning process.

Besides undertaking the above steps in JEA's planning process, JEA also deals with several external organizations in establishing expansion plans. The JEA is a member of the Peninsular Florida subregion of the Southeastern Electric Reliability Council (SERC). SERC is one of the nine regional councils of the National Electric Reliability Council (NERC). NERC through its regional councils establishes guidelines to augment the reliability of bulk power supply.

In Florida, the JEA is an active member in the Florida Electric Power Coordinating Group (FCG). The stated purpose of the FCG is to "engage in the active coordination of planning, construction, and utilization of generation and transmission facilities in Florida" with which JEA totally agrees. JEA has also directly participated in several studies conducted by the FCG which have investigated the joint planning of generation and transmission facilities and centralized dispatch for Peninsular Florida.

The JEA also keeps in close contact with various state agencies to ensure that the needs of its customers are adequately served.

M.4 FLORIDA POWER & LIGHT SYSTEM CAPACITY PLANNING PROCESS

System Capacity Planning is the analytical and decision making function responsible for identifying and evaluating facility and system expansion alternatives which will meet the challenges of today's planning environment.

FPL has a responsibility to its customers and stockholders to provide an adequate and reliable electric power system. This system should be provided as economically as possible with due consideration to financial, regulatory, and other established guidelines and policies. The "Planning Process" by which these goals are achieved involves many analytical evaluations combined with sound qualitative judgements to arrive at the final product; "A System Expansion Plan". The System Capacity Planning Process begins with a forecast of future system loads and ends with a selection of the next future generating unit or units.

The objective of the load forecasting function is to identify customer use patterns so that appropriate operational and/or planning responses can be developed. As such, load forecasting provides the basis for the identification of the need for, timing, and additions to generating capacity. The volatile nature of the energy situation requires that load forecasts be frequently reviewed and updated to incorporate current relevant information and latest trends.

The fundamental objective of generation planning is the determination of the amounts and types of generation necessary to adequately and reliably meet the load. Specifically, generation planning must answer the questions, "how much generation to add, what type of plants to construct (e.g., nuclear vs. fossil), when they should be in-service, and what size they should be".

In developing the generation expansion plan, numerous constraints must be considered and balanced; the plan must satisfy reliability, economic, regulatory, and other significant requirements. Because these various

elements are continually shifting, planning is of necessity a continuous process. Thus, even though there is always a current expansion plan, this plan is continuously updated and revised as new information is gained.

The following discussion is structured according to the major elements which are incorporated into a generation expansion plan.

Generation Reliability

A public utility must make every effort to provide sufficient capacity to meet the load imposed on its system and assure the dependability and reliability of its power supply. This means providing capacity equal to projected load plus an adequate reserve margin. This margin provides for such factors as unit forced outages, scheduled outages for maintenance, and load forecast uncertainty. For planning purposes, FPL utilizes percent reserves as a reliability index as well as a probabilistic technique (loss of load probability) to assure its customers of an adequate and reliable power system (refer to Chapter 1, Section 1.1.3 for further discussion of reserve margins and reliability).

Generation Economics

Economics, of course, plays an important role in the decision process during the generation planning step. This is due to the fact that generation plan investments and their associated operating costs are the primary contributors to the customers' cost of electricity. FPL's planning decisions are, therefore, very sensitive to economic and financing requirements and attempt to select the "Economic Choice" when all other planning criteria allow.

Generally, capacity additions can be designated for use as base load, intermediate, or peaking units. These different types of generation all have different values of fixed or variable costs. It is the comparison of these costs, along with the expected operation of the planned units, that

make up the economic analysis of production costs. The objective is to maintain a mix of generation types that yield the least total cost to FPL customers.

Regulatory Requirements

With the rapidly increasing regulatory requirements on industry in recent years, any decision concerning generation expansion must fully consider the regulatory impacts associated with each alternative.

Both nuclear and fossil generating plants have to meet state and federal regulations. On the federal level, there are several agencies such as the Nuclear Regulatory Commission and the Environmental Protection Agency that have some authority over the construction of power plants. Likewise, on the state level, generation additions have to meet the standards set forth by the Florida Department of Environmental Regulation and associated agencies.

Additionally, the emergence of the National Energy Act which strongly favors the use of alternate fuels such as coal in lieu of oil and gas, has a profound impact on the generation planning process. Oil and gas, as we know them today, are virtually eliminated as future fuel alternatives for base-load power plants.

In addition to the considerations addressed earlier concerning reliability and economics, regulatory considerations are becoming increasingly significant constraints in the generation planning process. As a result of the myriad of regulatory requirements, which are constantly changing, numerous uncertainties are created in the overall planning process. These uncertainties impact cost and timing and therefore increase financial risk of new generation additions. It is therefore one of the main objectives of the generation planner to assess existing and proposed federal and state regulations in order to develop a generation expansion plan that properly addresses these considerations.

In summary, Generation Planning, in considering the many influencing factors discussed, is designed for maximum flexibility to adapt to changing conditions through time. These conditions typically include changes in the load forecasts, load factor, financial climate, public acceptability, fuel costs and availability, construction schedule modifications, technological advances in fuels and generation methods, and changing environmental protection requirements. With this flexibility, the alternatives and options available are kept open as long as possible and sites are selected to accommodate the widest range of generation types and sizes.

FPL utilizes a wide variety of computer models to assist in the development of the System Capacity Plan.

The following models are used regularly:

1. Capacity Model (LOLP) Program
2. Area Load and Generation Balance Program
3. Optimized Generation Planning Program
4. Production Costing Program
5. Generation Plan Static Analysis Program
6. Economic Breakpoint Analysis Program

These models provide a wide range of information which, when incorporated in the generation planning process, is the basis for formulating the expansion plans (see Appendix M.5 for explanation of models).

In addition to its internal planning process, FPL also participates in several regional planning efforts which insure the most efficient and economic development of the future energy supply for the ratepayer of Florida. These regional planning efforts are:

Southeastern Electric Reliability Council

SERC is one of the nine regional councils of the National Electric Reliability Council. FPL is a member of the Peninsular Florida subregion and adheres to the SERC planning guidelines established to accomplish the following goal: "to augment further the reliability of bulk power supply in the areas serviced by its member systems".

Florida Electric Power Coordinating Group, Inc.

The purpose of the FCG is to "engage in the active coordination of planning, construction, and utilization of generation and transmission facilities in Florida". For example, FPL has participated in several studies such as the investigation of the advantages and disadvantages of centralized dispatch for Peninsular Florida.

M.5 FLORIDA POWER & LIGHT COMPANY PROGRAM SUMMARIES

Capacity Model Program

This program is used to evaluate system risk (LOLP) for a given expansion plan. Inputs include a description of the existing and planned generation system (unit size, forced outage rates, maintenance schedules, and installation dates) and forecast loads. By evaluating system risk, the program determines when additional generation is necessary to maintain a minimum risk level.

Area Load/Generator Balance Program

The Area Load/Generator Balance program is used in the evaluation of alternate generation siting plans. Inter-area transfer and reserve margins can be calculated directly. The program also considers loss of the largest unit in the area for import planning.

Optimal Generation Program

Used to optimize the size and type of generation additions on a year-by-year basis resulting in lowest overall cost taking into account capital cost, operating cost, and loss-of-load probability. It has the capacity to consider load forecasts and generation additions as much as 20 years in the future.

Production Costing Program

Used to simulate the production costs of a system consisting of many generators having different efficiencies, fuels, maintenance schedules, and outage rates. The program simulates the dispatching of these units on an economic basis to meet specific load models over a 20 year period. The output includes projected total system and individual unit operating costs and performance indicators such as unit capacity factors and projected average heat rate.

Generation Plan Static Analysis Program

This program, given a proposed plan, calculates reserves with the largest unit out, the percentage of installed capability by type, and low load analysis to determine possible cycling requirements in valley conditions.

Economic Breakpoint Analysis Program

Used to analyze levelized annual costs between various types of generation. The breakpoint program helps in making decisions as to the type of unit to be installed in different operating modes such as peaking, intermediate, or base load.

Table M-1 (Revision 1)

JACKSONVILLE ELECTRIC AUTHORITY

COMPARATIVE ECONOMIC/DEMOGRAPHIC FORECAST RESULTS

LOW, MOST PROBABLE, HIGH GROWTH CASES

	Actual	Forecast				Compound Annual Growth Rates %			
	1979	1985	1990	1995	2000	79-85	79-90	79-95	79-2000
Total Employment (SMSA)									
Low	338,270	351,140	349,660	370,180	400,250	0.6	0.3	0.6	0.8
Most Probable	338,270	353,680	366,380	385,670	415,220	0.7	0.7	0.8	1.0
High	338,270	361,550	388,740	415,520	451,190	1.1	1.3	1.3	1.4
Per Capital Disposal Income (Duval County, 1967$)									
Low	3,470	3,390	3,350	3,720	4,240	(0.4)	(0.3)	0.4	1.0
Most Probable	3,470	3,460	3,640	3,980	4,520	0.0	0.4	0.9	1.3
High	3,470	3,580	3,960	4,440	5,200	0.5	1.2	1.6	1.9
Total Population (Jacksonville SMSA)									
Low	705,370	741,700	777,540	802,730	820,910	0.8	0.9	0.8	0.7
Most Probable	705,370	742,550	781,440	813,790	845,050	0.9	0.9	0.9	0.9
High	705,370	743,930	787,800	827,890	865,570	0.9	1.0	1.0	1.0
Total Population (Duval County)									
Low	553,300	551,160	555,040	558,470	560,530	(0.1)	0.0	0.1	0.1
Most Probable	553,300	552,660	561,880	574,640	587,840	0.0	0.2	0.2	0.3
High	553,300	553,790	567,060	587,070	609,180	0.0	0.2	0.4	1.5
Total JEA Customers									
Low	221,824	232,840	242,420	252,748	262,963	0.8	0.8	0.8	0.8
Most Probable	221,824	233,508	245,733	259,928	275,060	0.9	0.9	1.0	1.0
High	221,824	234,225	248,600	266,105	285,405	0.9	1.0	1.1	1.2

Table M-2

JACKSONVILLE ELECTRIC AUTHORITY
MOST PROBABLE ENERGY AND DEMAND FORECAST
SUMMARY OF RESULTS

	Actual	Forecast				Compound Annual Growth Rates %			
	1979	1985	1990	1995	2000	79-85	79-90	79-95	79-2000
Energy (GWH)									
Rate 10	2,291	2,558	3,034	3,541	4,101	1.9	2.6	2.8	2.8
Rate 20	891	984	1,092	1,179	1,296	1.7	1.9	1.8	1.8
Rate 30	1,082	1,387	1,631	1,888	2,289	4.2	3.8	3.5	3.6
Rate 40	943	1,195	1,458	1,659	1,939	4.0	4.0	3.6	3.5
Rate 45	463	498	528	561	595	1.2	1.2	1.2	1.2
Rate 50-90	71	71	74	76	78	-	0.4	0.4	0.4
Total Energy Sales	5,741	6,693	7,817	8,904	10,298	2.6	2.8	2.8	2.8
Losses & Adjustments[a]	361	383	429	475	534	1.0	1.6	1.7	1.9
Net Energy for Load	6,102	7,076	8,246	9,379	10,832	2.5	2.8	2.7	2.8
Load (MW)									
1st Quarter Peak Load	1,180	1,464	1,874	2,163	2,447	3.7	4.3	3.9	3.5
3rd Quarter Peak Load	1,218	1,444	1,625	1,815	2,086	2.9	2.7	2.5	2.6
Annual Load Factor	.572	.522	.502	.495	.505				

a Losses & Adjustments as of % of net energy for load were assumd to decline slightly through the forecast period from 5.9% in 1979 to 4.9% in 2000.

Table M-3 (Revision 1)

JACKSONVILLE ELECTRIC AUTHORITY
MOST PROBABLE ENERGY AND DEMAND FORECAST
TOTAL SYSTEM ANNUAL RESULTS

Year	Total Sales (GWH)	Net Energy for Load (GWH)	First Quarter Peak Load (MW)	Third Quarter Peak Load (MW)	Annual Load Factor
1979	5,741	6,102	1,180	1,218	.572
1980	5,499	5,906	1,143	1,213	.556
1981	5,738	6,081	1,169	1,279	.543
1982	6,012	6,367	1,244	1,329	.547
1983	6,279	6,645	1,318	1,375	.552
1984	6,575	6,953	1,401	1,429	.555
1985	6,693	7,076	1,464	1,444	.552
1986	6,920	7,313	1,544	1,485	.541
1987	7,118	7,519	1,630	1,514	.527
1988	7,351	7,761	1,714	1,552	.517
1989	7,617	8,039	1,798	1,596	.510
1990	7,816	8,246	1,874	1,625	.502
1991	7,937	8,372	1,929	1,640	.495
1992	8,168	8,613	1,988	1,684	.495
1993	8,354	8,806	2,044	1,714	.492
1994	8,605	9,068	2,099	1,760	.493
1995	8,904	9,379	2,163	1,815	.495
1996	9,191	9,678	2,225	1,866	.497
1997	9,461	9,959	2,283	1,914	.498
1998	9,737	10,247	2,340	1,966	.500
1999	9,986	10,506	2,393	2,008	.501
2000	10,299	10,832	2,447	2,086	.505

Table M-4 (Revision 1)

JACKSONVILLE ELECTRIC AUTHORITY
MOST PROBABLE ENERGY AND DEMAND FORECAST
ANNUAL ENERGY SALES BY CUSTOMER CLASS

Year	Total Sales (GWH)	Rate 10 (GWH)	Rate 20 (GWH)	Rate 30 (GWH)	Rate 40 (GWH)	Other Categories (GWH)[a]
1979	5,741	2,291	891	1,082	943	534
1980	5,499	2,200	832	1,076	866	525
1981	5,738	2,253	875	1,151	915	544
1982	6,012	2,318	911	1,236	997	549
1983	6,279	2,385	937	1,313	1,088	556
1984	6,575	2,515	970	1,369	1,159	562
1985	6,693	2,558	984	1,387	1,195	569
1986	6,920	2,648	1,009	1,436	1,251	575
1987	7,118	2,726	1,030	1,470	1,310	582
1988	7,351	2,831	1,054	1,529	1,347	589
1989	7,617	2,936	1,081	1,601	1,404	595
1990	7,817	3,034	1,092	1,631	1,458	602
1991	7,937	3,121	1,096	1,636	1,475	609
1992	8,168	3,235	1,114	1,689	1,514	616
1993	8,354	3,315	1,132	1,742	1,543	623
1994	8,605	3,418	1,153	1,808	1,596	630
1995	8,904	3,541	1,179	1,888	1,659	637
1996	9,191	3,653	1,205	1,973	1,715	644
1997	9,461	3,759	1,226	2,048	1,776	652
1998	9,737	3,868	1,248	2,128	1,834	659
1999	9,986	3,975	1,267	2,195	1,883	666
2000	10,299	4,101	1,296	2,289	1,939	674

a Other categories include: Rate 45, Rates 50-90, Interchange

Table M-5 (Revision 1)

JACKSONVILLE ELECTRIC AUTHORITY
COMPARATIVE ANNUAL FORECAST RESULTS
LOW, MOST PROBABLE, HIGH GROWTH CASES

Year	Net Energy for Load			Annual System Peak Load		
	Low (GWh)	Most Probable (GWh)	High (GWh)	Low (MW)	Most Probable (MW)	High (MW)
1979	6,102	6,102	6,102	1,218	1,218	1,218
1980	5,901	5,906	5,916	1,211	1,213	1,216
1981	6,072	6,081	6,096	1,277	1,279	1,282
1982	6,359	6,367	6,376	1,327	1,329	1,331
1983	6,665	6,645	6,713	1,379	1,375	1,387
1984	6,929	6,953	7,066	1,427	1,429	1,448
1985	6,931	7,076	7,300	1,446[a]	1,464[a]	1,496[a]
1986	7,048	7,313	7,584	1,502	1,544	1,584
1987	7,107	7,519	7,834	1,565	1,630	1,678
1988	7,290	7,761	8,205	1,631	1,714	1,775
1989	7,469	8,039	8,589	1,702	1,798	1,879
1990	7,591	8,246	8,870	1,761	1,874	1,967
1991	7,829	8,372	9,028	1,821	1,929	2,030
1992	8,066	8,613	9,321	1,891	1,988	2,096
1993	8,189	8,806	9,602	1,935	2,044	2,163
1994	8,407	9,068	9,913	1,981	2,099	2,240
1995	8,648	9,379	10,104	2,035	2,163	2,282
1996	8,835	9,678	10,432	2,080	2,225	2,353
1997	9,144	9,959	10,708	2,136	2,283	2,405
1998	9,391	10,247	11,048	2,187	2,340	2,469
1999	9,534	10,506	11,400	2,222	2,393	2,530
2000	9,757	10,832	11,757	2,258	2,447	2,591
Compound Annual Growth Rates %						
1979-85	2.2	2.5	3.0	2.9	3.1	3.5
1979-90	2.0	2.8	3.5	3.4	4.0	4.5
1979-95	2.2	2.7	3.2	3.3	3.7	4.0
1979-2000	2.3	2.8	3.2	3.0	3.4	3.7

a System becomes Winter Peaking in 1985

Table M-6
JACKSONVILLE ELECTRIC AUTHORITY
APPLIANCE SATURATION FORECASTS
(% OF TOTAL RESIDENTIAL CUSTOMERS)

	Historical Saturation Level, %						Forecast Saturation Level, %			
	1975	1976	1977	1978	1979	1980	1985	1990	1995	2000
Electric Heat										
Total Heating Customers	16.4	20.6	20.0	24.1	30.2	32.1	53.0	80.0	91.0	95.0
Heat Pump							30.0	40.0	50.0	60.0
Non Heat Pump							27.0	40.0	41.0	35.0
Air Conditioning										
Total A.C. Customers	-	-	85.4	85.3	85.5	83.4	86.7	89.5	92.2	95.0
Central A.C. Customers	39.9	41.2	42.1	48.3	48.9	52.0	55.3	58.1	60.8	63.6
Heat Pump							30.0	40.0	50.0	60.0
Non Heat Pump Control							25.3	18.1	10.8	3.6
Room Air Customers										
1 Unit	42.1	38.8	26.6	22.4	22.2	19.4	19.4	19.4	19.4	19.4
2 Units	-	-	13.7	11.3	12.1	9.1	9.1	9.1	9.1	9.1
3 Units	-	-	3.0	3.3	2.3	2.9	2.9	2.9	2.9	2.9
Clothes Dryers	45.0	39.9	47.1	43.3	45.6	46.1	51.9	53.0	53.4	53.5
Range	79.3	73.9	78.9	79.2	81.3	79.8	89.0	90.4	93.0	95.0
Water Heater	78.6	79.2	82.7	81.4	85.0	85.0	88.4	91.2	93.4	95.0
Refrigerator										
Total with Refrigerator	99.9	98.2	98.9	99.7	99.8	99.0	100.0	100.0	100.0	100.0
Frost Free	67.9	66.1	68.7	69.1	75.0	76.0	78.6	80.7	82.9	85.0
Non Frost Free	32.0	32.1	30.2	30.6	24.8	23.0	21.4	19.3	17.1	15.0
Television										
Total Color	67.6	66.7	71.0	73.2	75.7	77.0	80.0	83.3	86.7	90.0
Total Black & White	52.1	49.7	47.6	41.2	41.3	39.0	37.9	36.9	36.0	35.0
Freezer	37.9	30.5	32.5	31.9	32.7	32.0	32.0	32.0	32.0	32.0
Dishwasher	31.3	26.4	32.1	34.4	36.0	38.0	45.5	49.3	51.4	52.4
Washing Machine	-	64.8	72.8	66.4	70.3	68.0	71.6	73.5	75.5	77.4

Table M-7

JACKSONVILLE ELECTRIC AUTHORITY
APPLIANCE OPERATING CHARACTERISTICS ASSUMPTIONS

	Annual kWh	Average Diversified Demand (kW/Unit) @ Summer Peak	Average Diversified Demand (kW/Unit) @ Winter Peak	Average Life (Years)	Efficiency Reduction (%)
Electric Heat	4,638				
Heat Pump			4.0	15	10
Non Heat Pump			4.0	30	10
Air Conditioning	2,456				
Heat Pump		0.64		15	10
Non Heat Pump Control		2.90		10	17
Room Air Unit		2.90		10	22
Clothes Dryer	851	0.20	0.17	14	4
Range	839	0.50	0.58	12	3
Water Heater	3,362	0.40	0.70	10	15
Refrigerator					
Frost Free	1,621	0.24	0.24	18	28
Non Frost Free	925	0.11	0.11	18	28
Television					
Color	358	0.16	0.32	12	35
Black and White	98	0.06	0.12	11	65
Freezer	1,313	0.20	0.15	20	22
Dishwasher	208	0.12	0.12	11	20
Washing Machine	85	0.03	0.03	11	26
Miscellaneous & Lighting	2,164	0.30	0.45	-	15

Table M-8

JACKSONVILLE ELECTRIC AUTHORITY
PERCENT OF TOTAL APPLIANCE STOCK WHICH
IS OPERATING AT TARGETED APPLIANCE EFFICIENCY STANDARDS

	Year			
	1985	1990	1995	2000
Electric Heat				
Heat Pump	85.9	97.1	100.0	100.0
Non Heat Pump	59.2	82.8	88.8	92.8
Air Conditioning				
Heat Pump	85.9	97.1	100.0	100.0
Non Heat Pump Central	72.5	100.0	100.0	100.0
Room Air Unit	78.5	100.0	100.0	100.0
Clothes Dryer	67.5	95.0	100.0	100.0
Range	72.5	100.0	100.0	100.0
Water Heater	83.3	100.0	100.0	100.0
Refrigerator				
Frost Free	55.6	79.5	100.0	100.0
Non Frost Free	46.0	77.1	100.0	100.0
Television				
Color	72.3	100.0	100.0	100.0
Black and White	73.0	100.0	100.0	100.0
Freezer	45.7	69.9	91.9	100.0
Dishwasher	81.3	100.0	100.0	100.0
Washing Machine	77.0	100.0	100.0	100.0
Miscellaneous: Lighting	100.0	100.0	100.0	100.0

Table M-9

JACKSONVILLE ELECTRIC AUTHORITY
SUMMARY OF POTENTIAL ENERGY SALES AND PEAK LOAD REDUCTIONS
TO MOST PROBABLE FORECAST DUE TO APPLIANCE EFFICIENCY
IMPROVEMENTS AND LOAD CONTROL

	Year			
	1985	1990	1995	2000
SOURCES OF SALES AND PEAK REDUCTIONS				
(1) RESIDENTIAL APPLIANCE EFFICIENCY IMPROVEMENTS				
Energy Sales Reduction (GWh)				
Unadjusted Base Case Sales	2,558	3,034	3,541	4,101
% Reduction	11.5	13.7	14.3	14.3
Total Reduction	294	416	506	587
Peak Load Reduction (MW)				
1st Quarter (Winter) Peak Load	108	168	200	220
3rd Quarter (Summer) Peak Load	99	132	144	152
(2) RESIDENTIAL LOAD CONTROL				
Peak Load Reduction (MW)				
1st Quarter (Winter) Peak Load	123	160	184	202
3rd Quarter (Summer) Peak Load	78	-	-	-
(3) TOTAL RESIDENTIAL ENERGY AND LOAD REDUCTIONS, (1) AND (2)				
Energy Sales Reduction	294	416	506	587
1st Quarter (Winter) Peak Load	231	328	384	422
3rd Quarter (Summer) Peak Load	177	132	144	152

Table M-10 (Revision 1)

JACKSONVILLE ELECTRIC AUTHORITY
ADJUSTED MOST PROBABLE ENERGY AND DEMAND FORECAST
SUMMARY OF RESULTSa

	Actual	Forecast				Compound Annual Growth Rates %			
	1979	1985	1990	1995	2000	79-85	79-90	79-95	79-2000
Energy (GWH)									
Rate 10	2,291	2,264	2,618	3,035	3,514	-	1.2	1.8	2.1
Rate 20	891	984	1,092	1,179	1,296	1.7	1.9	1.8	1.8
Rate 30	1,082	1,387	1,631	1,888	2,289	4.2	3.8	3.5	3.6
Rate 40	943	1,195	1,458	1,659	1,939	4.0	4.0	3.6	3.5
Rate 45	463	498	528	561	595	1.2	1.2	1.2	1.2
Rate 50-90	71	71	74	76	78	-	0.4	0.4	0.4
Total Energy Sales	5,741	6,399	7,401	8,398	9,711	1.8	2.3	2.4	2.5
Losses & Adjustments	361	371	413	454	509	0.9	1.8	2.0	2.2
Net Energy for Load	6,102	6,770	7,814	8,852	10,220	1.7	2.3	2.4	2.5
Load (MW)									
1st Quarter Peak Load	1,180	1,233	1,547	1,779	2,025	0.7	2.5	2.6	2.6
3rd Quarter Peak Load	1,218	1,267	1,493	1,672	1,934	0.7	1.9	2.0	2.2
Annual Load Factor	.572	.610	.577	.568	.576				

a Adjusted to include potential impact of:

(1) Residential appliance efficiency improvements
(2) Load control of water heating, electric space heating and central air conditioning

Table M-11

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF SYSTEM NET SUMMER PEAK LOAD
(60 Minute Net)

Year	Peak MW	Annual % Change
1965	2,529	11.6
1966	2,827	11.8
1967	3,160	11.8
1968	3,789	19.9
1969	4,329	14.3
1970	5,001	15.5
1971	5,378	7.5
1972	6,011	11.8
1973	6,894	14.7
1974	7,235	4.9
1975	7,076	(2.2)
1976	7,598	7.4
1977	7,841	3.2
1978	8,345	6.4
1979	8,650	3.7
1980	9,623	11.2

Compound Average Annual Growth Rate

1965 through 1980 - 9.3%
1970 through 1980 - 6.8%

Year	Low Peak MW	Most Probable Peak MW	High Peak MW
1981	-	9,630	-
1982	9,439	9,972	10,422
1983	9,610	10,317	10,810
1984	9,785	10,690	11,214
1985	9,963	11,077	11,632
1986	10,205	11,445	12,256
1987	10,366	11,792	12,634
1988	10,543	12,179	13,077
1989	10,745	12,621	13,621
1990	10,941	12,858	14,145

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
1.3%	2.9%	3.9%

Table M-12

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF SYSTEM NET WINTER PEAK LOAD
(60 Minute Net)

Year	Peak MW	Annual % Change
1964-65	2,529	6.6
1965-66	2,914	15.2
1966-67	3,160	8.4
1967-68	3,789	19.9
1968-69	4,329	14.3
1969-70	4,716	8.9
1970-71	5,059	7.3
1971-72	4,816	(4.8)
1972-73	5,853	21.5
1973-74	6,258	6.9
1974-75	5,807	(7.2)
1975-76	7,287	25.5
1976-77	8,606	18.1
1977-78	8,617	0.1
1978-79	8,791	2.0
1979-80	9,732	10.7

Compound Average Annual Growth Rate

1965 through 1980 - 9.4%
1970 through 1980 - 7.5%

Forecast Assuming Normal Weather Patterns

Year	Low Peak MW	Most Probable Peak MW	High Peak MW
1980-81	-	10,015	-
1981-82	9,805	10,330	10,805
1982-83	9,845	10,660	11,385
1983-84	10,060	10,950	11,740
1984-85	10,285	11,280	12,110
1985-86	10,510	11,620	12,495
1986-87	10,745	11,965	12,885
1987-88	10,980	12,325	13,290
1988-89	11,225	12,700	13,710
1989-90	11,470	13,080	14,140

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
1.7%	3.0%	3.8%

Table M-13

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF NET ENERGY FOR COMPANY LOAD

Year	Million kWh	Annual % Change
1965	13,372	11.3
1966	15,056	12.6
1967	16,640	10.5
1968	19,347	16.3
1969	22,218	14.8
1970	25,113	13.0
1971	27,884	11.0
1972	31,498	13.0
1973	35,185	11.7
1974	35,465	0.8
1975	37,151	4.8
1976	38,025	2.4
1977	40,712	7.1
1978	43,706	7.4
1979	45,342	3.7
1980	48,450	6.9

Compound Average Annual Growth Rate

1965 through 1980 - 9.0%
1970 through 1980 - 6.8%

Year	Low Million kWh	Most Probable Million kWh	High Million kWh
1981	-	50,454	-
1982	51,781	53,000	54,930
1983	53,607	55,878	59,245
1984	55,188	58,075	61,840
1985	56,816	60,359	64,549
1986	58,493	62,733	67,376
1987	60,220	65,200	70,327
1988	61,996	67,764	73,408
1989	63,825	70,429	76,623
1990	65,709	73,199	79,980

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
3.1%	4.2%	5.1%

Table M-14

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF ENERGY SALES

Year	Million kWh	Annual % Change
1965	12,088	10.5
1966	13,736	13.6
1967	15,289	11.3
1968	17,751	16.1
1969	20,445	15.2
1970	23,115	13.1
1971	25,789	11.6
1972	28,928	12.2
1973	32,467	12.2
1974	32,711	0.8
1975	34,111	4.3
1976	34,930	2.4
1977	37,529	7.4
1978	40,602	8.2
1979	41,966	3.4
1980	44,708	6.5

Compound Average Annual Growth Rate

1965 through 1980 - 9.1%
1970 through 1980 - 6.8%

Year	Low Million kWh	Most Probable Million kWh	High Million kWh
1981	-	46,660	-
1982	47,794	48,916	50,700
1983	49,318	51,407	54,505
1984	50,773	53,429	56,893
1985	52,271	55,530	59,385
1986	53,814	57,714	61,986
1987	55,402	59,984	64,701
1988	57,036	62,343	67,535
1989	58,719	64,795	70,493
1990	60,452	67,343	73,581

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
3.1%	4.2%	5.1%

Table M-15

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF RESIDENTIAL ENERGY SALES

Year	Million kWh	Annual % Change	% System Total Sales
1965	5,540	9.5	45.8
1966	6,495	17.2	47.3
1967	7,211	11.0	47.2
1968	8,640	19.8	48.7
1969	10,277	19.0	50.3
1970	11,814	15.0	51.1
1971	13,080	10.7	50.7
1972	14,653	12.0	50.7
1973	16,823	14.8	51.8
1974	16,802	(0.1)	51.4
1975	17,313	3.0	50.8
1976	17,626	1.8	50.5
1977	19,073	8.2	50.8
1978	20,736	8.7	51.1
1979	21,062	1.6	50.2
1980	22,433	6.5	50.2

Compound Average Annual Growth Rate

1965 through 1980 - 9.8%
1970 through 1980 - 6.6%

Year	Low Million kWh	Most Probable Million kWh	High Million kWh
1981	-	23,253	-
1982	23,688	24,250	25,129
1983	24,434	25,474	27,002
1984	24,837	26,150	27,831
1985	25,292	26,845	28,736
1986	25,700	27,559	29,605
1987	26,144	28,293	30,533
1988	26,712	29,043	31,451
1989	27,026	29,817	32,449
1990	27,460	30,609	33,425

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
2.0%	3.2%	4.1%

Table M-16

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF COMMERCIAL ENERGY SALES

Year	Million kWh	Annual % Change	% System Total Sales
1965	3,793	8.5	31.4
1966	4,177	10.1	30.4
1967	4,678	12.0	30.6
1968	5,252	12.3	29.6
1969	5,689	8.3	27.8
1970	6,476	13.8	28.0
1971	7,395	14.2	28.7
1972	8,389	13.4	29.0
1973	10,180	21.3	31.4
1974	11,041	8.5	33.8
1975	11,851	7.3	34.7
1976	12,117	2.2	34.7
1977	12,885	6.3	34.3
1978	13,748	6.7	33.9
1979	14,373	4.6	34.3
1980	15,089	5.0	33.8

Compound Average Annual Growth Rate

1965 through 1980 - 9.6%
1970 through 1980 - 8.8%

Year	Low Million kWh	Most Probable Million kWh	High Million kWh
1981	-	15,571	-
1982	15,963	16,315	16,934
1983	16,374	17,071	18,096
1984	17,111	18,009	19,173
1985	17,877	18,999	20,310
1986	18,674	20,043	21,509
1987	19,502	21,144	22,775
1988	20,516	22,306	24,178
1989	21,315	23,531	25,589
1990	22,307	24,824	27,151

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
4.0%	5.1%	6.1%

Table M-17

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF INDUSTRIAL ENERGY SALES

Year	Million kWh	Annual % Change	% System Total Sales
1965	1,719	14.6	14.2
1966	1,868	8.7	13.6
1967	2,025	8.4	13.2
1968	2,217	9.5	12.5
1969	1,814	(18.2)	8.9
1970	2,044	12.7	8.8
1971	2,236	9.4	8.7
1972	2,468	10.4	8.5
1973	2,755	11.6	8.5
1974	2,646	(4.0)	8.1
1975	2,534	(4.2)	7.4
1976	2,596	2.4	7.4
1977	2,756	6.2	7.3
1978	2,993	8.6	7.4
1979	3,147	5.1	7.5
1980	3,348	6.4	7.5

Compound Average Annual Growth Rate

1965 through 1980 - 4.5%
1970 through 1980 - 5.1%

Year	Low Million kWh	Most Probable Million kWh	High Million kWh
1981	-	3,421	-
1982	3,518	3,599	3,732
1983	3,640	3,794	4,023
1984	3,681	3,874	4,125
1985	3,722	3,955	4,228
1986	3,767	4,037	4,339
1987	3,823	4,121	4,464
1988	3,868	4,208	4,559
1989	3,893	4,295	4,674
1990	3,929	4,385	4,783

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
1.6%	2.7%	3.6%

Table M-18

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF STREET AND HIGHWAY LIGHTING SALES

Year	Million kWh	Annual % Change	% System Total Sales
1965	124	11.7	1.0
1966	134	8.1	1.0
1967	153	14.2	1.0
1968	162	5.9	0.9
1969	175	8.0	0.9
1970	185	5.7	0.8
1971	204	10.3	0.8
1972	216	5.9	0.8
1973	240	11.1	0.7
1974	257	7.1	0.8
1975	285	10.9	0.8
1976	308	8.1	0.9
1977	329	6.8	0.9
1978	343	4.3	0.8
1979	358	4.4	0.9
1980	372	3.9	0.8

Compound Average Annual Growth Rate

1965 through 1980 - 7.6%
1970 through 1980 - 7.2%

Year	Low Million kWh	Most Probable Million kWh	High Million kWh
1981	-	385	-
1982	390	399	414
1983	387	405	430
1984	382	402	428
1985	372	395	422
1986	361	388	415
1987	353	382	412
1988	344	375	405
1989	336	368	400
1990	325	362	395

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
(1.3%)	(0.3%)	0.6%

Table M-19

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF OTHER SALES TO PUBLIC AUTHORITIES

Year	Million kWh	Annual % Change	% System Total Sales
1965	660	20.2	5.5
1966	741	12.3	5.4
1967	841	13.5	5.5
1968	973	15.7	5.5
1969	1,841	89.2	9.0
1970	1,810	(1.7)	7.8
1971	1,927	6.5	7.5
1972	2,080	7.9	7.2
1973	1,119	(46.2)	3.5
1974	490	(56.2)	1.5
1975	524	6.9	1.5
1976	482	(8.0)	1.4
1977	474	(1.7)	1.3
1978	478	.8	1.2
1979	463	(3.1)	1.1
1980	463	0.0	1.0

Compound Average Annual Growth Rate

1965 through 1980 - (2.3%)
1970 through 1980 - (12.7%)

Year	Low Million kWh	Most Probable Million kWh	High Million kWh
1981	-	482	-
1982	507	519	537
1983	538	559	594
1984	548	577	614
1985	565	598	641
1986	576	618	663
1987	587	638	686
1988	602	657	709
1989	617	679	740
1990	629	700	765

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
3.1%	4.2%	5.1%

Table M-20

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF SALES FOR RESALE

Year	Million kWh	Annual % Change	% System Total Sales
1965	252	14.0	2.1
1966	321	27.4	2.3
1967	381	18.7	2.5
1968	507	33.1	2.9
1969	649	28.0	3.2
1970	786	21.1	3.4
1971	947	20.5	3.7
1972	1,122	18.5	4.2
1973	1,350	20.3	4.2
1974	1,475	9.3	4.5
1975	1,604	8.7	4.7
1976	1,801	12.3	5.2
1977	2,012	11.7	5.4
1978	2,304	14.5	5.7
1979	2,563	11.2	6.1
1980	3,003	17.2	6.7

Compound Average Annual Growth Rate

1965 through 1980 - 18.0%
1970 through 1980 - 14.3%

Year	Low Million kWh	Most Probable Million kWh	High Million kWh
1981	-	3,548	-
1982	3,728	3,834	3,954
1983	3,945	4,104	4,360
1984	4,214	4,417	4,722
1985	4,443	4,738	5,048
1986	4,736	5,069	5,455
1987	4,993	5,406	5,831
1988	5,264	5,754	6,233
1989	5,532	6,105	6,641
1990	5,802	6,463	7,062

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
6.8%	8.0%	8.9%

Table M-21

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF AVERAGE CUSTOMERS*

Year	Average Customers	Annual % Change
1965	949,591	5.1
1966	1,000,020	5.3
1967	1,051,334	5.1
1968	1,109,220	5.5
1969	1,177,347	6.1
1970	1,253,124	6.4
1971	1,340,416	7.0
1972	1,446,114	7.9
1973	1,567,648	8.4
1974	1,676,035	6.9
1975	1,738,079	3.7
1976	1,795,797	3.3
1977	1,875,825	4.5
1978	1,967,364	4.9
1979	2,074,340	5.4
1980	2,184,985	5.3

Compound Average Annual Growth Rate

1965 through 1980 - 5.7%
1970 through 1980 - 5.7%

Year	Low Average Customers	Most Probable Average Customers	High Average Customers
1981	-	2,295,420	-
1982	2,331,400	2,377,045	2,407,000
1983	2,359,200	2,466,045	2,520,500
1984	2,387,100	2,555,000	2,639,400
1985	2,419,600	2,648,000	2,763,900
1986	2,482,200	2,733,000	2,860,400
1987	2,546,500	2,820,000	2,960,300
1988	2,612,400	2,910,000	3,063,600
1989	2,680,000	3,002,000	3,170,600
1990	2,749,300	3,098,000	3,281,200

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
2.3%	3.6%	4.2%

* "Average Customers" is the sum of the actual customers for each month divided by twelve.

Table M-22

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF AVERAGE RESIDENTIAL CUSTOMERS*

Year	Million kWh	Annual % Change	% System Total Sales
1965	841,604	5.4	88.6
1966	887,896	5.5	88.8
1967	934,843	5.3	88.9
1968	985,706	5.4	88.9
1969	1,045,744	6.1	88.8
1970	1,115,070	6.6	89.0
1971	1,194,015	7.1	89.1
1972	1,289,027	8.0	89.1
1973	1,397,228	8.4	89.1
1974	1,498,262	7.2	89.4
1975	1,555,834	3.8	89.5
1976	1,607,015	3.3	89.5
1977	1,677,532	4.4	89.4
1978	1,758,838	4.8	89.4
1979	1,854,884	5.5	89.4
1980	1,955,240	5.4	89.5

Compound Average Annual Growth Rate

1965 through 1980 - 5.8%
1970 through 1980 - 5.8%

Year	Low Average Customers	Most Probable Average Customers	High Average Customers
1981	-	2,051,528	-
1982	2,080,586	2,121,300	2,147,984
1983	2,104,530	2,199,808	2,248,351
1984	2,128,004	2,277,649	2,352,863
1985	2,155,375	2,358,859	2,462,286
1986	2,208,509	2,431,616	2,545,004
1987	2,264,192	2,507,413	2,632,240
1988	2,321,446	2,585,850	2,722,107
1989	2,379,957	2,665,917	2,815,574
1990	2,440,467	2,749,905	2,912,291

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
2.3%	3.5%	4.1%

* "Average Customers" is the sum of the actual customers for each month divided by twelve.

Table M-23

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF AVERAGE COMMERCIAL CUSTOMERS*

Year	Commercial Customers	Annual % Change	% System Total Sales
1965	94,929	1.8	10.0
1966	98,327	3.6	9.8
1967	101,782	3.5	9.7
1968	108,343	6.4	9.8
1969	115,712	6.8	9.8
1970	121,353	4.9	9.7
1971	129,371	6.6	9.7
1972	139,743	8.0	9.7
1973	158,977	13.8	10.1
1974	168,991	6.3	10.1
1975	171,575	1.5	9.9
1976	177,046	3.2	9.9
1977	184,676	4.3	9.9
1978	192,850	4.4	9.8
1979	202,673	5.1	9.8
1980	212,956	5.1	9.8

Compound Average Annual Growth Rate

1965 through 1980 - 5.5%
1970 through 1980 - 5.8%

Year	Low Average Customers	Most Probable Average Customers	High Average Customers
1981	-	226,777	-
1982	232,300	236,864	239,900
1983	235,900	246,613	252,100
1984	239,800	256,700	265,200
1985	243,900	266,900	278,400
1986	252,000	277,500	290,400
1987	259,200	287,000	301,200
1988	266,400	296,800	312,700
1989	274,000	306,900	324,200
1990	281,600	317,400	336,300

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
2.8%	4.1%	4.7%

* "Average Customers" is the sum of the actual customers for each month divided by twelve.

Table M-24

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF AVERAGE INDUSTRIAL CUSTOMERS*

Year	Industrial Customers	Annual % Change	% System Total Sales
1965	4,321	2.9	.46
1966	4,361	0.9	.44
1967	4,454	2.1	.42
1968	4,670	4.8	.42
1969	4.924	5.4	.42
1970	5,055	2.7	.40
1971	5,116	1.2	.40
1972	5,208	1.8	.40
1973	5,275	1.3	.30
1974	7,147	35.5	.40
1975	8,977	25.6	.50
1976	9,994	11.3	.50
1977	11,796	18.0	.60
1978	13,799	17.0	.70
1979	14,837	7.5	.70
1980	14,734	(.7)	.70

Compound Average Annual Growth Rate

1965 through 1980 - 8.5%
1970 through 1980 - 11.3%

Year	Low Average Customers	Most Probable Average Customers	High Average Customers
1981	-	14,958	-
1982	16,330	16,654	16,860
1983	16,590	17,344	17,720
1984	17,120	18,320	18,930
1985	18,150	19,860	20,730
1986	19,490	21,460	22,460
1987	20,880	23,120	24,270
1988	22,300	24,840	26,150
1989	23,770	26,630	28,130
1990	24,930	28,100	29,860

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
5.4%	6.7%	7.3%

* "Average Customers" is the sum of the actual customers for each month divided by twelve.

Table M-25

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF AVERAGE STREET AND HIGHWAY CUSTOMERS*

Year	Street & Highway Customers	Annual % Change	% System Total Sales
1965	278	12.1	-
1966	330	18.7	-
1967	523	58.5	-
1968	560	7.1	0.1
1969	683	22.0	0.1
1970	929	36.0	0.1
1971	1,015	9.3	0.1
1972	1,069	5.3	0.1
1973	1,172	9.6	0.1
1974	1,289	10.0	0.1
1975	1,328	3.0	0.1
1976	1,366	2.9	0.1
1977	1,438	5.3	0.1
1978	1,491	3.7	0.1
1979	1,553	4.2	0.1
1980	1,657	6.7	0.1

Compound Average Annual Growth Rate

1965 through 1980 - 12.6%
1970 through 1980 - 5.9%

Year	Low Average Customers	Most Probable Average Customers	High Average Customers
1981	-	1,743	-
1982	1,768	1,803	1,826
1983	1,765	1,845	1,886
1984	1,762	1,886	1,948
1985	1,759	1,925	2,009
1986	1,778	1,958	2,049
1987	1,798	1,991	2,090
1988	1,818	2,025	2,132
1989	1,837	2,058	2,173
1990	1,855	2,090	2,214

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
1.1%	2.4%	3.0%

* "Average Customers" is the sum of the actual customers for each month divided by twelve.

Table M-26

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF AVERAGE OTHER CUSTOMERS*

Year	Other Customers	Annual % Change	% System Total Sales
1965	8,437	13.2	0.9
1966	9,082	7.6	0.9
1967	9,707	6.9	0.9
1968	9,913	2.1	0.9
1969	10,255	3.5	0.9
1970	10,687	4.2	0.9
1971	10,865	1.7	0.9
1972	11,030	1.5	0.8
1973	4,957	(55.1)	0.3
1974	307	(93.8)	-
1975	325	5.9	-
1976	334	2.8	-
1977	339	1.5	-
1978	343	1.2	-
1979	350	2.0	-
1980	354	1.1	-

Compound Average Annual Growth Rate

1965 through 1980 - (19.1%)
1970 through 1980 - (28.9%)

Year	Low Average Customers	Most Probable Average Customers	High Average Customers
1981	-	367	-
1982	372	379	384
1983	371	388	397
1984	370	396	409
1985	371	406	424
1986	377	415	434
1987	383	424	445
1988	388	432	455
1989	394	441	466
1990	399	450	477

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
1.2%	2.4%	3.0%

* "Average Customers" is the sum of the actual customers for each month divided by twelve.

Table M-27

FLORIDA POWER & LIGHT COMPANY
HISTORY AND FORECAST OF AVERAGE RESALE CUSTOMERS*

Year	Other Customers	Annual % Change	% System Total Sales
1965	22	4.8	-
1966	24	9.1	-
1967	25	4.2	-
1968	28	12.0	-
1969	29	3.6	-
1970	30	3.4	-
1971	34	13.3	-
1972	37	8.8	-
1973	39	5.4	-
1974	39	0.0	-
1975	40	2.6	-
1976	42	5.0	-
1977	44	4.8	-
1978	43	(2.3)	-
1979	43	0.0	-
1980	44	2.3	-

Compound Average Annual Growth Rate

1965 through 1980 - 4.7%
1970 through 1980 - 3.9%

Year	Low Average Customers	Most Probable Average Customers	High Average Customers
1981	-	45	-
1982	44	45	46
1983	44	45	46
1984	44	49	50
1985	45	50	51
1986	46	51	53
1987	47	52	55
1988	48	53	56
1989	48	54	57
1990	49	55	58

Compound Average Annual Growth Rate
1980 Through 1990

Low	Most Probable	High
1.1%	2.3%	2.8%

* "Average Customers" is the sum of the actual customers for each month divided by twelve.

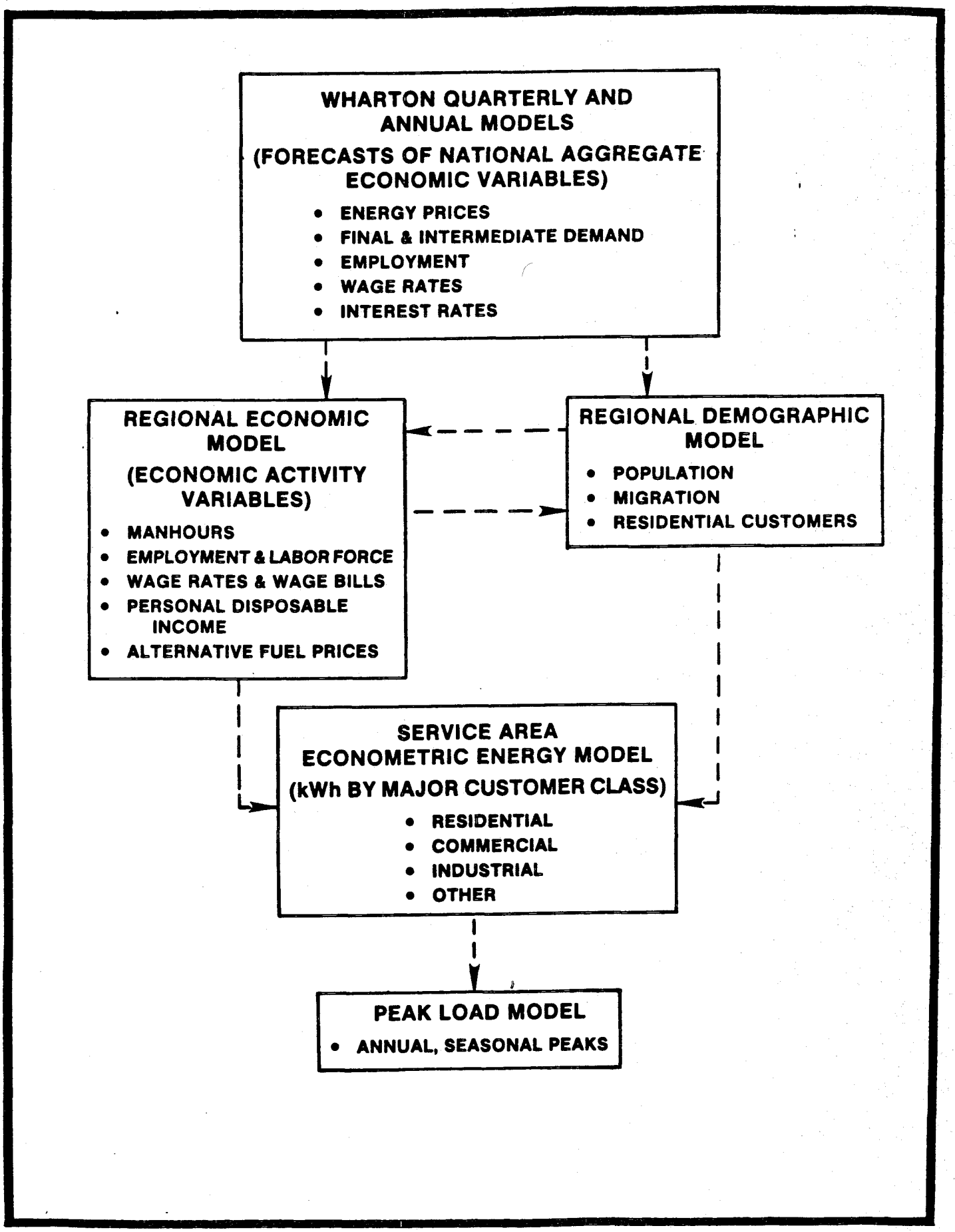


Figure M-1 Jacksonville Electric Authority-Integrated Electric Energy and Demand Forecasting System

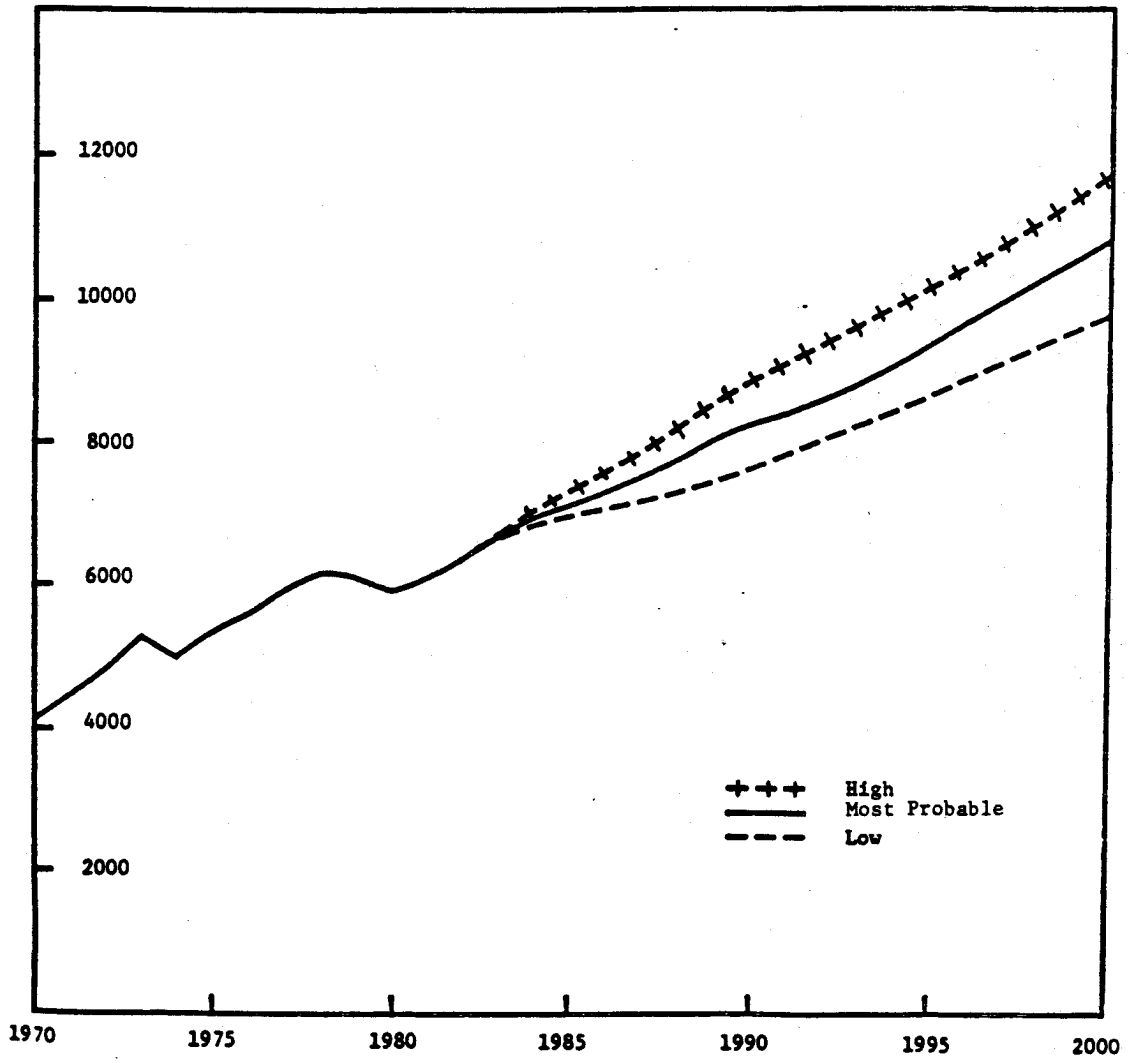


Figure M-2 Jacksonville Electric Authority - Net Energy for Load

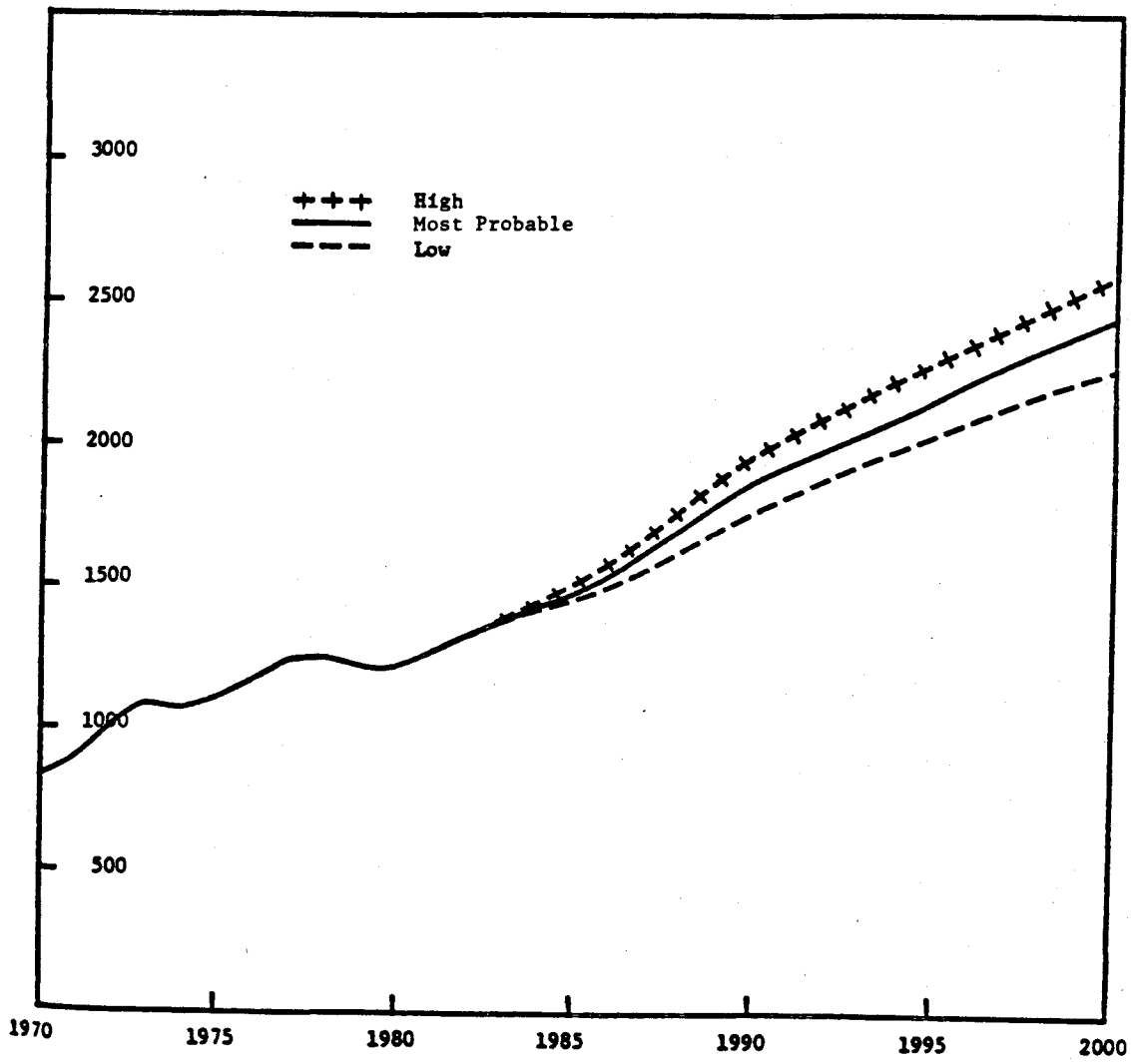


Figure M-3 Jacksonville Electric Authority - Annual System Peak Load

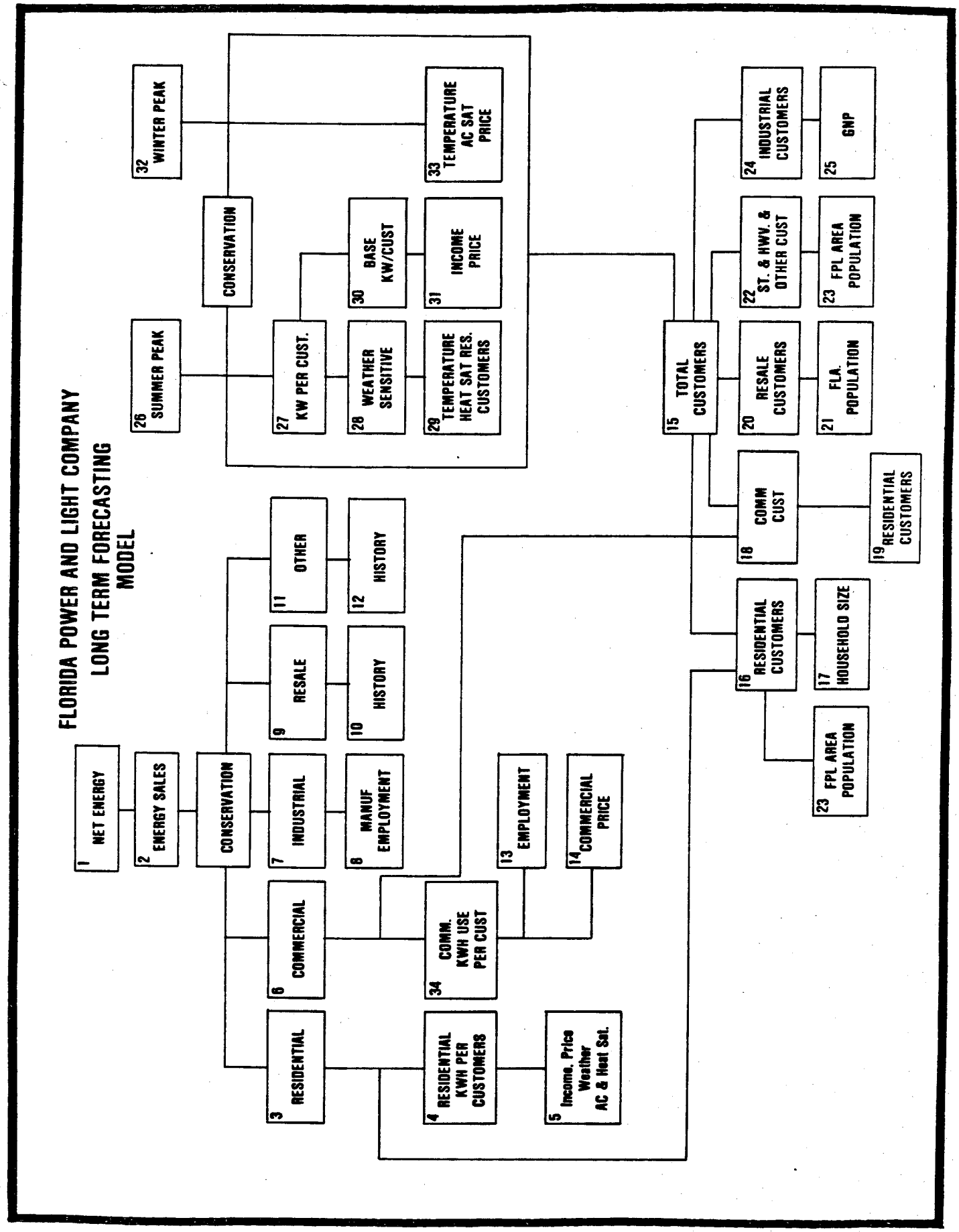


Figure M-4 Florida Power & Light Company Long Term Forecasting Model

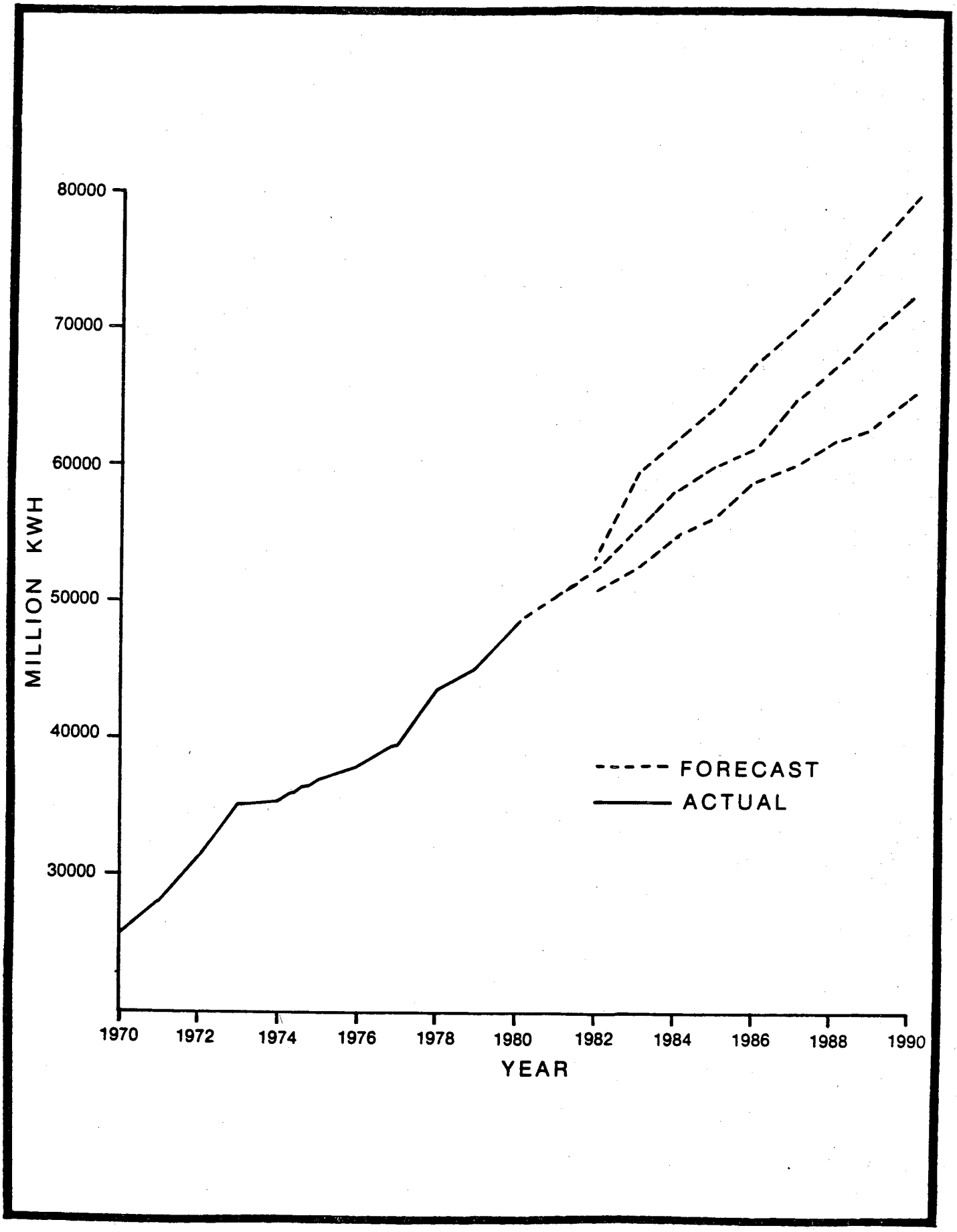


Figure M-6 Florida Power & Light Company - Ten Year Forecast - Net Energy for Company Load

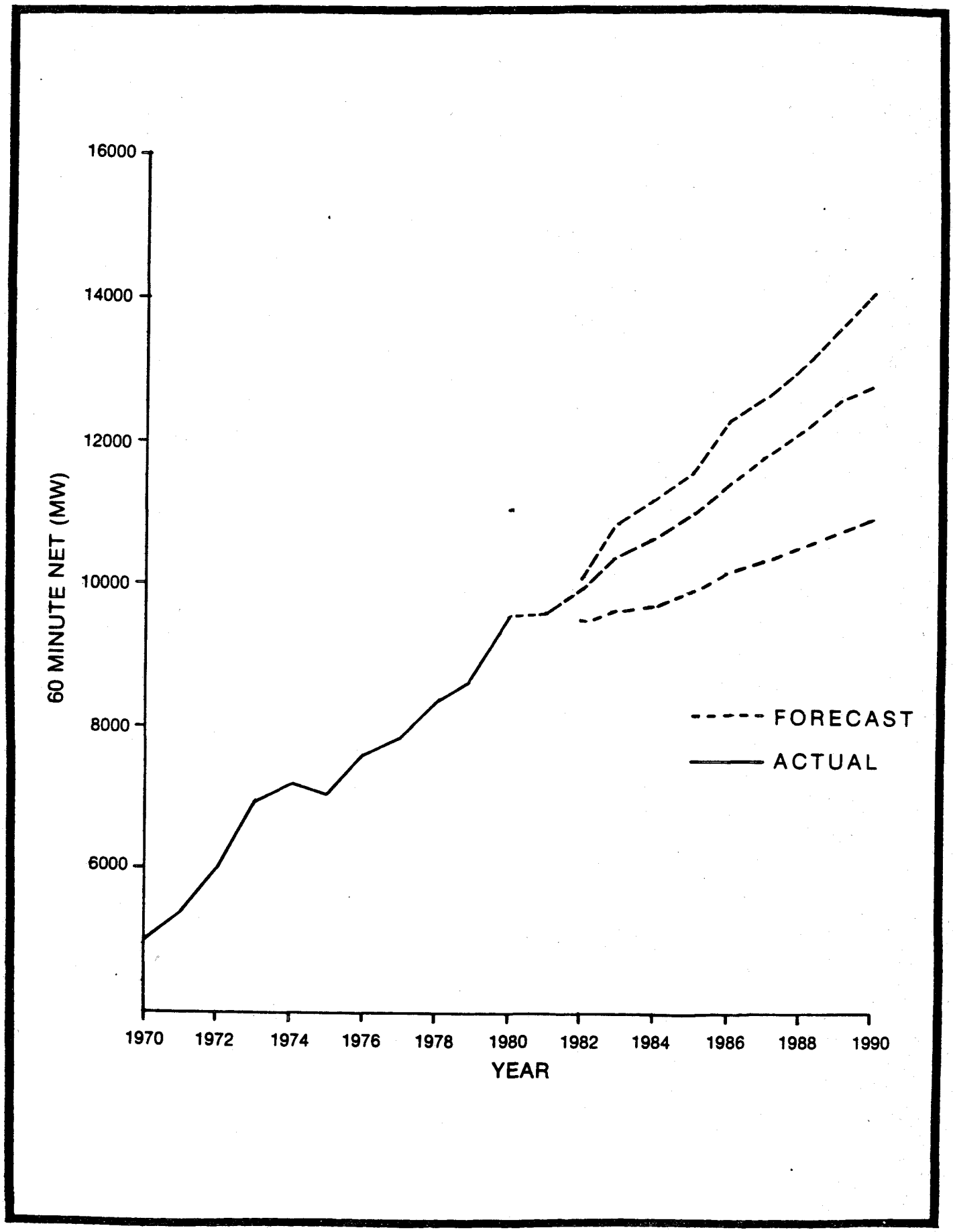


Figure M-7 Florida Power & Light Company - Ten Year Forecast - Summer Peak

N

NOISE

APPENDIX N

NOISE

APPENDIX N

NOISE SURVEY DATA SHEETS

The data sheets contained in this appendix contain detailed descriptions of each noise monitoring location, hourly L_{eq}, L_{10}, L_{50}, and L_{90} values over the 24-hour monitoring period, and a list of the monitoring equipment utilized. One data sheet was completed for each monitoring location for each of the two noise surveys.

NOISE SURVEY

MONITORING LOCATION: House - New Berlin Rd. - Nearest Residence

START DATE AND TIME: 3/6/80 1445

STOP DATE AND TIME: 3/7/80 1445

TEST DURATION: 24 HRS

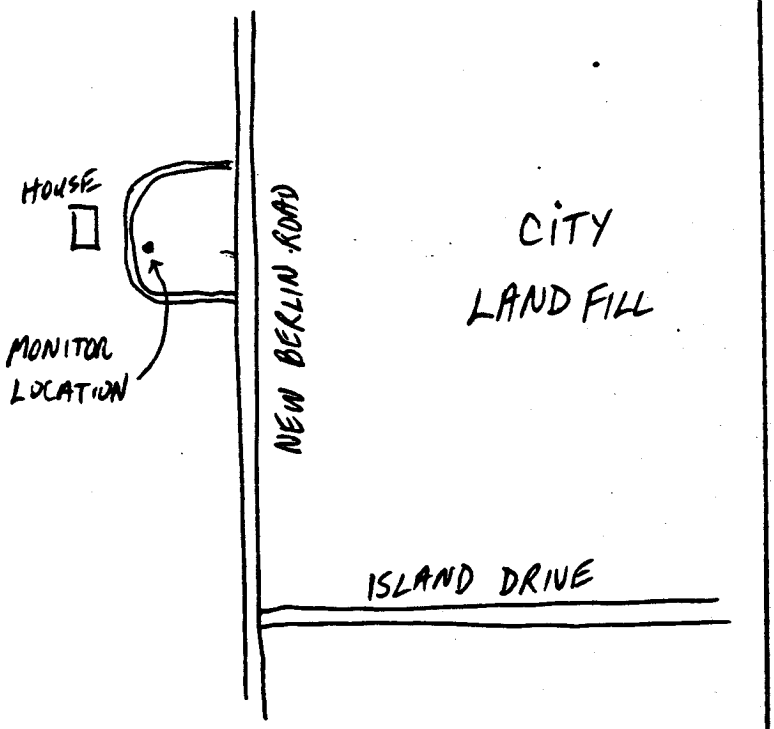
WEATHER: WIND: 10 MPH NE RAIN: 0 TEMPERATURE: 60°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: LOCATED IN FRONT YARD OF NEAREST RESIDENT, TRUCK TRAFFIC ON NEW BERLIN ROAD AND HEAVY EQUIPMENT WORKING IN LANDFILL ACROSS THE ROAD.

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	55	58	50	44
2	55	57	49	42
3	54	54	45	40
4	53	53	44	39
5	57	54	41	38
6	56	55	42	38
7	52	51	40	38
8	58*	51	40	37
9	57*	48	38	36
10	49*	43	40	36
11	46	44	39	38
12	51*	42	39	38
13	43	44	40	38
14	45	44	40	38
15	44	42	39	37
16	53	53	42	38
17	61	61	51	44
18	55	59	47	43
19	55	57	47	43
20	56	56	48	44
21	56	58	49	43
22	54*	54*	44*	40*
23	56*	58*	50*	42*
24	55*	57*	50*	45*

VOID DUE TO HIGH WIND SPEED

Sketch of Monitor Location:



MONITOR MODEL: METRASONICS DB-602 S.N. 1175

MICROPHONE MODEL: GENRAD MCL-9601 S.N. 45902

CALIBRATOR MODEL: _____ S.N. _____

CALIBRATOR OUTPUT @ 1000 Hz: _____ dB

CALIBRATION LEVEL BEFORE SAMPLE: _____ dB

CALIBRATION LEVEL AFTER SAMPLE: _____ dB

OPERATOR'S SIGNATURE: Curtis K. Churchill

NOISE SURVEY

MONITORING LOCATION: North Site Boundry

START DATE AND TIME: March 7 1510

STOP DATE AND TIME: March 8 1520

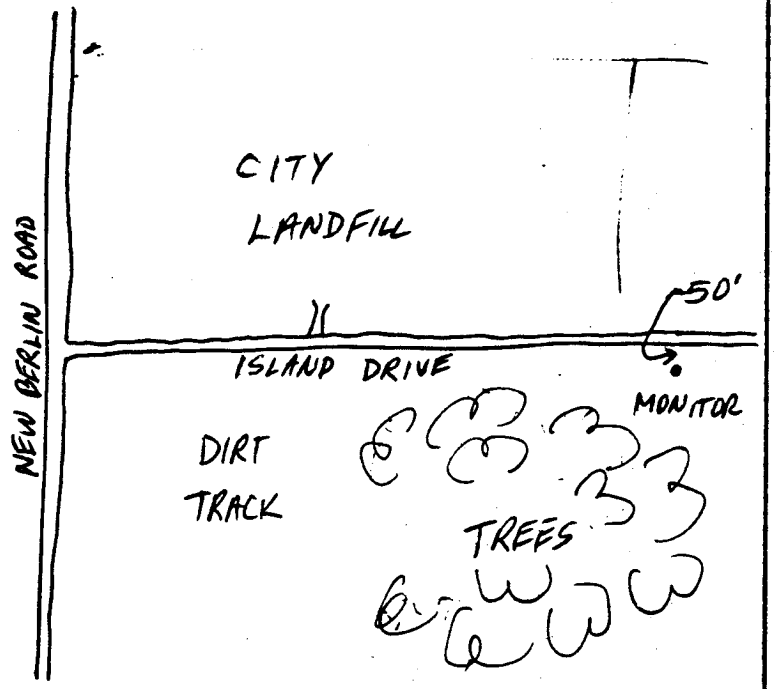
TEST DURATION: 24 Hr. 10 min.

WEATHER: WIND: 10 mph NE RAIN: 0 TEMPERATURE: 60°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: Located off dirt road in underbrush City Land Fill several hundred yards away

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	61*	51	44	39
2	49	51	44	40
3	59	57	45	40
4	55	53	45	39
5	62	61	50	42
6	49	51	44	40
7	58	57	46	40
8	55*	43	38	37
9	41	42	38	36
10	44	42	37	35
11	40	41	37	36
12	41	42	39	37
13	42	44	39	37
14	42	44	39	36
15	42	44	40	37
16	47	47	43	40
17	48	49	44	41
18	50	52	46	42
19	51	53	48	43
20	50	51	47	42
21	50	53	48	43
22	54	54	48	43
23	51	52	48	44
24	53	53	47	42

Sketch of Monitor Location:



MONITOR MODEL: METROSONICS DB-602 S.N. 1175

MICROPHONE MODEL: GENRAD 1962-9601 S.N. 45902

CALIBRATOR MODEL: _____ S.N. _____

CALIBRATOR OUTPUT @ 1000 Hz: _____ dB

CALIBRATION LEVEL BEFORE SAMPLE: _____ dB

CALIBRATION LEVEL AFTER SAMPLE: _____ dB

OPERATOR'S SIGNATURE: Curtis K Churchill

NOISE SURVEY

MONITORING LOCATION: NEW BERLIN

START DATE AND TIME: 2/6/80 1007

STOP DATE AND TIME: 2/7/80 1007

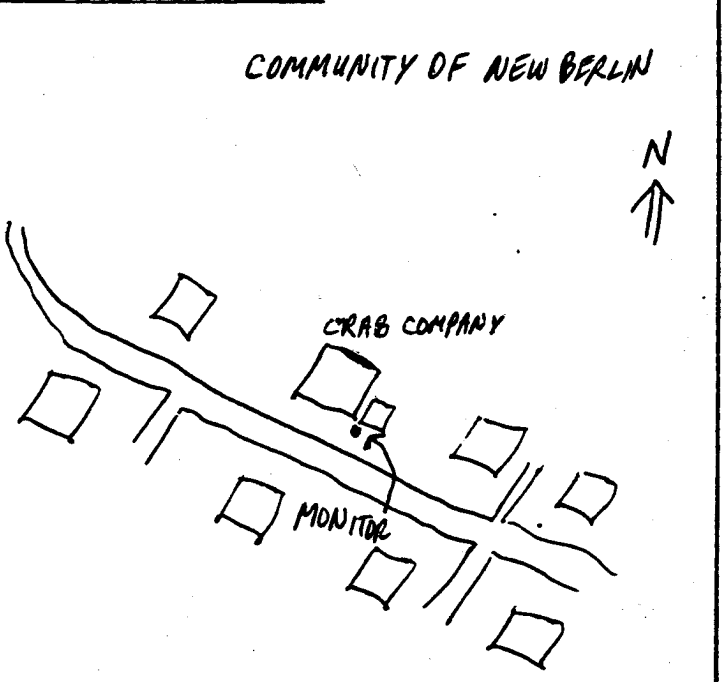
TEST DURATION: 24 HRS.

WEATHER: WIND: LIGHT RAIN: 0 TEMPERATURE: 30-40°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: LOCATED ON SHED ROOF OF CRAB COMPANY BUILDING IN THE CENTER OF THE NEW BERLIN COMMUNITY

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	57	60	52	48
2	56	57	51	48
3	60	62	56	50
4	63	61	53	49
5	58	59	51	49
6	57	59	51	47
7	58	60	52	48
8	57	58	48	47
9	56	58	48	47
10	52	51	48	48
11	54	56	48	48
12	52	54	46	45
13	49	49	46	45
14	49	48	47	46
15	48	47	46	46
16	51	50	46	46
17	49	48	46	45
18	47	49	45	44
19	46	46	44	43
20	52	54	47	45
21	55	55	48	47
22	54	54	49	48
23	57	57	51	49
24	60	63	51	47

Sketch of Monitor Location:



MONITOR MODEL: METROSONICS DB-602 S.N. 1175

MICROPHONE MODEL: GENRAD 1962-9601 S.N. 45902

CALIBRATOR MODEL: _____ S.N. _____

CALIBRATOR OUTPUT @ 1000 Hz: _____ dB

CALIBRATION LEVEL BEFORE SAMPLE: _____ dB

CALIBRATION LEVEL AFTER SAMPLE: _____ dB

OPERATOR'S SIGNATURE: Thomas L. Adams

NOISE SURVEY

MONITORING LOCATION: FISHING CAMP

START DATE AND TIME: FEB. 8 1107

STOP DATE AND TIME: FEB. 9 1543

TEST DURATION: 28 HR. 36 MIN

WEATHER: WIND: MODERATE RAIN: 0 TEMPERATURE: 35°F - 70°F

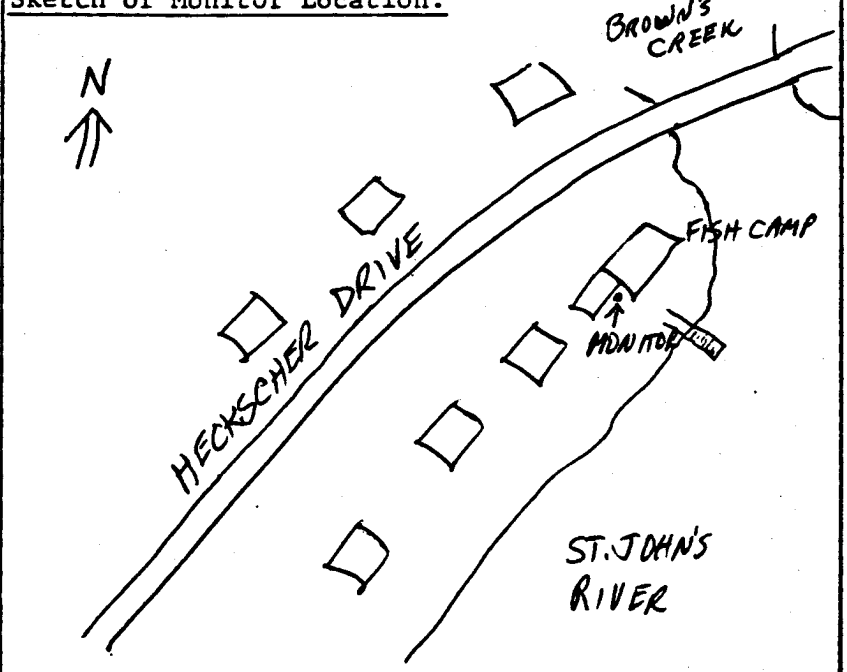
BRIEF DESCRIPTION OF NOISE ENVIRONMENT: WITHIN 100' OF PAVED ROAD AND ST. JOHN'S RIVER. LOCATION WINDY BECAUSE OF WATER NEARBY. LOCATED ON MAST ABOUT 6' ABOVE ROOF OF FISH CAMP STORE.

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	78*	80*	75*	69*
2	76*	79*	73*	65*
3	76*	79*	72*	65*
4	75*	77*	71*	64*
5	73	76	70	62
6	72	75	68	59
7	65	67	60	51
8	63	66	58	50
9	61	63	57	51
10	56	59	52	48
11	55	58	50	46
12	54	56	49	46
13	52	54	46	44
14	52	55	46	44
15	52	53	45	44
16	49	49	45	44
17	55*	47	44	44
18	48	46	44	43
19	57*	48	45	44
20	56	55	47	44
21	54	57	49	46
22	55	57	49	46
23	63	65	58	52
24	71*	73*	68*	62*

VOID DUE TO HIGH WIND (hours 1–4)

VOID DUE TO HIGH WIND (hour 24)

Sketch of Monitor Location:



MONITOR MODEL: METRASONICS DB-602 S.N. 1175

MICROPHONE MODEL: GENRAD 1962-9601 S.N. 45902

CALIBRATOR MODEL: _____ S.N. _____

CALIBRATOR OUTPUT @ 1000 Hz: _____ dB

CALIBRATION LEVEL BEFORE SAMPLE: _____ dB

CALIBRATION LEVEL AFTER SAMPLE: _____ dB

OPERATOR'S SIGNATURE: Curtis K. Churchill

NOISE SURVEY

MONITORING LOCATION: CEDAR POINT RD. AT EASTPORT SITE

START DATE AND TIME: 2/13/80 1350

STOP DATE AND TIME: 2/14/80 1527

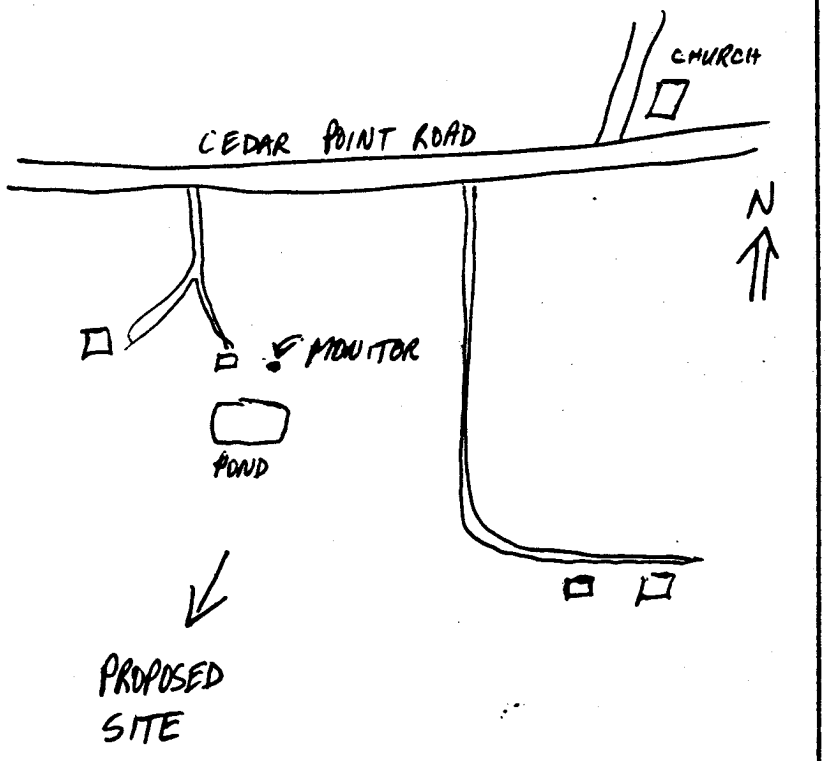
TEST DURATION: 25 HRS 37 MIN.

WEATHER: WIND: 8 MPH N-NW RAIN: 0 TEMPERATURE: 39-63°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: LOCATED AT AIR QUALITY TRAILER IN COW PASTURE. OCCASSIONAL AIRCRAFT AND LIGHT TRAFFIC ON ROAD 200 YDS. NORTH.

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	48	48	42	38
2	47	49	44	41
3	46	48	43	39
4	44	45	41	38
5	48	47	42	38
6	44	45	40	36
7	45	46	41	36
8	44	46	38	35
9	48	47	39	36
10	56*	48	41	37
11	45	45	36	34
12	58*	52	38	34
13	49*	43	36	33
14	57*	41	35	34
15	45*	41	35	33
16	38	37	35	34
17	43	43	39	36
18	43	45	41	38
19	45	47	41	38
20	51	53	46	41
21	50	52	45	40
22	55	58	49	41
23	57	60	51	42
24	57	60	52	44

Sketch of Monitor Location:



MONITOR MODEL: METROSONICS DB-602 S.N. 1175

MICROPHONE MODEL: GENRAD 1962-9601 S.N. 45902

CALIBRATOR MODEL: _____ S.N. _____

CALIBRATOR OUTPUT @ 1000 Hz: _____ dB

CALIBRATION LEVEL BEFORE SAMPLE: _____ dB

CALIBRATION LEVEL AFTER SAMPLE: _____ dB

OPERATOR'S SIGNATURE: Curtis K. Churchill

NOISE SURVEY

MONITORING LOCATION: Outside Main Guard Gate - JEA Northside Station

START DATE AND TIME: 2/14/80 1618

STOP DATE AND TIME: 2/16/80 1300

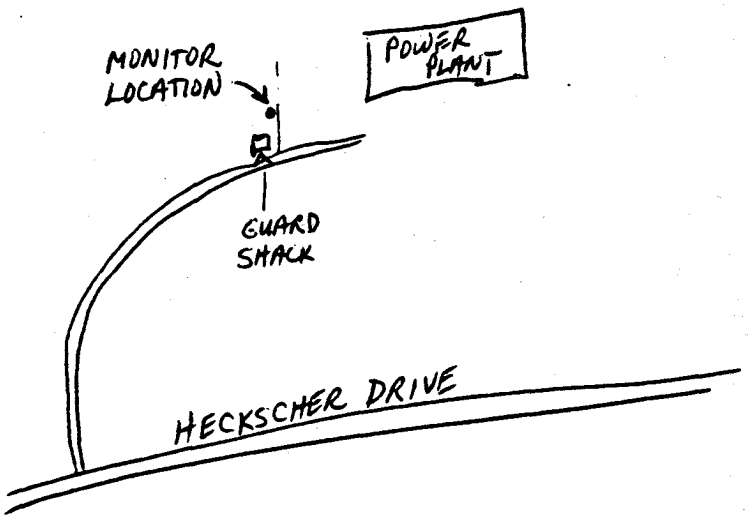
TEST DURATION: 44 HRS. 42 MIN.

WEATHER: WIND: 8 MPH NE RAIN: 0.05" TEMPERATURE: 45-60°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: About 100 yards from oil-fired power plant steady noise level from plant with occassional vehicle traffic in + out of gate

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	65	67	60	57
2	87*	92*	61*	57*
3	88*	91*	59*	55*
4	58	58	56	54
5	58	59	54	53
6	61	60	59	59
7	62	62	60	59
8	64	65	62	61
9	64	61	59	58
10	60	59	59	58
11	60	60	59	58
12	60	60	59	59
13	61	60	60	59
14	61	60	60	59
15	61	61	60	59
16	61	61	60	59
17	64	66	60	59
18	67	70	62	59
19	64	64	59	58
20	62	61	59	58
21	71	73	63	59
22	75	78	70	62
23	76	79	71	63
24	76	80	72	63

Sketch of Monitor Location:



MONITOR MODEL: Metrasonics DB-602 S.N. 1175

MICROPHONE MODEL: Gencom 1962-9601 S.N. 45902

CALIBRATOR MODEL: _____ S.N. _____

CALIBRATOR OUTPUT @ 1000 Hz: _____ dB

CALIBRATION LEVEL BEFORE SAMPLE: _____ dB

CALIBRATION LEVEL AFTER SAMPLE: _____ dB

OPERATOR'S SIGNATURE: Curtis K. Churchill

NOISE SURVEY

MONITORING LOCATION: HOUSE 11572 NEW BERLIN ROAD

START DATE AND TIME: 7/18/80 1308 NEAREST RESIDENCE

STOP DATE AND TIME: 7/19/80 1832

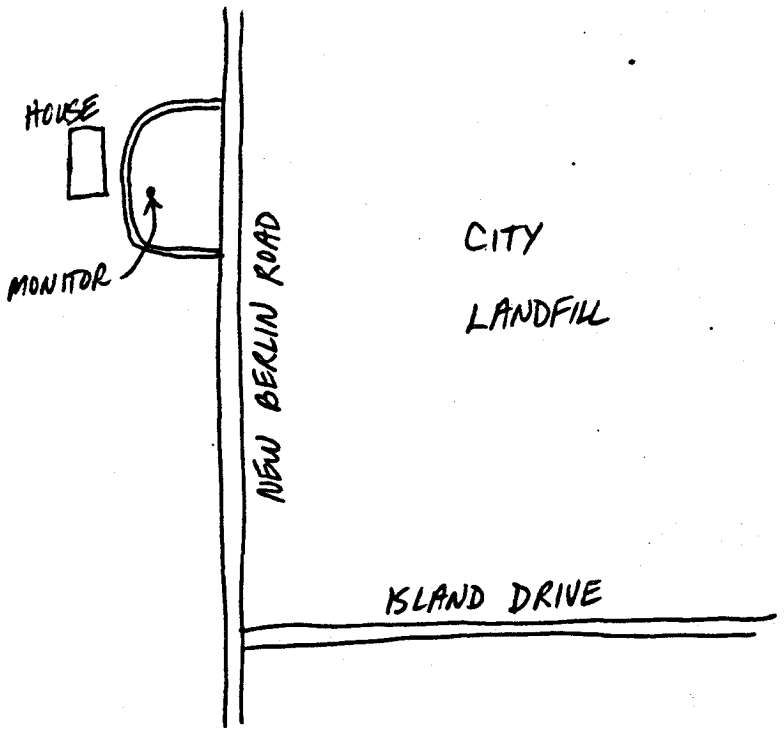
TEST DURATION: 29 HRS. 24 MIN.

WEATHER: WIND: SSE 5-10 MPH RAIN: 0 TEMPERATURE: 80-90°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: LOCATED ON NEW BERLIN ROAD ACROSS FROM CITY LANDFILL ABOUT 100' FROM TWO LANE MEDIUM TRAFFIC ROAD

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	56	58	52	45
2	57	59	53	47
3	59	61	55	47
4	57	58	53	47
5	58	60	54	47
6	55	57	52	41
7	52	53	46	37
8	58	58	57	55
9	51	55	41	36
10	49	51	42	37
11	46	47	38	35
12	47	43	36	34
13	44	43	38	36
14	42	43	37	35
15	44	44	39	36
16	44	43	38	36
17	46	45	40	37
18	48	49	42	38
19	48	49	42	38
20	49	50	42	38
21	51	53	45	41
22	54	58	49	41
23	54	57	49	41
24	54	58	47	38

Sketch of Monitor Location:



MONITOR MODEL: METROSONICS DB602 S.N. 1175

MICROPHONE MODEL: GENRAD 1962-9601 S.N. 45902

CALIBRATOR MODEL: C1-301 S.N. 046831

CALIBRATOR OUTPUT @ 1000 Hz: 102 dB

CALIBRATION LEVEL BEFORE SAMPLE: 102 dB

CALIBRATION LEVEL AFTER SAMPLE: 102 dB

OPERATOR'S SIGNATURE: Curtis K Churchill

NOISE SURVEY

MONITORING LOCATION: Island Drive Across From Land Fill

START DATE AND TIME: 7/19/80 1917

STOP DATE AND TIME: 7/21/80 1049

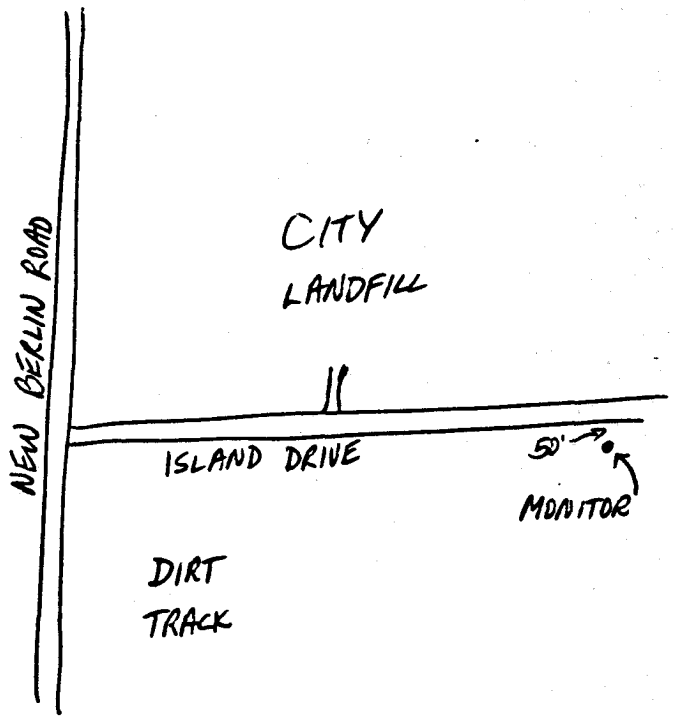
TEST DURATION: 39 HRS.

WEATHER: WIND: SE 12 MPH RAIN: 0.02 TEMPERATURE: 85°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: 100' From little used unpaved Road Across From Land Fill

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	59*	51*	36*	30*
2	47	43	31	30
3	44	41	33	30
4	45	47	38	31
5	50	52	44	38
6	50	52	42	36
7	50	53	43	37
8	50	52	42	35
9	50	53	42	36
10	51	54	45	38
11	49	51	41	34
12	48	50	42	35
13	49	51	42	34
14	47	50	40	31
15	51	54	43	33
16	49	51	45	43
17	44	45	43	41
18	44	44	42	41
19	45	45	43	41
20	45	45	44	41
21	42	43	40	39
22	44	44	43	39
23	40	43	33	31
24	33	33	30	30

Sketch of Monitor Location:



MONITOR MODEL: Metrosonics DB 602 S.N. 1175

MICROPHONE MODEL: Genrad 1962-9601 S.N. 45902

CALIBRATOR MODEL: C1-301 S.N. 046831

CALIBRATOR OUTPUT @ 1000 Hz: 102 dB

CALIBRATION LEVEL BEFORE SAMPLE: 102 dB

CALIBRATION LEVEL AFTER SAMPLE: 102 dB

OPERATOR'S SIGNATURE: Curtis K. Churchill

NOISE SURVEY

MONITORING LOCATION: CRAB FACTORY NEW BERLIN ROAD

START DATE AND TIME: 7/21/80 1138

STOP DATE AND TIME: 7/22/80 1210

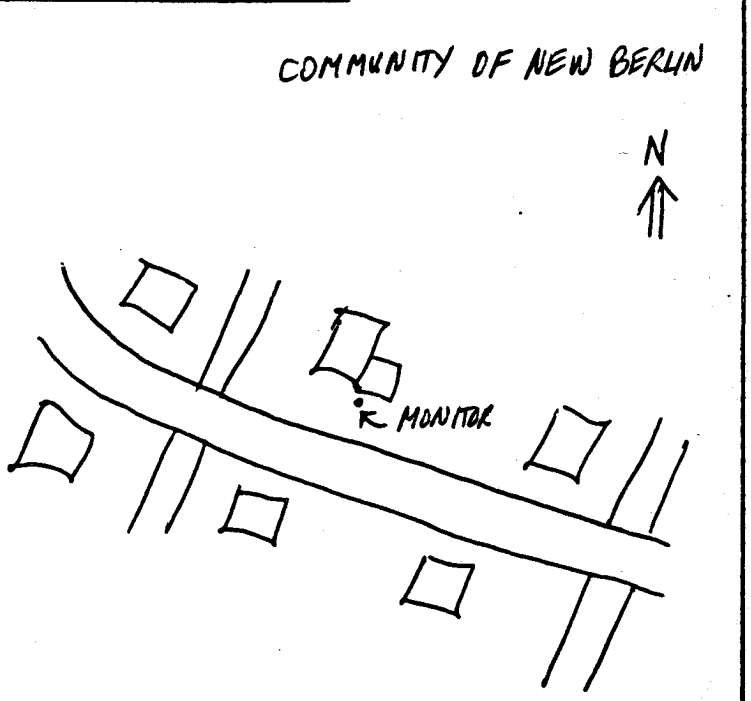
TEST DURATION: 24 HRS. 32 MIN.

WEATHER: WIND: SE 10-15 MPH RAIN: 0.03 TEMPERATURE: 85°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: MONITOR ON ROOF OF CRAB FACTORY IN RESIDENTIAL AREA

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	60	62	56	52
2	57	58	53	51
3	59	59	53	51
4	61	63	54	52
5	62	62	53	51
6	59	60	53	51
7	59	57	51	49
8	57	56	49	46
9	55	57	51	48
10	57	57	53	52
11	55	53	52	50
12	54	52	50	50
13	56	55	50	49
14	51	50	50	48
15	144*	52	51	50
16	53	52	51	50
17	53	51	51	50
18	51	50	49	49
19	58	59	52	49
20	56	58	52	49
21	57	57	53	51
22	62	61	54	52
23	30*	43*	33*	31*
24	64	63	54	51

Sketch of Monitor Location:



MONITOR MODEL: METROSONICS DB-602 S.N. 1175

MICROPHONE MODEL: GENRAD 1962-9601 S.N. 45902

CALIBRATOR MODEL: CI-301 S.N. 046831

CALIBRATOR OUTPUT @ 1000 Hz: 102 dB

CALIBRATION LEVEL BEFORE SAMPLE: 102 dB

CALIBRATION LEVEL AFTER SAMPLE: 102 dB

OPERATOR'S SIGNATURE: Curtis Churchill

NOISE SURVEY

MONITORING LOCATION: FISH CAMP

START DATE AND TIME: 7/26/80 1956

STOP DATE AND TIME: 7/28/80 1007

TEST DURATION: 38 HRS 11 MIN

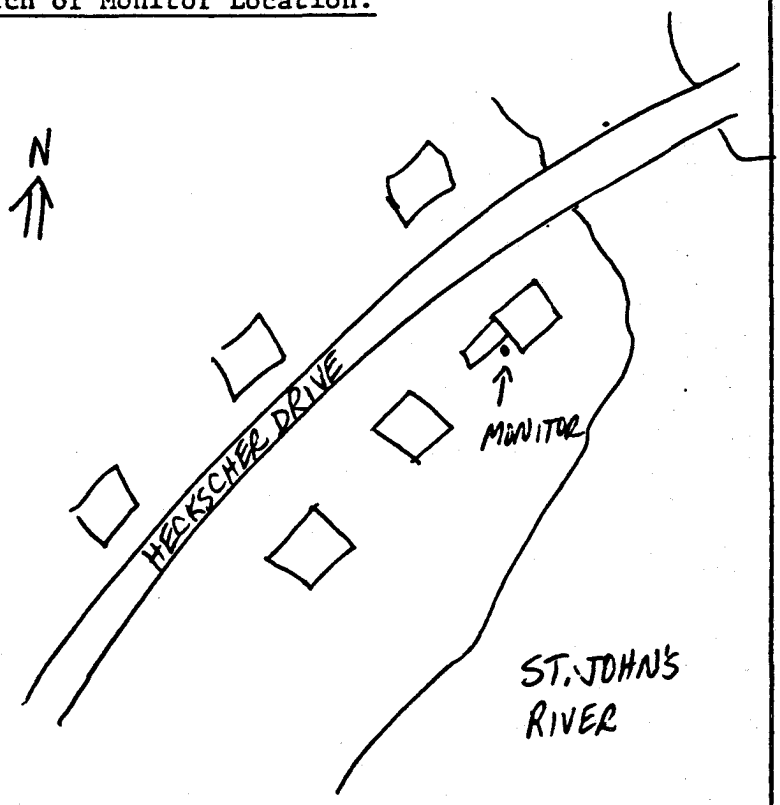
WEATHER: WIND: W 5 MPH RAIN: 0 TEMPERATURE: 85°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: LOCATED ON ROOF OF FISH CAMP IN RESIDENTAL AREA ABOUT 100' FROM HECKSCHER DRIVE

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	59	61	56	54
2	58	59	55	54
3	61	63	56	54
4	59	61	55	53
5	57	59	53	52
6	57	57	53	52
7	56	56	53	52
8	55	55	52	51
9	60*	54	51	50
10	58*	53	51	50
11	63*	59	52	51
12	57	58	53	52
13	57	58	53	51
14	57	59	54	52
15	59	61	54	52
16	59	61	55	52
17	63	65	59	54
18	66	69	61	55
19	70*	71*	60*	55*
20	75*	78*	72*	65*
21	78*	80*	75*	68*
22	70*	73*	64*	54*
23	69	69	59	53
24	59	60	54	52

HIGH WIND (rows 19–22)

Sketch of Monitor Location:



MONITOR MODEL: METROSONICS DB-602 S.N. 1175

MICROPHONE MODEL: GR 962-9601 S.N. 45902

CALIBRATOR MODEL: CI-301 S.N. 046831

CALIBRATOR OUTPUT @ 1000 Hz: 102 dB

CALIBRATION LEVEL BEFORE SAMPLE: 102 dB

CALIBRATION LEVEL AFTER SAMPLE: 102 dB

OPERATOR'S SIGNATURE: Curtis K. Churchill

NOISE SURVEY

MONITORING LOCATION: EASTPORT AIR QUALITY SITE

START DATE AND TIME: 7/15/80 1707

STOP DATE AND TIME: 7/16/80 1707

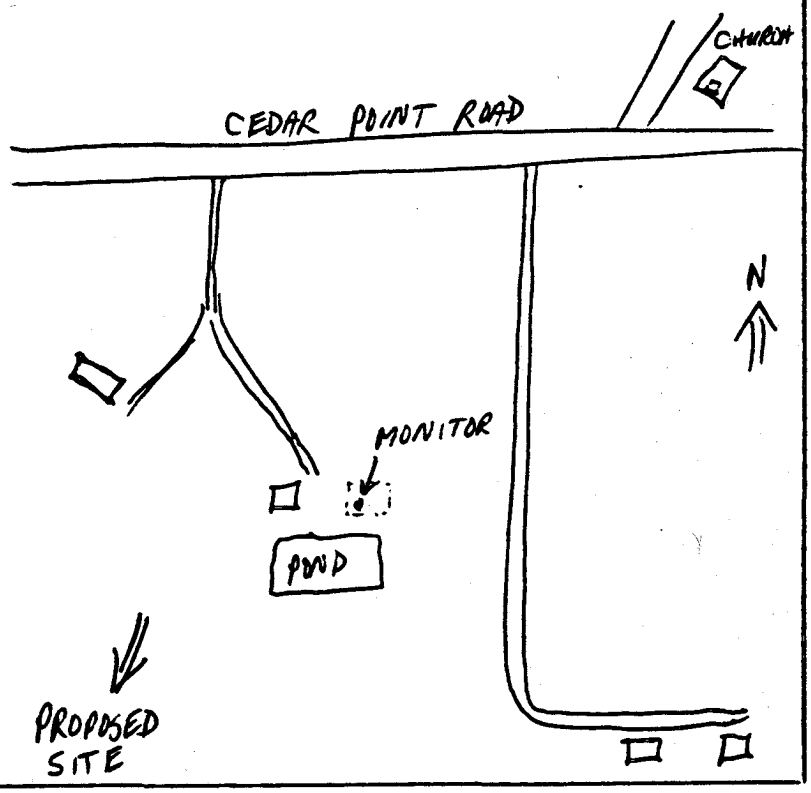
TEST DURATION: 24 HRS.

WEATHER: WIND: NE 5-10 mph RAIN: 0 TEMPERATURE: 72-85°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: OPEN PASTURE APPROX. 100 METERS FROM LIGHTLY TRAVELED TWO LANE PAVED ROAD

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	59	60	51	44
2	53	54	48	44
3	49	51	46	44
4	49	50	47	44
5	48	48	47	44
6	46	47	43	42
7	44	44	42	41
8	43	43	40	39
9	42	41	39	38
10	41	40	39	38
11	40	40	38	38
12	40	41	38	37
13	43	44	40	38
14	48	49	44	37
15	48	46	43	41
16	55*	47	42	40
17	46	48	42	39
18	45	47	41	39
19	46	49	42	40
20	51	54	46	40
21	53	56	47	41
22	53	55	46	40
23	54	57	48	41
24	53	56	47	42

Sketch of Monitor Location:



MONITOR MODEL: METRONICS DB-602 S.N. 1175

MICROPHONE MODEL: GENRAD 1962-9601 S.N. 45902

CALIBRATOR MODEL: CI-301 S.N. 046831

CALIBRATOR OUTPUT @ 1000 Hz: 102 dB

CALIBRATION LEVEL BEFORE SAMPLE: 102 dB

CALIBRATION LEVEL AFTER SAMPLE: 102 dB

OPERATOR'S SIGNATURE: Curtis K Churchill

NOISE SURVEY

MONITORING LOCATION: SEA GUARD SHACK (NORTHSIDE)

START DATE AND TIME: 7/16/80 1817

STOP DATE AND TIME: 7/18/80 1040

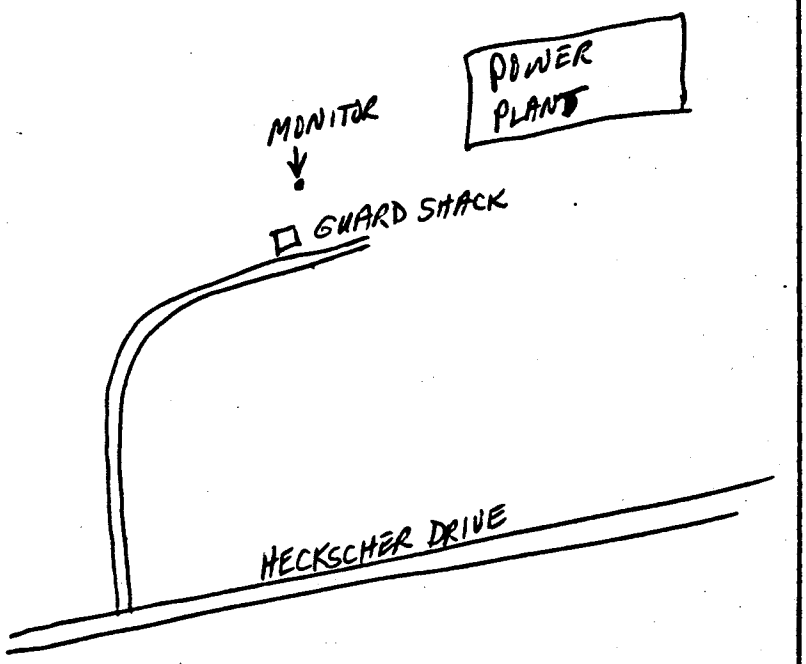
TEST DURATION: 40 HRS. 23 MIN.

WEATHER: WIND: SE 10 MPH RAIN: 0 TEMPERATURE: 75-90 °F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: NEAR (10 YDS) GUARD SHACK OF POWER PLANT CONSTANT NOISE

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	63	63	62	61
2	63	63	62	61
3	63	62	62	61
4	63	63	62	62
5	64	64	63	62
6	64	64	63	62
7	64	64	63	63
8	65	65	64	63
9	64	64	63	62
10	64	64	63	62
11	65	65	64	62
12	64	64	63	62
13	66	66	65	63
14	65	65	64	63
15	64	63	62	61
16	63	63	62	61
17	63	63	62	61
18	63	63	62	61
19	64	64	62	61
20	65	66	63	62
21	65	65	63	62
22	64	65	63	62
23	63	63	62	61
24	64	64	62	61

Sketch of Monitor Location:



MONITOR MODEL: METROSONICS DB-602 S.N. 1175

MICROPHONE MODEL: GENRAD 1962-9601 S.N. 45902

CALIBRATOR MODEL: C1-301 S.N. 046831

CALIBRATOR OUTPUT @ 1000 Hz: 102 dB

CALIBRATION LEVEL BEFORE SAMPLE: 102 dB

CALIBRATION LEVEL AFTER SAMPLE: 102 dB

OPERATOR'S SIGNATURE: Curtis K Churchill

NOISE SURVEY

MONITORING LOCATION: BLOUNT ISLAND

START DATE AND TIME: 7/28/80 1055

STOP DATE AND TIME: 7/29/80 1055

TEST DURATION: 24 HRS.

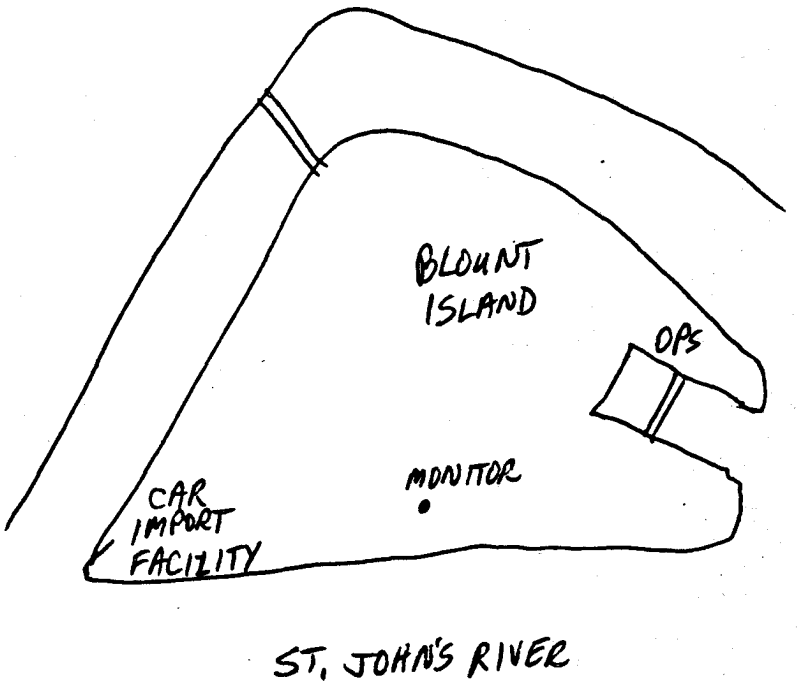
WEATHER: WIND: SW 5MPH RAIN: 0 TEMPERATURE: 85°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: MONITOR LOCATED IN OPEN AREA NEAR CAR IMPORT FACILITY

HOUR	La L_{eq}	Lb L_{10}	Lc L_{50}	Ld L_{90}
1	56	58	50	46
2	63	66	55	47
3	64	67	56	47
4	65	67	57	47
5	69*	72*	62*	50*
6	69*	72*	62*	50*
7	69*	72*	63*	52*
8	70*	72*	65*	54*
9	70*	73*	63*	51*
10	62	64	48	40
11	49	50	46	42
12	59	61	51	42
13	62	64	53	43
14	61	65	54	45
15	56	58	49	43
16	48	50	45	42
17	48	48	43	36
18	50	52	44	36
19	53	55	45	38
20	52	54	46	38
21	55	57	47	40
22	61	64	54	47
23	60	62	53	49
24	61	63	54	49

H WINDS

Sketch of Monitor Location:



MONITOR MODEL: METROSONICS DB 602 S.N. 42935

MICROPHONE MODEL: GENRAD M62-9601 S.N. 45902

CALIBRATOR MODEL: C1-301 S.N. 46831

CALIBRATOR OUTPUT @ 1000 Hz: 102 dB

CALIBRATION LEVEL BEFORE SAMPLE: 102 dB

CALIBRATION LEVEL AFTER SAMPLE: 102 dB

OPERATOR'S SIGNATURE: Curtis K. Churchill

NOISE SURVEY

MONITORING LOCATION: BEACON HILLS

START DATE AND TIME: 8/10/80 2200

STOP DATE AND TIME: 8/11/80 2200

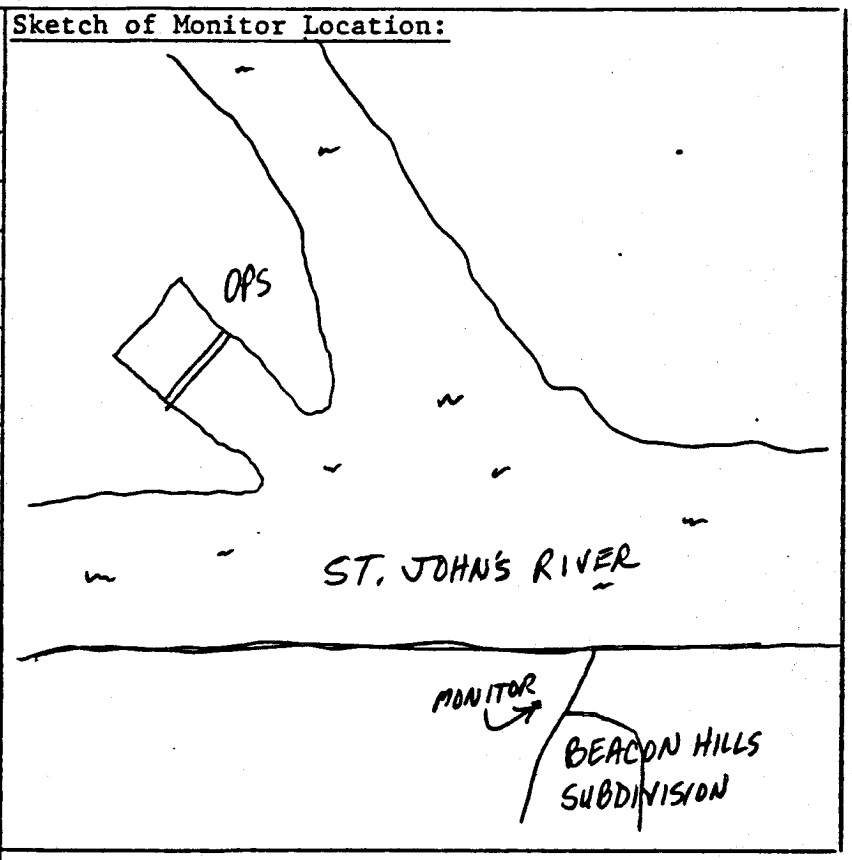
TEST DURATION: 24 HRS

WEATHER: WIND: SE 5 RAIN: 0 TEMPERATURE: 85°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: QUIET RESIDENTAL

HOURS		1400-2200	2200-0600	0600-1400
1	L_{max}	75	61	63
2	L.01	63	58	61
3	L1	59	54	59
4	L10	53	52	56
5	L50	48	50	53
6	L90	41	44	50
7	L99	38	36	45
8	L_{min}	36	34	42
9	.5/24	57	52	58
10	1/24	55	52	56
11	8/24	52	51	53
12	.5/8	54	52	56
13	L2	57	52	58
14	L5	54	52	56
15	L20	52	51	55
16	L_{eq}	51	50	53
17				
18				
19				
20				
21				
22				
23				
24				

Sketch of Monitor Location:



MONITOR MODEL: GENRAD 1945 S.N. 283

MICROPHONE MODEL: GENRAD 1962-9601 S.N. 10865

CALIBRATOR MODEL: GR 1562A S.N. 090259

CALIBRATOR OUTPUT @ 1000 Hz: 114 dB

CALIBRATION LEVEL BEFORE SAMPLE: 114 dB

CALIBRATION LEVEL AFTER SAMPLE: 114 dB

OPERATOR'S SIGNATURE: Curtis K. Churchill

NOISE SURVEY

MONITORING LOCATION: DAME POINT

START DATE AND TIME: 8/9/80 1400

STOP DATE AND TIME: 8/10/80 1400

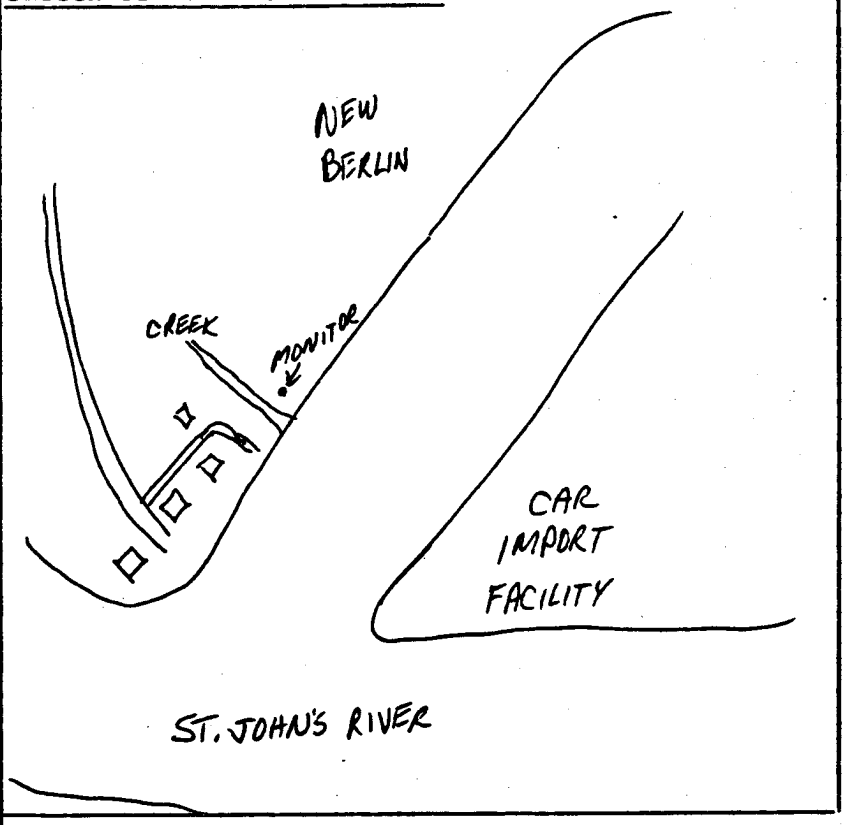
TEST DURATION: 24 HRS.

WEATHER: WIND: SE 10 MPH RAIN: 0 TEMPERATURE: 85°F

BRIEF DESCRIPTION OF NOISE ENVIRONMENT: MONITOR LOCATED IN EDGE OF BRUSH ABOUT 50' FROM RIVER ACROSS FROM CAR IMPORT FACILITY

HOUR		1400-2200	2200-0600	0600-1400
1	LMAX	102	75	79
2	L.01	84	71	74
3	L1	72	59	66
4	L10	61	53	62
5	L50	54	48	54
6	L90	48	45	47
7	L99	43	43	39
8	LMIN	41	42	38
9	.5/24	71	56	65
10	1/24	68	54	64
11	8/24	56	50	56
12	.5/8	63	53	64
13	L2	71	56	65
14	L5	66	54	64
15	L20	58	51	58
16	L66	65	51	61
17				
18				
19				
20				
21				
22				
23				
24				

Sketch of Monitor Location:



MONITOR MODEL: GENRAD 1945 S.N. 283

MICROPHONE MODEL: GENRAD 1962-9601 S.N. 10865

CALIBRATOR MODEL: GR 1562A S.N. 090259

CALIBRATOR OUTPUT @ 1000 Hz: 114 dB

CALIBRATION LEVEL BEFORE SAMPLE: 114 dB

CALIBRATION LEVEL AFTER SAMPLE: 114 dB

OPERATOR'S SIGNATURE: Curtis K. Churchill

O

PERMIT APPLICATIONS

APPENDIX O

PERMIT APPLICATIONS

TABLE OF CONTENTS

APPENDIX O

PERMIT APPLICATIONS

Section

O.1 JOINT APPLICATION, DEPARTMENT OF THE ARMY/FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION FOR ACTIVITIES IN WATERS OF THE STATE OF FLORIDA

O.2 NATIONAL POLLUTION DISCHARGE ELIMINATION SYSTEM APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER

O.3 USEPA HAZARDOUS WASTE PERMIT APPLICATION

0.1 JOINT APPLICATION, DEPARTMENT OF THE ARMY/FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION FOR ACTIVITIES IN WATERS OF THE STATE OF FLORIDA

FORM APPROVED
OMB No. 158-R0100

FOR AGENCY USE

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
APPLICATION FOR PERMIT TO DISCHARGE WASTEWATER

STANDARD FORM C – MANUFACTURING AND COMMERCIAL

SECTION I. APPLICANT AND FACILITY DESCRIPTION

Unless otherwise specified on this form all items are to be completed. If an item is not applicable indicate 'NA.'

ADDITIONAL INSTRUCTIONS FOR SELECTED ITEMS APPEAR IN SEPARATE INSTRUCTION BOOKLET AS INDICATED. REFER TO BOOKLET BEFORE FILLING OUT THESE ITEMS.

Please Print or Type

1. **Legal Name of Applicant** (see instructions)	101	JACKSONVILLE ELECTRIC AUTHORITY
2. **Mailing Address of Applicant** (see instructions) Number & Street	102a	233 WEST DUVAL STREET
City	102b	JACKSONVILLE
State	102c	FLORIDA
Zip Code	102d	32201
3. **Applicant's Authorized Agent** (see instructions) Name and Title	103a	D. A. MOEHLE DIVISION CHIEF, NEW FOSSIL GENERATION
Number & Street Address	103b	233 WEST DUVAL STREET
City	103c	JACKSONVILLE
State	103d	FLORIDA
Zip Code	103e	32201
Telephone	103f	904 (Area Code) 633-3665 (Number)
4. **Previous Application** If a previous application for a National or Federal discharge permit has been made, give the date of application. Use numeric designation for date.	104	81-2-17 (YR MO DAY)

I certify that I am familiar with the information contained in this application and that to the best of my knowledge and belief such information is true, complete, and accurate.

Royce Lyles Printed Name of Person Signing	102e	Managing Director Title
Signature of Applicant or Authorized Agent	102f	81-8-14 (YR MO DAY) Date Application Signed

18 U.S.C. Section 1001 provides that:

Whoever, in any matter within the jurisdiction of any department or agency of the United States knowingly and wilfully falsifies, conceals or covers up by any trick, scheme, or device a material fact, or makes any false, fictitious or fraudulent statement or representation, or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years, or both.

FOR AGENCY USE

Received ___ ___ ___ (YR MO DAY)

OFFICE: ___EPA Region Number
___State

FOR AGENCY USE

5. **Facility/Activity** (see instructions) Give the name, ownership, and physical location of the plant or other operating facility where discharge(s) does or will occur.

Name	105a	ST. JOHNS RIVER POWER PARK UNITS 1 & 2
Ownership (Public, Private or Both Public and Private)	105b	☒ PUB ☐ PRV ☐ BPP
Check block if Federal Facility and give GSA Inventory Control Number	105c	☐ FED
	105d	
Location Street & Number	105e	NEW BERLIN ROAD & ISLAND DRIVE
City	105f	JACKSONVILLE
County	105g	DUVAL
State	105h	FLORIDA

6. **Nature of Business** State the nature of the business conducted at the plant or operating facility.

	106a	STEAM ELECTRIC POWER GENERATION
	106b	AGENCY USE

7. **Facility Intake Water** (see instructions) Indicate water intake volume per day by sources. Estimate average volume per day in thousand gallons per day.

Municipal or private water system	107a	_____ thousand gallons per day
Surface water	107b	49,536 thousand gallons per day
Groundwater	107c	3,807 thousand gallons per day
Other*	107d	229 thousand gallons per day
Total Item 7	107e	53,572 thousand gallons per day
*If there is intake water from 'other,' specify the source.	107f	RAINFALL

8. **Facility Water Use** Estimate average volume per day in thousand gallons per day for the following types of water usage at the facility. (see instructions)

Noncontact cooling water	108a	49,536 thousand gallons per day
Boiler feed water	108b	131 thousand gallons per day
Process water (including contact cooling water)	108c	3,890 thousand gallons per day
Sanitary water	108d	15 thousand gallons per day
Other*	108e	-- thousand gallons per day
Total Item 8	108f	53,572 thousand gallons per day
*If there are discharges to 'other,' specify.	108g	
If there is 'Sanitary' water use, give the number of people served.	108h	375 people served

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OMB No. 158-R0100

FOR AGENCY USE

9. All Facility Discharges and other Losses; Number and Discharge (see instructions) Volume Specify the number of discharge points and the volume of water discharged or lost from the facility according to the categories below. Estimate average volume per day in thousand gallons per day.

		Number of Discharge Points		Total Volume Used or Discharged, Thousand Gal/Day
Surface Water	109a1	1	109a2	36,249
Sanitary wastewater transport system	109b1		109b2	
Storm water transport system	109c1		109c2	
Combined sanitary and storm water transport system	109d1		109d2	
Surface impoundment with no effluent	109e1		109e2	
Underground percolation	109f1		109f2	
Well Injection	109g1		109g2	
Waste acceptance firm	109h1		109h2	
Evaporation	109i1		109i2	16,757
Consumption	109j1		109j2	566
Other*	109k1		109k2	
Facility discharges and volume Total Item 9.	109l1		109l2	53,572
*If there are discharges to 'other,' specify.	109m1			

10. Permits, Licenses and Applications
List all existing, pending or denied permits, licenses and applications related to discharges from this facility (see instructions).

110	Issuing Agency (a)	For Agency Use (b)	Type of Permit or License (c)	ID Number (d)	Date Filed YR/MO/DA (e)	Date Issued YR/MO/DA (f)	Date Denied YR/MO/DA (g)	Expiration Date YR/MO/DA (h)
1.	USEPA		PSD Approval (air emissions)		80/5/28			
2.	US Army/ COE & FDER		Dredge & Fill (10/404)		81/2/17			
3.	FL Dept. of Env. Reg.		401 Certification		81/2/17			

11. Maps and Drawings
Attach all required maps and drawings to the back of this application. (see instructions)

12. Additional Information

112 Item Number	Information
10	Power plant operating license was applied for on 2/17/81, upon submittal of the Site Certification Application/ Environmental Information Document (SCA/EID).

FORM APPROVED
OMB No. 158-R0100

STANDARD FORM C – MANUFACTURING AND COMMERCIAL

FOR AGENCY USE

SECTION II. BASIC DISCHARGE DESCRIPTION

Complete this section for **each** discharge indicated in Section I, Item 9, that is to surface waters. This includes discharges to municipal sewerage systems in which the wastewater does not go through a treatment works prior to being discharged to surface waters. Discharges to wells must be described where there are also discharges to surface waters from this facility. **SEPARATE DESCRIPTIONS OF EACH DISCHARGE ARE REQUIRED EVEN IF SEVERAL DISCHARGES ORIGINATE IN THE SAME FACILITY.** All values for an existing discharge should be representative of the twelve previous months of operation. If this is a proposed discharge, values should reflect best engineering estimates.

ADDITIONAL INSTRUCTIONS FOR SELECTED ITEMS APPEAR IN SEPARATE INSTRUCTION BOOKLET AS INDICATED. REFER TO BOOKLET BEFORE FILLING OUT THESE ITEMS.

1. Discharge Serial No. and Name

a. **Discharge Serial No.** (see instructions) — 201a: 001 (See Additional Information Item 26 Page II-9 for this Discharge Serial Number

b. **Discharge Name** Give name of discharge, if any. (see instructions) — 201b: NORTHSIDE GENERATING STATION DISCHARGE CHANNEL

c. **Previous Discharge Serial No.** If previous permit application was made for this discharge (see Item 4, Section I), provide previous discharge serial number. — 201c: NA

2. Discharge Operating Dates

a. **Discharge Began Date** If the discharge described below is in operation, give the date (within best estimate) the discharge began. — 202a: NA (YR / MO)

b. **Discharge to Begin Date** If the discharge has never occurred but is planned for some future date, give the date (within best estimate) the discharge will begin. — 202b: 85 9 (YR / MO)

c. **Discharge to End Date** If discharge is scheduled to be discontinued within the next 5 years, give the date (within best estimate) the discharge will end. — 202c: NA (YR / MO)

3. Engineering Report Available Check if an engineering report is available to reviewing agency upon request. (see instructions) — 203: ☒ (See Note, Item 26)

4. Discharge Location Name the political boundaries within which the point of discharge is located.

			Agency Use	
State	204a	FLORIDA	204d	
County	204b	DUVAL	204e	
(if applicable) City or Town	204c	JACKSONVILLE	204f	

5. Discharge Point Description Discharge is into (check one): (see instructions)

Stream (includes ditches, arroyos, and other intermittent watercourses)	205a	☒STR
Lake		☐LKE
Ocean		☐OCE
Municipal Sanitary Wastewater Transport System		☐MTS
Municipal Combined Sanitary and Storm Transport System		☐MCS

DISCHARGE SERIAL NUMBER

001

FOR AGENCY USE

Municipal Storm Water Transport System		☐ STS
Well (Injection)		☐ WEL
Other		☐ OTH
If 'other' is checked, specify	205b	

6. **Discharge Point — Lat/Long** Give the precise location of the point of discharge to the nearest second.

Latitude	206a	30 DEG 24 MIN 30 SEC
Longitude	206b	81 DEG 32 MIN 49 SEC

7. **Discharge Receiving Water Name** Name the waterway at the point of discharge (see instructions)

207a: ST. JOHNS RIVER VIA NORTHSIDE GENERATING STATION DISCHARGE CHANNEL

If the discharge is through an outfall that extends beyond the shoreline or is below the mean low water line, complete Item 8.

207b:

For Agency Use		
Major	Minor	Sub

207c: For Agency Use 303e

8. **Offshore Discharge**

a. Discharge Distance from Shore	208a	NA feet
b. Discharge Depth Below Water Surface	208b	feet

9. **Discharge Type and Occurrence**

a. **Type of Discharge** Check whether the discharge is continuous or intermittent. (see instructions) — 209a:
☒ (con) Continuous
☐ (int) Intermittent

b. **Discharge Occurrence Days per Week** Enter the average number of days per week (during periods of discharge) this discharge occurs. — 209b: 7 days per week

c. **Discharge Occurrence** — Months If this discharge normally operates (either intermittently, or continuously) on less than a year-around basis (excluding shutdowns for routine maintenance), check the months during the year when the discharge is operating. (see instructions) — 209c: NA
☐ JAN ☐ FEB ☐ MAR ☐ APR
☐ MAY ☐ JUN ☐ JUL ☐ AUG
☐ SEP ☐ OCT ☐ NOV ☐ DEC

Complete Items 10 and 11 if "intermittent" is checked in Item 9.a. Otherwise, proceed to Item 12.

10. **Intermittent Discharge Quantity** State the average volume per discharge occurrence in thousands of gallons. — 210: NA thousand gallons per discharge occurrence.

11. **Intermittent Discharge Duration and Frequency**

a. **Intermittent Discharge Duration Per Day** State the average number of hours per day the discharge is operating. — 211a: NA hours per day

b. **Intermittent Discharge Frequency** State the average number of discharge occurrences per day during days when discharging. — 211b: NA discharge occurrences per day

12. **Maximum Flow Period** Give the time period in which the maximum flow of this discharge occurs. — 212: NA From ____ (month) to ____ (month)

DISCHARGE SERIAL NUMBER

001

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FOR AGENCY USE

13. **Activity Description** Give a narrative description of activity producing this discharge.(see instructions)

213a This discharge is the final effluent from the St. Johns River Power Park. It is produced by various activities in the plant and consists mainly of cooling tower blowdown, materials storage area runoff, and other plant low volume wastes. Details of the activities generating this discharge are provided in the attached Water and Waste Management Study.

14. **Activity Causing Discharge** For each SIC Code which describes the activity causing this discharge, supply the type and maximum amount of either the raw material consumed (Item 14a) or the product produced (Item 14b) in the units specified in Table I of the Instruction Booklet. For SIC Codes not listed in Table I, use raw material or production units normally used for measuring production.(see instructions)

a. **Raw Materials**

	SIC Code	Name	Maximum Amount/Day	Unit (See Table I)	Shared Discharges (Serial Number)
214a	(1)	(2)	(3)	(4)	(5)

b. **Products** (See Note, Item 26)

	SIC Code	Name	Maximum Amount/Day	Unit (See Table I)	Shared Discharges (Serial Number)
214b	(1)	(2)	(3)	(4)	(5)
	4911	Power Generation	1.2	Z-1	None

DISCHARGE SERIAL NUMBER

001

FOR AGENCY USE

15. **Waste Abatement**

a. **Waste Abatement Practices** Describe the waste abatement practices used on this discharge with a brief narrative. (see instructions)

215a Narrative: The in-plant wastewater flows are segregated and treated for regulated pollutant removal before mixing with other flows. Recycling and reuse are utilized whenever practicable. Except for the cooling tower blowdown, all flows will be treated, as necessary, to meet effluent limitations. By-product solid wastes may be sold as raw materials for other activities. Details of waste abatement practices are described in the Water and Waste Management Study.

b. **Waste Abatement Codes** Using the codes listed in Table II of the Instruction Booklet, describe the waste abatement processes for this discharge in the order in which they occur if possible.

215b

(1) ESEGRE	(2) RECOVE	(3) RUSEOR
(4) RECYCL	(5) LOCALS	(6) OMONIT
(7) PEQUAL	(8) PSEDIM	(9) CNEUTR
(10) CCOAGU	(11) CFLOCC	(12) PSANDF
(13) STHICK	(14) SPRESS	(15) SLANDD
(16) BACTIV	(17) CCLDIS	(18)
(19)	(20)	(21)
(22)	(23)	(24)
(25)		

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16. Wastewater Characteristics (See Note, Item 26)

Check the box beside each constituent which is present in the effluent (discharge water). This determination is to be based on actual analysis or best estimate.(see instructions)

Parameter 216	Present	Parameter 216	Present
Color 00080		Copper 01042	X
Ammonia 00610	X	Iron 01045	X
Organic nitrogen 00605	X	Lead 01051	X
Nitrate 00620	X	Magnesium 00927	X
Nitrite 00615	X	Manganese 01055	X
Phosphorus 00665	X	Mercury 71900	X
Sulfate 00945	X	Molybdenum 01062	
Sulfide 00745	X	Nickel 01067	X
Sulfite 00740		Selenium 01147	X
Bromide 71870	X	Silver 01077	X
Chloride 00940	X	Potassium 00937	X
Cyanide 00720	X	Sodium 00929	X
Fluoride 00951	X	Thallium 01059	
Aluminum 01105	X	Titanium 01152	
Antimony 01097	X	Tin 01102	
Arsenic 01002	X	Zinc 01092	X
Beryllium 01012	X	Algicides* 74051	
Barium 01007		Chlorinated organic compounds* 74052	
Boron 01022	X	Pesticides* 74053	
Cadmium 01027	X	Oil and grease 00550	X
Calcium 00916	X	Phenols 32730	X
Cobalt 01037		Surfactants 38260	
Chromium 01034	X	Chlorine 50060	X
Fecal coliform bacteria 74055	X	Radioactivity* 74050	

*Specify substances, compounds and/or elements in Item 26.

Pesticides (insecticides, fungicides, and rodenticides) must be reported in terms of the acceptable common names specified in *Acceptable Common Names and Chemical Names for the Ingredient Statement on Pesticide Labels*, 2nd Edition, Environmental Protection Agency, Washington, D.C. 20250, June 1972, as required by Subsection 162.7(b) of the Regulations for the Enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act.

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17. **Description of Intake and Discharge** (See note, Item 26)

For each of the parameters listed below, enter in the appropriate box the value or code letter answer called for.(see instructions)

In addition, enter the parameter name and code and all required values for any of the following parameters if they were checked in Item 16: ammonia, cyanide, aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, phenols, oil and grease, and chlorine (residual).

Parameter and Code 217a	Influent		Effluent					
	Untreated Intake Water (Daily Average) (1)	In-Plant Treated Intake Water (Daily Average) (2)	Daily Average (3)	Minimum Value Observed or Expected During Discharge Activity (4)	Maximum Value Observed or Expected During Discharge Activity (5)	Frequency of Analysis (6)	Number of Analyses (7)	Sample Type (8)
Flow* MGD 50050	53.5		36.2	20.1	40.4			
pH Units 00400	8.0		X	6.0	9.0			
Temperature (winter) ° F 74028	59.5		75.9	52.4	85.9			
Temperature (summer) ° F 74027	82.5		87.8	77.3	93.0			
Biochemical Oxygen Demand (BOD 5-day) mg/l 00310	2.1		UNABLE TO PREDICT					
Chemical Oxygen Demand (COD) mg/l 00340	NOT AVAILABLE		UNABLE TO PREDICT					
Total Suspended (nonfilterable) Solids mg/l 00530	55		UNABLE TO PREDICT					
Specific Conductance micromhos/cm at 25° C 00095	33,400		X	UNABLE TO PREDICT				
Settleable Matter (residue) ml/l 00545	NOT AVAILABLE			UNABLE TO PREDICT				

*Other discharges sharing intake flow (serial numbers).(see instructions)

Temperature, BOD, pH, and specific conductance are given for the surface water flow of 49.5 MGD.

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17. (Cont'd.)

Parameter and Code 217a	Influent: Untreated Intake Water (Daily Average) (1)	Influent: In-Plant Treated Intake Water (Daily Average) (2)	Effluent: Daily Average (3)	Effluent: Minimum Value Observed or Expected During Discharge Activity (4)	Effluent: Maximum Value Observed or Expected During Discharge Activity (5)	Effluent: Frequency of Analysis (6)	Effluent: Number of Analyses (7)	Effluent: Sample Type (8)
Ammonia 00610	0.12		UNABLE TO PREDICT					
Cyanide 00720	0.01		0.013	0.0005	0.121			
Aluminum 01105	0.45		0.65	0.014	4.9			
Arsenic 01002	0.00077		0.0049	0.00049	0.0055			
Beryllium 01012	0.00009		0.0019	0.000029	0.002			
Cadmium 01027	0.00033		0.0063	0.00019	0.009			
Chromium 01034	0.00159		0.013	0.0009	0.018			
Chlorine (residual) 50060	0.04		0.05		0.27			

18. **Plant Controls** Check if the following plant controls are available for this discharge. 218

Alternate power source for major pumping facility. ☒ APS

Alarm or emergency procedure for power or equipment failure ☒ ALM

Complete item 19 if discharge is from cooling and/or steam water generation and water treatment additives are used.

19. **Water Treatment Additives** If the discharge is treated with any conditioner, inhibitor, or algicide, answer the following: NA

a. Name of Material(s) 219a

b. Name and address of manufacturer 219b

c. Quantity (pounds added per million gallons of water treated). 219c

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17. (Cont'd.)

Parameter and Code 217a	Influent		Effluent					
	Untreated Intake Water (Daily Average) (1)	In-Plant Treated Intake Water (Daily Average) (2)	Daily Average (3)	Minimum Value Observed or Expected During Discharge Activity (4)	Maximum Value Observed or Expected During Discharge Activity (5)	Frequency of Analysis (6)	Number of Analyses (7)	Sample Type (8)
Copper 01042	0.065		0.096	0.011	0.375			
Lead 01051	0.0018		0.011	LT 0.001	0.025			
Mercury 71900	0.0002		0.0037	0.0005	0.0043			
Nickel 01067	0.0036		0.072	0.0019	0.091			
Selenium 01147	0.0011		0.157	0.00049	0.163			
Zinc 01092	0.043		0.084	0.005	0.218			
Phenols 32730	0.010		0.011	UNABLE TO PREDICT	0.072			
Oil & Grease 00550	2.0		0.0026	UNABLE TO PREDICT	0.012			

18. **Plant Controls** Check if the following plant controls are available for this discharge. — 218

Alternate power source for major pumping facility. ☒ APS

Alarm or emergency procedure for power or equipment failure ☒ ALM

Complete item 19 if discharge is from cooling and/or steam water generation and water treatment additives are used.

19. **Water Treatment Additives** If the discharge is treated with any conditioner, inhibitor, or algicide, answer the following:

a. Name of Material(s) — 219a _____

b. Name and address of manufacturer — 219b _____

c. Quantity (pounds added per million gallons of water treated). — 219c _____

JOINT APPLICATION
DEPARTMENT OF THE ARMY/FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION
FOR
ACTIVITIES IN WATERS OF THE STATE OF FLORIDA

Refer to Instruction Pamphlet for explanation of numbered items and attachments required.

1. Application number (To be assigned)	2. Date Day Mo. Yr.	3. For official use only

4. Name, address and zip code of applicant

Jacksonville Electric Authority
233 W. Duval St.
Jacksonville, Florida 32201

Telephone Number (904) 633-4779

5. Name, address, zip code and title of applicant's authorized agent for permit application coordination

Mr. Dale Moehle
Division Chief, New Fossil Generation
Jacksonville Electric Authority
233 W. Duval St.
Jacksonville, Florida 32201

Telephone Number (904) 633-4517

6. Describe the proposed activity, its purpose and intended use, including a description of the type of structures, if any, to be erected on fills, or pipe or float-supported platforms, and the type, composition and quantity of materials to be discharged or dumped and means of conveyance.

See attached sheets.

	Dredged/Excavated		Filled/Deposited	
Volume of Material:*	582,000 CY Waterward of O.H.W. or M.H.W.	21,000 CY Landward of O.H.W. or M.H.W.	45,000 CY Waterward of O.H.W. or M.H.W.	649,400 CY Landward of O.H.W. or M.H.W.

*Sum of all dredge/fill quantities

7. Proposed use

Private [ ] Public [x] Commercial [ ] Other [ ] (Explain in remarks)

8. Name and address including zip code of adjoining property owners whose property also adjoins the waterway

Jacksonville Port Authority
2831 Talleyrand Ave.
Jacksonville, Florida 32206

Offshore Power Systems
8000 Arlington Expressway
Jacksonville, Florida 32211

9. Location where proposed activity exists or will occur (Coal Unloading Facility/Power Plant Site)

Street address

Longitude 81°32'W/81°33'W Latitude 30°23.4'N/30°25.8'N (If known)

Sec. 30/43 Twp. 1S Rge. 28E/27E

Florida	Duval	Jacksonville	
State	County	In City or Town	Near City or Town

10. Name of waterway at location of the activity St. Johns River

SAJ FORM 983
21 Jul 77

11. Date activity is proposed to commence 1 Jan 1982

Date activity is expected to be completed 1 Oct 1985

12. Is any portion of the activity for which authorization is sought now complete? Yes [ ] No [x]

If answer is "Yes" give reasons in the remarks section. Month and year the activity was completed _____

_____. Indicate the existing work on the drawings.

13. List all approvals or certifications required by other Federal interstate, state or local agencies for any structures, construction, discharges, deposits or other activities described in this application, including whether the project is a Development of Regional impact.

Issuing Agency	Type of Approval	Identification No.	Date of Application	Date of Approval
FDER	Site Certification		18 Feb 1981	
USEPA	NPDES Permit		18 Feb 1981	
USEPA	RCRA (Part A) Permit		18 Feb 1981	

Project is to be licensed under the Florida Power Plant Siting Act and is not a Development of Regional Impact.

14. Has any agency denied approval for the activity described herein or for any activity directly related to the activity described herein?

Yes [ ] No [x] (If "Yes" explain in remarks)

15. Remarks (see Instruction Pamphlet for additional information required for certain activities)

See attached sheets and drawings.

16. Application is hereby made for a permit or permits to authorize the activities described herein. I agree to provide any additional information/data that may be necessary to provide reasonable assurance or evidence to show that the proposed project will comply with the applicable State Water Quality Standards or other environmental protection standards both during construction and after the project is completed. I also agree to provide entry to the project site for inspectors from the environmental protection agencies for the purpose of making preliminary analyses of the site and monitoring permitted works, if permit is granted. I certify that I am familiar with the information contained in this application, and that to the best of my knowledge and belief such information is true, complete, and accurate. I further certify that I possess the authority to undertake the proposed activities.

Roger Lee — Signature of Applicant

2-17-81 — Date

18 U.S.C. Section 1001 provides that: Whoever, in any manner within the jurisdiction of any department or agency of the United States knowingly and willfully falsifies, conceals, or covers up by any trick, scheme, or device a material fact or makes any false, fictitious or fraudulent statements or representations or makes or uses any false writing or document knowing same to contain any false, fictitious or fraudulent statement or entry, shall be fined not more than $10,000 or imprisoned not more than five years, or both.

The application must be signed by the person who desires to undertake the proposed activity; however, the application may be signed by a duly authorized agent if accompanied by a statement by that person designating the agent and agreeing to furnish upon request, supplemental information in support of the application.

FEE: Attach Checks/Money Orders on front
Payable to Department of Environmental Regulation
$200 Standard form projects
$20 Short forms and Chapter 403 projects only

6. DESCRIPTION OF PROPOSED ACTIVITY

The activities in waters of the State of Florida relating to the construction of the proposed Jacksonville Electric Authority's (JEA) St. Johns River Power Park (SJRPP), Units 1 and 2 (a 1200 MWe coal-fired electric generating station), and its directly associated facilities and transmission lines include the following elements:

A. Approximately 31 acres of bayhead/hardwood swamp located within the rail loop of the proposed SJRPP plant site will be filled with clean sand. Several structures within the power plant area will be located on the fill.

Volume of Dredged/Excavated Material:

Waterward of MHW		Landward of MHW	
0	CY	0	CY

Volume of Filled/Deposited Material:

Waterward of MHW		Landward of MHW	
0	CY	98,400	CY

B. Approximately 21 acres of river bottom from wharfline to channel, in the Fulton-Dame Point Cutoff of the St. Johns River will be dredged and a wharf constructed for an ocean vessel coal unloading facility

on Blount Island. No fuel pumps or toilet facilities will be constructed on the wharf. Spoil material will be placed in an engineered disposal area on Quarantine Island while dredged material suitable for fill will be placed landward of the wharf within the facility boundaries.

Volume of Dredged/Excavated Material:

Waterward of MHW		Landward of MHW
531,000 CY		20,000 CY

Volume of Filled/Deposited Material:

Waterward of MHW		Landward of MHW
0 CY		551,000 CY

C. A water intake structure, consisting of a sheet pile channel, nearshore bulkheads and pumphouse, will be constructed in San Carlos Creek adjacent to the JEA Northside Generating Station (NGS). The water, to provide makeup to the SJRPP closed cycle condenser cooling system, will be withdrawn from the existing NGS cooling water discharge structure.

Volume of Dredged/Excavated Material:

Waterward of MHW		Landward of MHW
4,000 CY		1,200 CY

Volume of Filled/Deposited Material:

Waterward of MHW		Landward of MHW
535 CY		2,265 CY

D. Transmission line towers associated with the SJRPP power transmission system will be constructed in and near San Carlos Creek and Mill Cove.

Revised 10/31/84

on Blount Island. No fuel pumps or toilet facilities will be constructed on the wharf. Spoil material will be placed in an engineered disposal area on Quarantine Island while dredged material suitable for fill will be placed landward of the wharf within the facility boundaries.

Volume of Dredged/Excavated Material:

Waterward of MHW		Landward of MHW
531,000 CY		20,000 CY

Volume of Filled/Deposited Material:

Waterward of MHW		Landward of MHW
0 CY		551,000 CY

C. A water intake structure, consisting of a sheet pile channel, nearshore bulkheads and pumphouse, will be constructed in San Carlos Creek adjacent to the JEA Northside Generating Station (NGS). The water, to provide makeup to the SJRPP closed cycle condenser cooling system, will be withdrawn from the existing NGS cooling water discharge structure.

Volume of Dredged/Excavated Material:

Waterward of MHW		Landward of MHW
6,000 CY		1,000 CY

Volume of Filled/Deposited Material:

Waterward of MHW		Landward of MHW
2,620 CY		180 CY

D. Transmission line towers associated with the SJRPP power transmission system will be constructed in and near San Carlos Creek and Mill Cove.

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on Blount Island. No fuel pumps or toilet facilities will be constructed on the wharf. Spoil material will be placed in an engineered disposal area on Quarantine Island while dredged material suitable for fill will be placed landward of the wharf within the facility boundaries.

Volume of Dredged/Excavated Material:

531,000 CY (Waterward of MHW) 20,000 CY (Landward of MHW)

Volume of Filled/Deposited Material:

0 CY (Waterward of MHW) 551,000 CY (Landward of MHW)

C. A water intake structure, consisting of a sheet pile channel, will be constructed in San Carlos Creek adjacent to the JEA Northside Generating Station (NGS). The water, to provide makeup to the SJRPP closed cycle condenser cooling system, will be withdrawn from the existing NGS cooling water discharge structure.

Volume of Dredged/Excavated Material:

6,000 CY (Waterward of MHW) 1,000 CY (Landward of MHW)

Volume of Filled/Deposited Material:

0 CY (Waterward of MHW) 0 CY (Landward of MHW)

D. Transmission line towers associated with the SJRPP power transmission system will be constructed in and near San Carlos Creek and Mill Cove.

Volume of Dredged/Excavated Material:

45,000 (max) CY Waterward of MHW 0 CY Landward of MHW

Volume of Filled/Deposited Material:

45,000 (max) CY Waterward of MHW 0 CY Landward of MHW

Additional descriptive information is presented under Item 15 of this application (below) and in the attached drawings.

15. REMARKS

ALL APPLICATIONS

A. Description of Proposed Work

(1) Location

The location of each of the specific activities included within this permit application is depicted in Sheet 1 of the attached drawings. The proposed St. Johns River Power Park site occupies approximately 1,656 acres of land located in Duval County and is contiguous to the existing Jacksonville Electric Authority's (JEA) Northside Generating Station. The proposed power plant site, shown on Sheet 2, borders New Berlin Road and the Jacksonville City Landfill to the west, and salt marshes to the north, east and south. The St. Johns River is located approximately 0.5 miles to the southwest of the site. The bayhead/hardwood swamp, a portion of which is to be filled, is located in the southern portion of the site as shown in Sheet 2. It is drained by an intermittent stream which empties into the salt marsh associated with Browns Creek.

The proposed coal unloading facility is located on the southern half of Blount Island bordering the Fulton-Dame Point Cutoff of the St. Johns River. It is comprised primarily of a 55 acre tract and associated railroad trackage which requires an additional 35 acres, all of which is disturbed and artifically elevated land (principally dredged material). The location of this facility is depicted in Sheet 3 of the attached drawings.

A dredge spoil disposal area is located on Quarantine Island, and shown on Sheet 4. This spoil area was designed by the Corps of Engineers to meet maintenance dredging requirements and authorized for use as a dredge spoil site for the dredging associated with the coal unloading facility on Blount Island by letter to the JEA dated 18 November, 1980. Quarantine Island is located in the St. Johns River to the southwest of Blount Island as shown in Sheet 1.

The location of the proposed makeup water intake structure in relation to existing structures at the Northside Generating Station is depicted in Sheet 5 of the attached drawings. The proposed makeup water intake structure is located on the west side of the existing Northside Generating Station discharge canal and shown in detail on Sheet 6.

The proposed transmission line tower construction areas included within this application are located in both Mill Cove and San Carlos Creek (see Sheet 1). Only one of the tower locations in the San Carlos Creek area is included within this application. This one tower is in an elevated and previously impacted portion of the salt marsh, to the southeast of an existing percolation pond. The exact location is shown in Sheet 5 of the attached drawings. The other wetland tower locations are in an area known as Mill Cove, which is to the south of the Fulton-Dame Point Cutoff of the St. Johns River. The locations of the towers within Mill Cove are shown on Sheet 7.

(2) Waterway Width

The waterway width at the plant site is not applicable since there are no waterways on the plant site. The width of the portion of the wetland (Sheet 2) to be filled is approximately 1,500 feet and the length about 2,500 feet. This area is drained by an intermittent stream.

The waterway width of the Fulton-Dame Point Cutoff Channel at the site of the proposed Blount Island coal unloading facility is approximately 1,300 feet with a dredged channel width of approximately 470 feet (maintained at a depth of 38 feet below MSL).

The width of the waterway at the point where the makeup water intake structure is to be constructed (San Carlos Creek) is approximately 150 feet. The width of the waterway adjacent to the one transmission line tower in the San Carlos Creek area is approximately 50 feet. The distance over which the transmission line towers will be crossing Mill Cove is approximately 8,500 feet.

(3) Overall Plan of Development

An overall plan of development has been prepared and appears in Section 2.1 of the Site Certification Application, a public document available through the Florida Department of Environmental Regulation (FDER) and the U.S. Army Corps of Engineers, Jacksonville District.

B. Need for the Proposed Work

Jacksonville Electric Authority (JEA) proposes to construct a coal-fired generating facility at the St. Johns River Power Park (SJRPP) to be located in Duval County, Florida. The project will consist of two 600 MW class units, jointly owned by the JEA and Florida Power & Light Company (FPL). JEA and FPL believe that this project offers both utilities the capability to offset the level of oil consumption on their systems. In addition, the proposed facility will be needed to meet load growth requirements. The failure of JEA and FPL to complete the proposed facility as planned would result in

detrimental effects on system reliability and levels of oil consumption. In addition, changes to these systems supply parameters would ultimately cause significant impacts on the customers of both utilities.

The proposed coal unloading facility planned for Blount Island is expected to afford a significant savings to the operating costs for the proposed coal-fired generating facility. Not only would it provide an alternate means of transportation of coal and improve reliability of supplies because of source diversification, but it would also provide a significant economic savings through the purchase of spot market coal.

C. Alternatives Considered

(1) Coal-Fired Generating Facility

Three different orientations of the proposed plant within the confines of the site were evaluated in terms of minimizing the engineering costs (primarily piping costs for intake and discharge), and maximizing the use of the available site area for efficient utilization and wetlands preservation. As a result of this evaluation, the orientation depicted in Sheet 2 was considered to be the best compromise between engineering economics and wetlands preservation.

(2) Coal Unloading Facility

Six basic areas were reviewed as potential sites for a coal unloading facility. Two sites were selected from these areas for detailed analysis, one at Dame Point and the other at Blount Island. The Dame Point site was compared with the Blount Island site in terms of

environmental impacts, construction, land and operating costs, and access to the proposed plant. The Dame Point site was judged to be more costly from both an environmental and economic perspective than the Blount Island site and, hence, the Blount Island site was chosen as the preferred site.

Either San Carlos Creek or the St. Johns River could serve as the source of makeup water for the proposed plant, but locating the structure in either could result in adverse impacts to the aquatic ecosystem. In order to eliminate these and other impacts, it was decided that makeup water would be drawn from the Northside Generating Station discharge.

After alternate transmission line corridors were evaluated, it was concluded that the least environmental impact would occur from a line located parallel and adjacent to the existing line. The location of transmission line towers within the preferred corridor was based on both environmental and engineering considerations. Towers were spaced to avoid construction impacts to ecologically sensitive areas, where possible, by lessening the number of overwater towers required and increasing the span distance between these towers.

The location of towers in San Carlos Creek and Mill Cove as depicted in Sheets 5 and 7 are optimized locations from both environmental and engineering perspectives.

D. Environmental Considerations

There may be some short term degradation of the waters adjacent to areas where the specific construction activities are planned. Efforts will be made to minimize sediment load and restore the construction

areas, if possible, to their preconstruction condition. Precautions to be taken will include: the use of settling ponds to reduce sediment load before discharge into receiving water bodies, where possible; confining the dredging activities to the late fall and early winter to minimize effects in aquatic communities; and returning spoil runoff to the main channels of the St. Johns River to minimize effects on adjacent creeks.

DREDGING

A. Description of Dredged Areas

(1) Coal Unloading Facility

Dredging of approximately 21 acres will be required in the area of the proposed ocean vessel coal unloading wharf (Sheet 8). It will be dredged to a depth of 38 feet below MSL, which is consistent with the design depth of the Fulton-Dame Point Cutoff Channel. A total of 551,000 cubic yards of material will be removed from this area. Of this total, 381,000 cubic yards is suitable for fill material and 170,000 is spoil material, which will be disposed of on Quarantine Island (Sheet 4). The area to be dredged in relation to the adjacent dredged areas is illustrated on Sheet 3 of the attached drawings.

(2) Transmission Line Towers

Construction of the transmission line towers in the Mill Cove area will be accomplished via a barge mounted crane. A temporary channel will be required for access into Mill Cove (Sheet 7). The channel

will be approximately 45 feet in width and -8 feet MSL in depth (worst case). It is estimated that approximately 45,000 cubic yards of material will have to be dredged, assuming maximum barge draft and beam. The dredged material will be temporarily placed at the side of the construction channel and turbidity screens will be used where necessary. As each tower is completed, the dredged material will be backfilled into the channel, restoring it to its original level. A cross-section of the dredged area in relation to the tower is depicted in Sheet 9.

B. Description of Disposal Site(s)

(1) Location

The dredge spoil material from the proposed coal unloading facility on the Fulton-Dame Point Channel side of Blount Island will be pumped, via submerged pipeline, to a disposal site on Quarantine Island designed by the Corps of Engineers and owned by the Jacksonville Port Authority (Sheet 4). The Quarantine Island disposal site is located in the St. Johns River, approximately 2,000 feet to the south-southwest of the coal unloading facility site.

Material resulting from any maintenance dredging subsequent to the construction dredging will be pumped to the Quarantine Island site or an alternative disposal area located to the north-northeast of the Northside Generating Station. The location of this alternative disposal area in relation to the other project components is depicted in Sheet 5. The design of this area (provided by the Corps of Engineers) is shown in Sheet 10.

(2) Size

The dredge spoil disposal area on Quarantine Island is sized to contain several years of channel maintenance dredging (approximately three million cubic yards). The configuration of this area is shown on Sheet 4 of the attached drawings. Dikes and wiers will be constructed to Corps of Engineers specifications.

An alternate dredge spoil disposal area, to the north-northeast of the Northside Generating Station, is approximately 50 acres in size. The configuration of this area is depicted on Sheet 10 of the attached drawings.

C. Description of Disposal Methods

Dredged material will be removed with a suction dredge to minimize the generation of turbidity and the release of other contaminants to the St. Johns River. Spoil material will be pumped to the receiving area on Quarantine Island via a submerged pipeline, placed below the -38 MSL channel requirement to insure that accidental rupture by ship traffic will be avoided. Overflow from the settling pond will be released to the St. Johns River through a standard standpipe and culvert arrangement (Sheets 4 and 10).

D. Description of Disposal Materials

The surficial dredged material (170,000 cu. yd.) from the ocean vessels coal unloading wharf area consists of very loose silty and fine sand with silty clay seams and some organic matter. Due to the high percentage of fines and presence of organic matter, this material

is not suitable for backfill and will be disposed of in the Quarantine Island disposal area. An additional 381,000 cubic yards of suitable fill material (silty to clean sand) will be dredged and utilized on the coal unloading facility site.

E. Environmental Considerations

The spoil site and settling pond(s) will comply with designs approved by the Army Corps of Engineers and the FDER and variances for several parameters will be sought in those cases where the ambient receiving waters exceed the surface water quality standards.

Excess water from the alternate maintenance dredging disposal area, which is located to the north-northeast of the Northside Generating Station, will be pumped back to the St. Johns River after sufficient settling to meet turbidity guidelines. This will comply with existing permit requirements and avoid any adverse impacts on San Carlos Creek. The piping easments with match lines to this area are shown in Sheet 11 of the attached drawings.

FILLING

A. Size of Areas to be Filled

The bayhead/hardwood swamp within the plant site (water elevation $\pm$7 feet above MSL) is the principal area to be filled. It is located in the southern portion of the proposed site (Sheet 2) and is approximately 31 acres in size. In terms of the total area of this wetland type within proposed plant site boundaries, the amount filled

is only ±30 percent of this total. All of the area to be filled is at least 4.5 feet above mean high water line. A cross-section through the area to be filled, which depicts the existing and finished grade, is shown in Sheet 12 of the attached drawings. Approximately 98,400 cubic yards of fill material will be used.

Some suitable fill material dredged from the ocean vessel coal unloading wharf area will be used as fill on the coal handling storage area (Sheet 4). Approximately 381,000 cubic yards of material will be placed in this area and is shown on Sheet 13.

Some cut and fill will also be required for the new rail trackage to be constructed along the drainage easement on Blount Island. The area to be filled is about 50-60 feet wide and 2,700 feet in length. A typical section through this area is shown in Sheet 14.

B. Description of Fill Material

The type of fill material to be used is fine to medium sand.

C. Structures to be Placed on Filled Material

A number of structures will be placed on the filled portion of the hardwood swamp including a portion of the plant rail loop, coal and limestone unloading facility, fly ash silos, air quality control system (AQCS) area, AQCS service building, gypsum loading area, inactive limestone storage, transient limestone storage, and the sanitary and wastewater treatment areas.

The structures to be constructed on the filled coal handling and storage area on Blount Island include: a coal storage area, stacker-reclaimer, coal handling building, emergency reclaim hopper, holding basin, pump station, and pipeline. The location of these structures is depicted on Sheet 15 of the attached drawings.

Railroad trackage is the only type of structure to be constructed on the fill areas which border the drainage easement on Blount Island (Sheet 3). The fill to be used for this structure will come from a cut in the grade of the existing dike, which the rail trackage will parallel. A typical section of this new rail trackage and the existing dike is shown in Sheet 14 of the attached drawings.

D. Environmental Considerations

(1) Alternatives Considered

Three different orientations of the proposed plant and rail loop within the confines of the site were evaluated in terms of minimizing the engineering costs, minimizing the amount of wetlands disturbed, and maximizing the use of the available land within the site boundaries. The orientation shown on Sheet 2 was determined to be the best among the factors considered.

(2) Effects on Aquatic Ecology

Due to the intermittently wet nature of the area to be filled, it is considered to be of only limited or no value to aquatic life. No commercially important or rare and endangered species were observed in this area during the on-site field sampling program. The potential

for adverse effects from turbidity, due to construction, is expected to be minimal since settling ponds will be used and many of the organisms found in this area are tolerant of turbid conditions. No adverse impacts to the aquatic life in the Browns Creek salt marsh complex from the filling of the on-site wetland are expected.

CONSTRUCTION

A. Coal Unloading Facility

The coal unloading wharf proposed for Blount Island is comprised of two parallel concrete decks set on piles (Sheets 16 and 17). Sheet piling will be used on the channel side of the front deck and will extend below the dredge line (-38 feet). All piling will be driven, anchored, and capped prior to dredging activities. The wharf deck will carry two rails, each designed for 60 tons wheel loads. The rails will be parallel to the river, with a span of 115 feet. One rail will be 10 feet from the river side of the wharf. The proposed wharf will be approximately 1,200 feet in length. A portion of the wharf will be contiguous with the existing shoreline (Sheet 17). The remaining portion of the wharf (about 600 feet) will extend over the water. The existing shoreline, at the point where the wharf ties into it, will be stabilized with riprap.

Two 1,500 ton per hour grab-bucket type unloaders will be constructed on the wharf as shown in Sheet 18. These will be rope-trolley machines with a board receiving bins, bin discharge feeders, and transverse conveyors which discharge to a gathering conveyor. All of the conveyor galleries will be enclosed, except for the gathering conveyor.

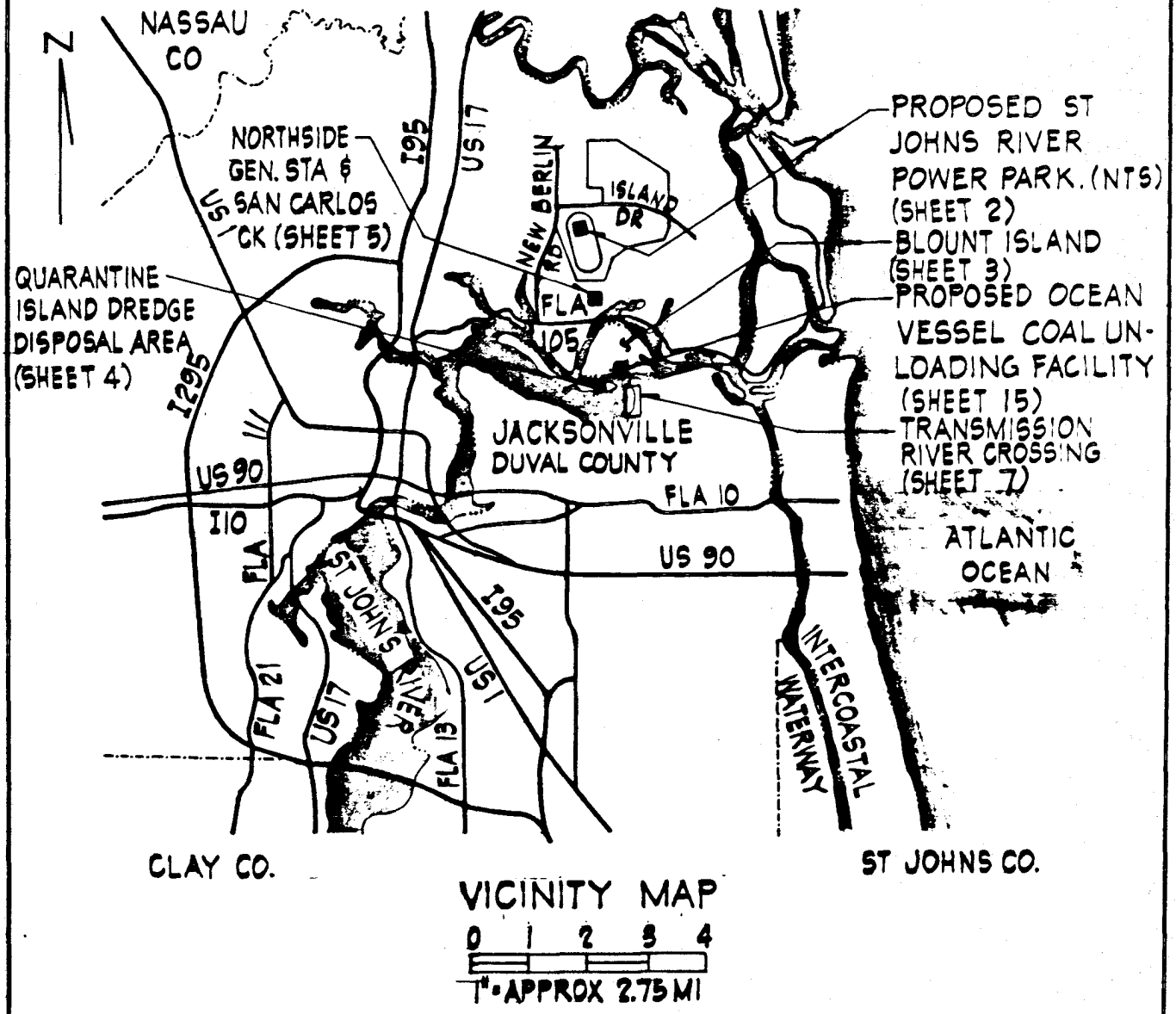
The wharf, which will be the only structure placed on or beyond the mean high water line shown on Sheet 19, will be capable of docking large colliers, sea going barges, and river barges. It will be fitted with bumpers, bitts, and cleats for docking. Since its function is for offloading coal, no sewage pumpout facilities are planned, nor are any refueling facilities.

B. Makeup Water Intake Structures

An intake channel is proposed to be constructed in San Carlos Creek. The channel will have sheet piling sides and will have a stone blanket for its base. It will draw water from the existing Northside Station discharge flume. The plan for this structure is depicted in Sheet 6, and a cross section in Sheet 20.

C. Transmission Line Towers

The transmission line towers to be constructed in Mill Cove will be set on piles with five piles per each of the four tower base points (Sheets 7 and 9). Construction will be from a barge which will require the temporary dredging of channel to accommodate its access to the tower sites.



VICINITY MAP

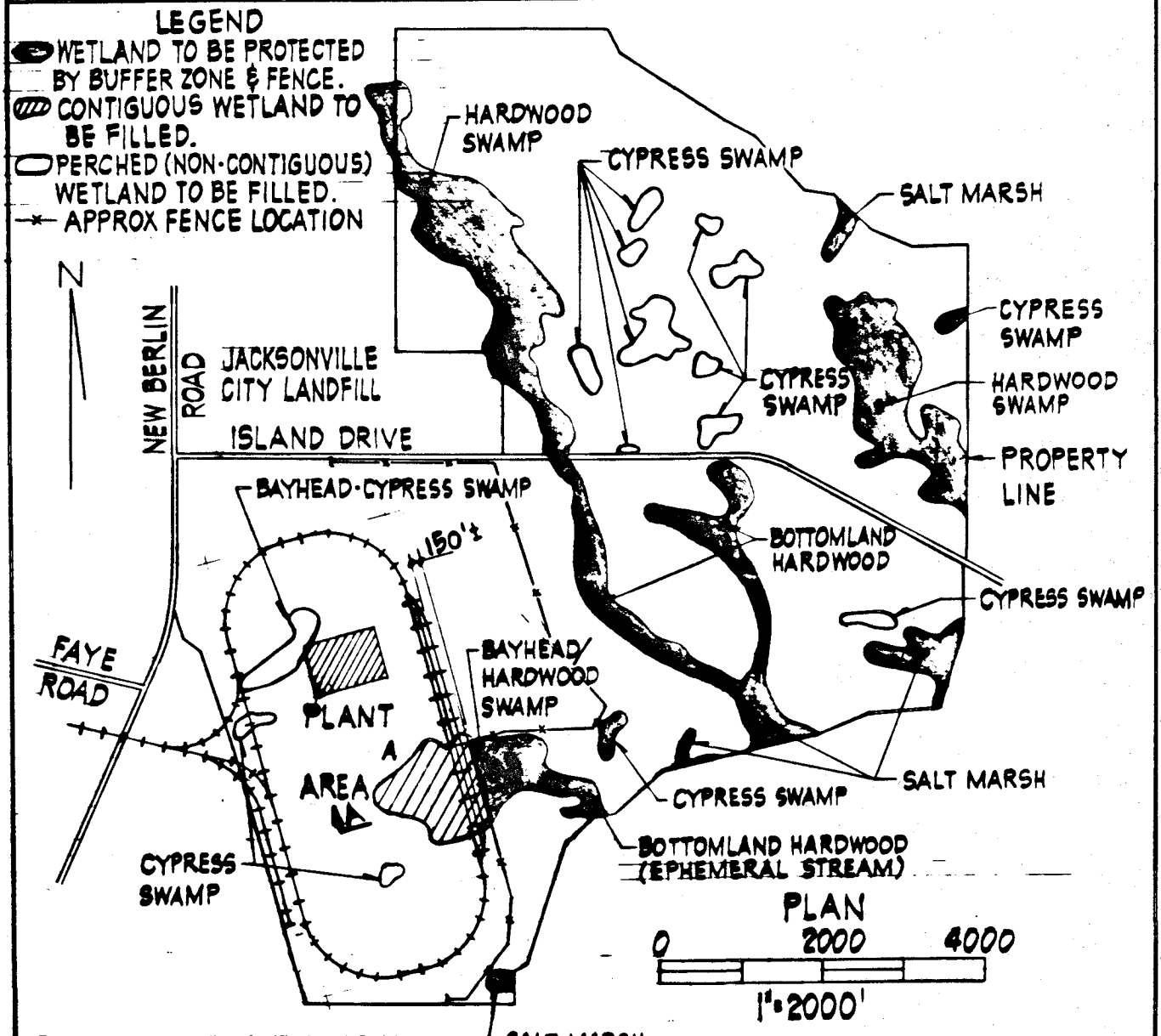
0 1 2 3 4

1" = APPROX 2.75 MI

PURPOSE: POWER STATION AND OCEAN VESSEL COAL UNLOADING FACILITY DEVELOPMENT
DATUM: MEAN SEA LEVEL.

PROPOSED ST JOHNS RIVER POWER PARK AND OCEAN VESSEL COAL UNLOADING FACILITY AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA.
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 1 OF 20 DATE FEB 18 1981

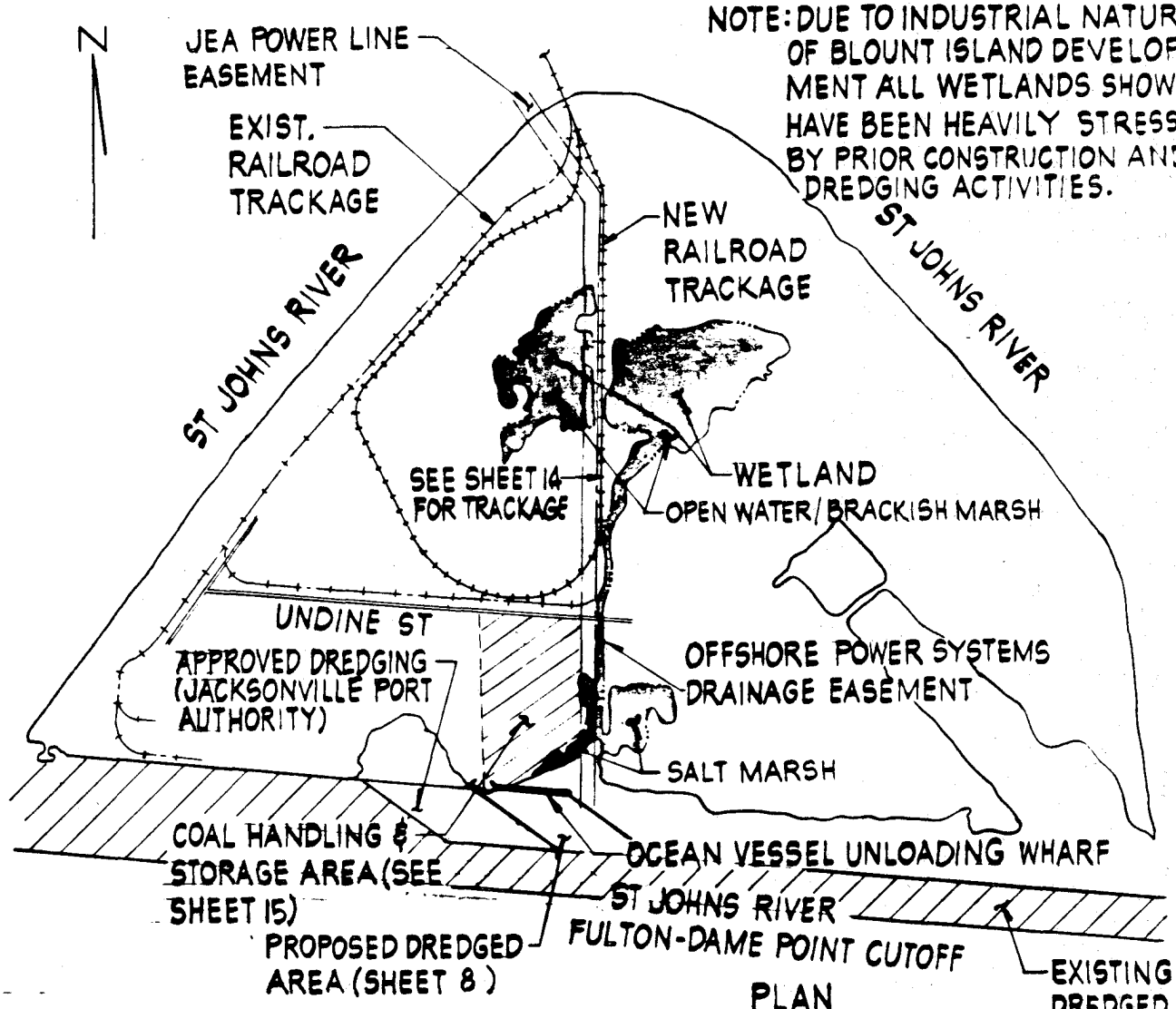


PURPOSE: WET LAND FILLING FOR SITE PREPARATION.
DATUM: MEAN SEA LEVEL

CONTIGUOUS WETLAND	AREA	FILL REQD
A	30.5 ACRES	98,400 CY

PROPOSED WET LAND FILLING FOR ST JOHNS RIVER POWER PARK. AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA. APPLICATION BY JACKSONVILLE ELECTRIC AUTHORITY.

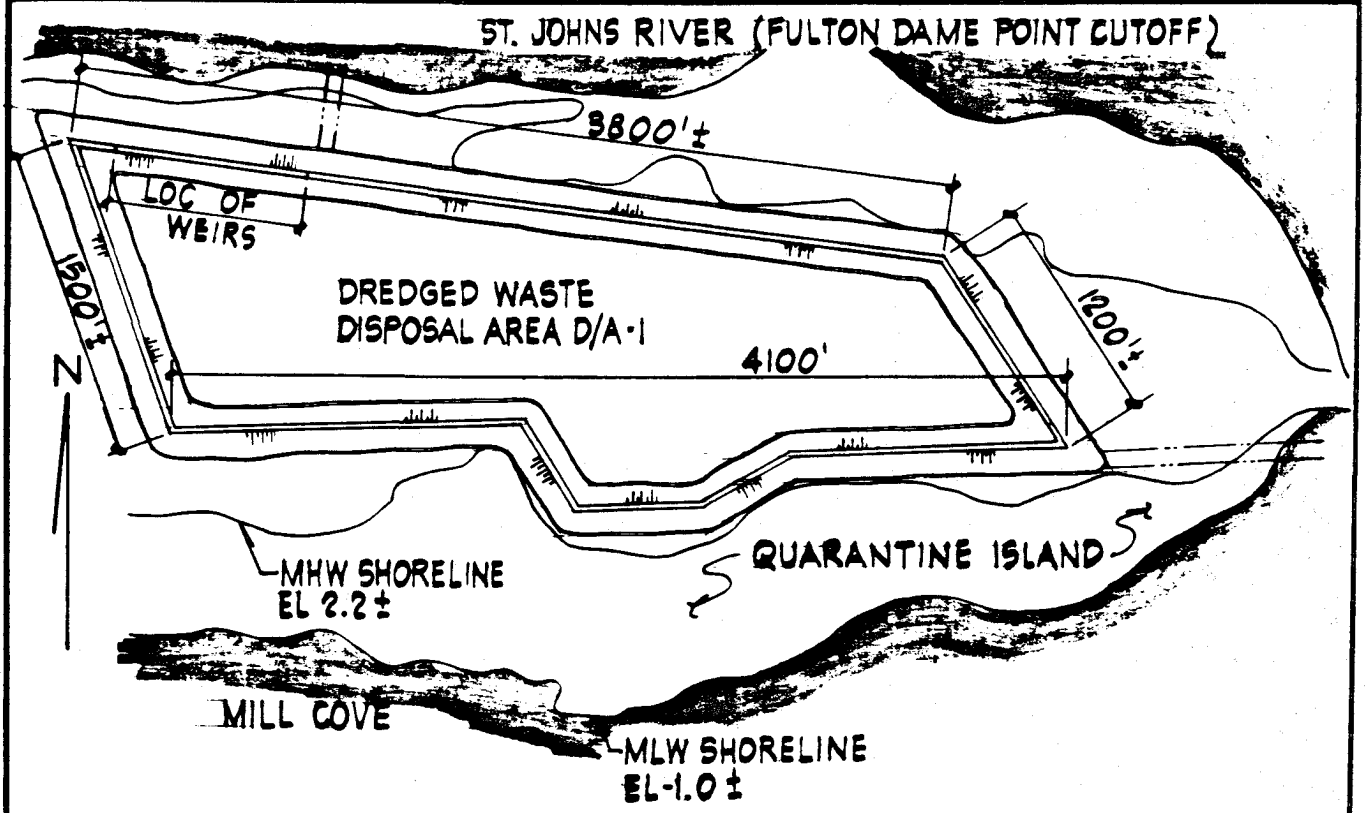
SHEET 2 OF 20 DATE FEB 10 1981



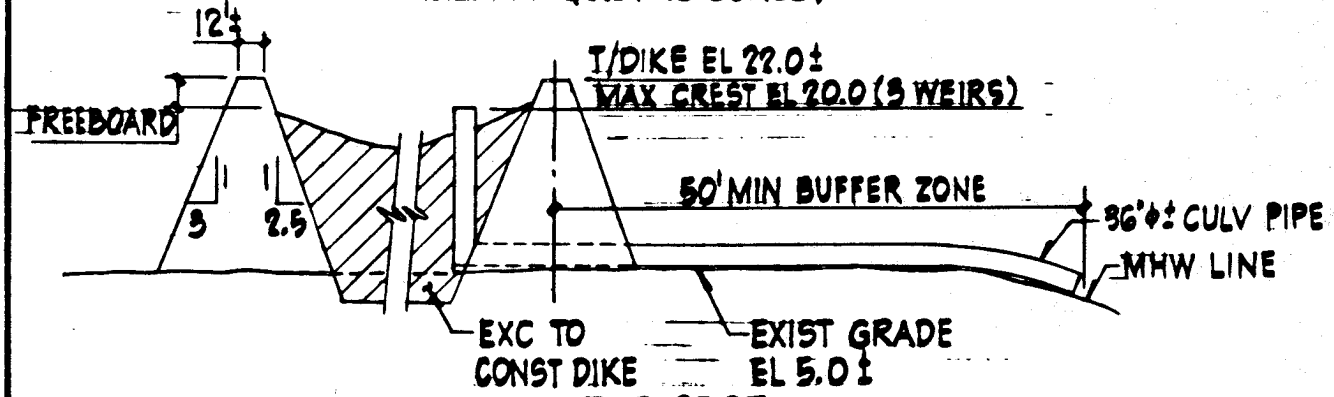
PURPOSE: BLOUNT ISLAND WETLAND LOCATION

PROPOSED: COAL UNLOADING FACILITY ON BLOUNT ISLAND AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 9 OF 20 DATE: FEB 18 1981



PLAN
(NOT TO SCALE)

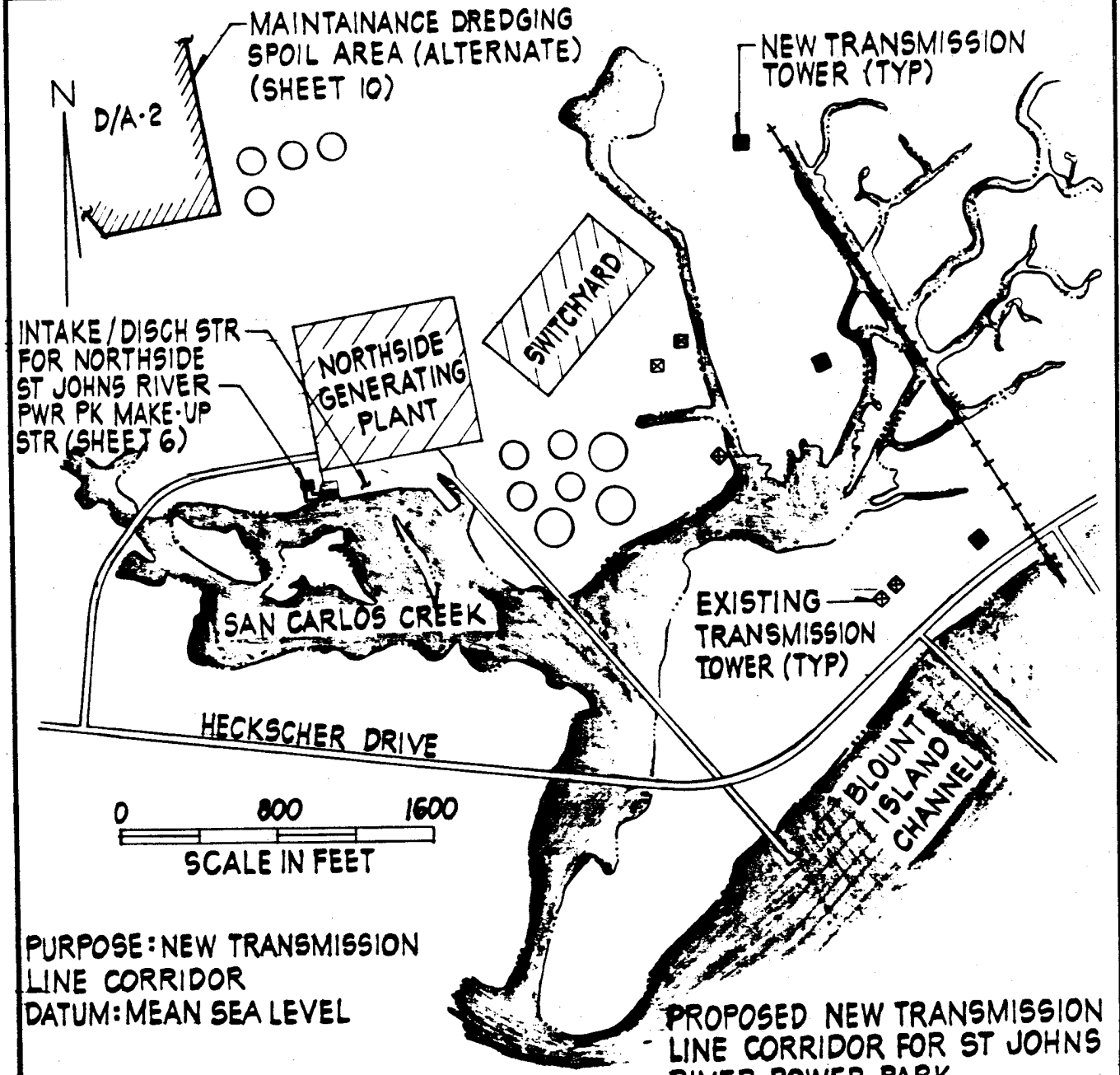


TYP SECT

PURPOSE: SPOIL AREA FOR DREDGED MATERIAL
DATUM: MEAN SEA LEVEL

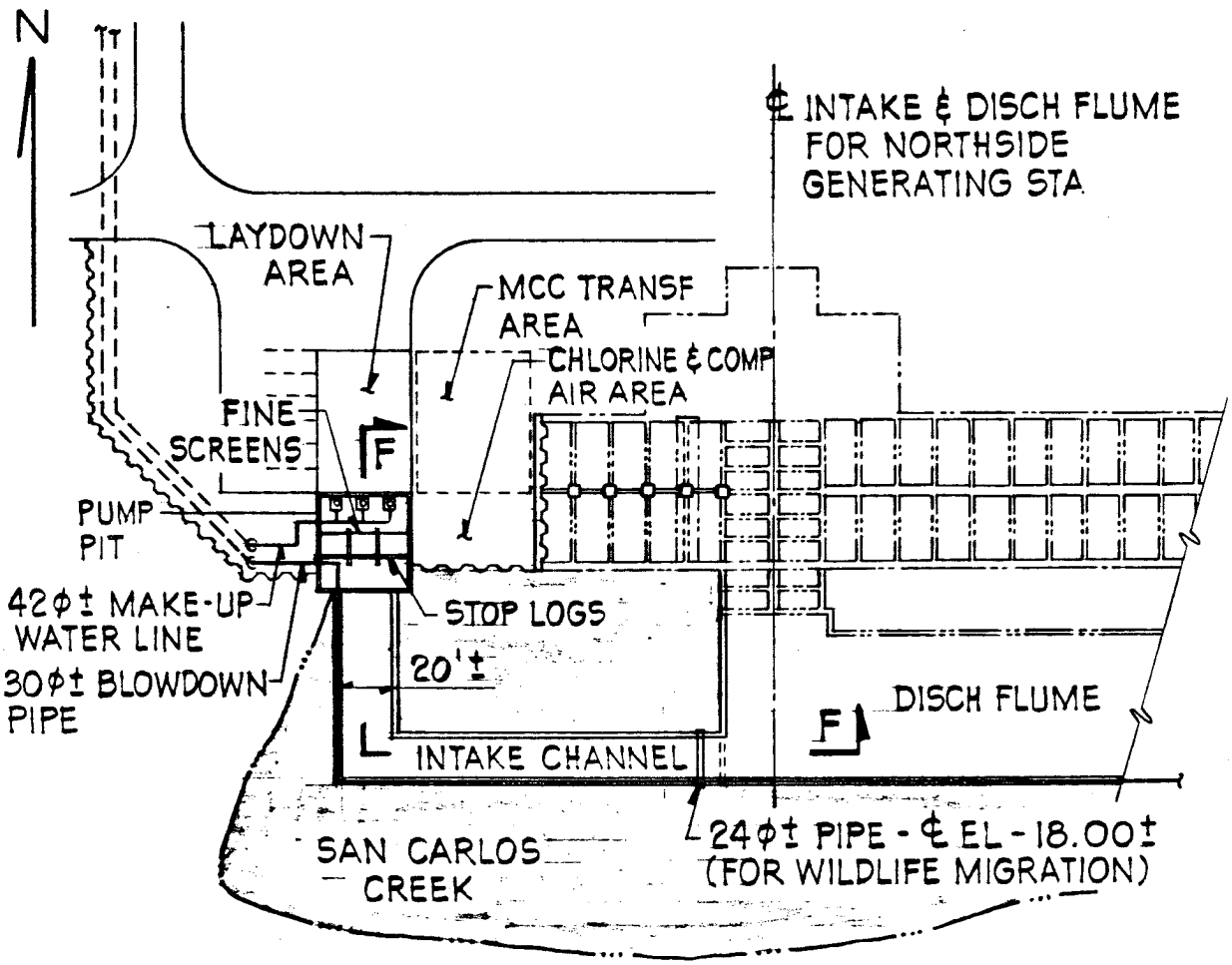
PROPOSED SPOIL AREA FOR MAINTAINANCE DREDGING FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 4 OF 20 DATE: FEB 18 198



PURPOSE: NEW TRANSMISSION LINE CORRIDOR
DATUM: MEAN SEA LEVEL

PROPOSED NEW TRANSMISSION LINE CORRIDOR FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY
SHEET 5 OF 20 DATE FEB 13 1981



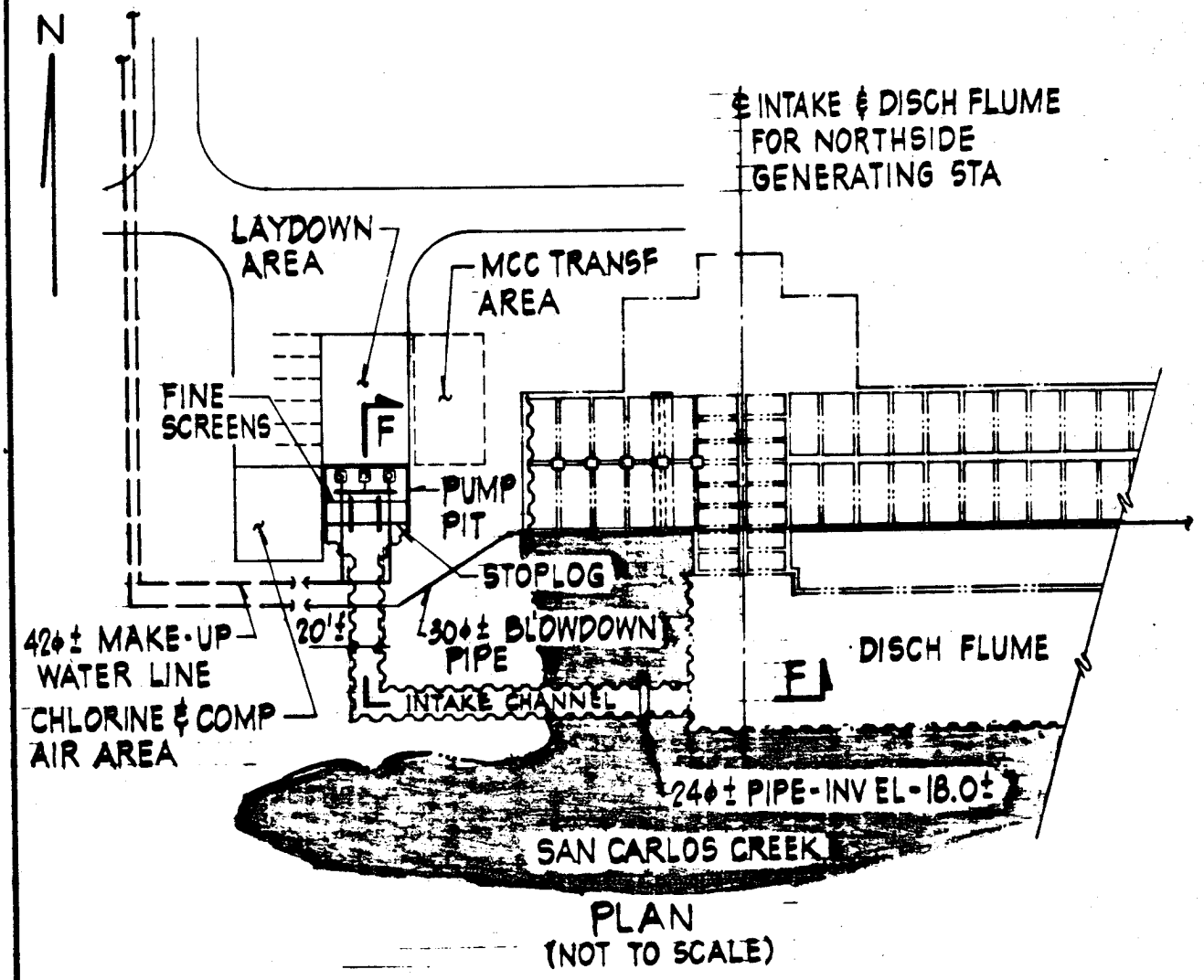
PLAN
(NOT TO SCALE)

PURPOSE: MAKE-UP WATER INTAKE STRUCTURE
DATUM: MEAN SEA LEVEL

PROPOSED MAKE-UP WATER INTAKE FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 6 OF 20 DATE: FEB 18, 1981

REVISED: OCT 16, 1984

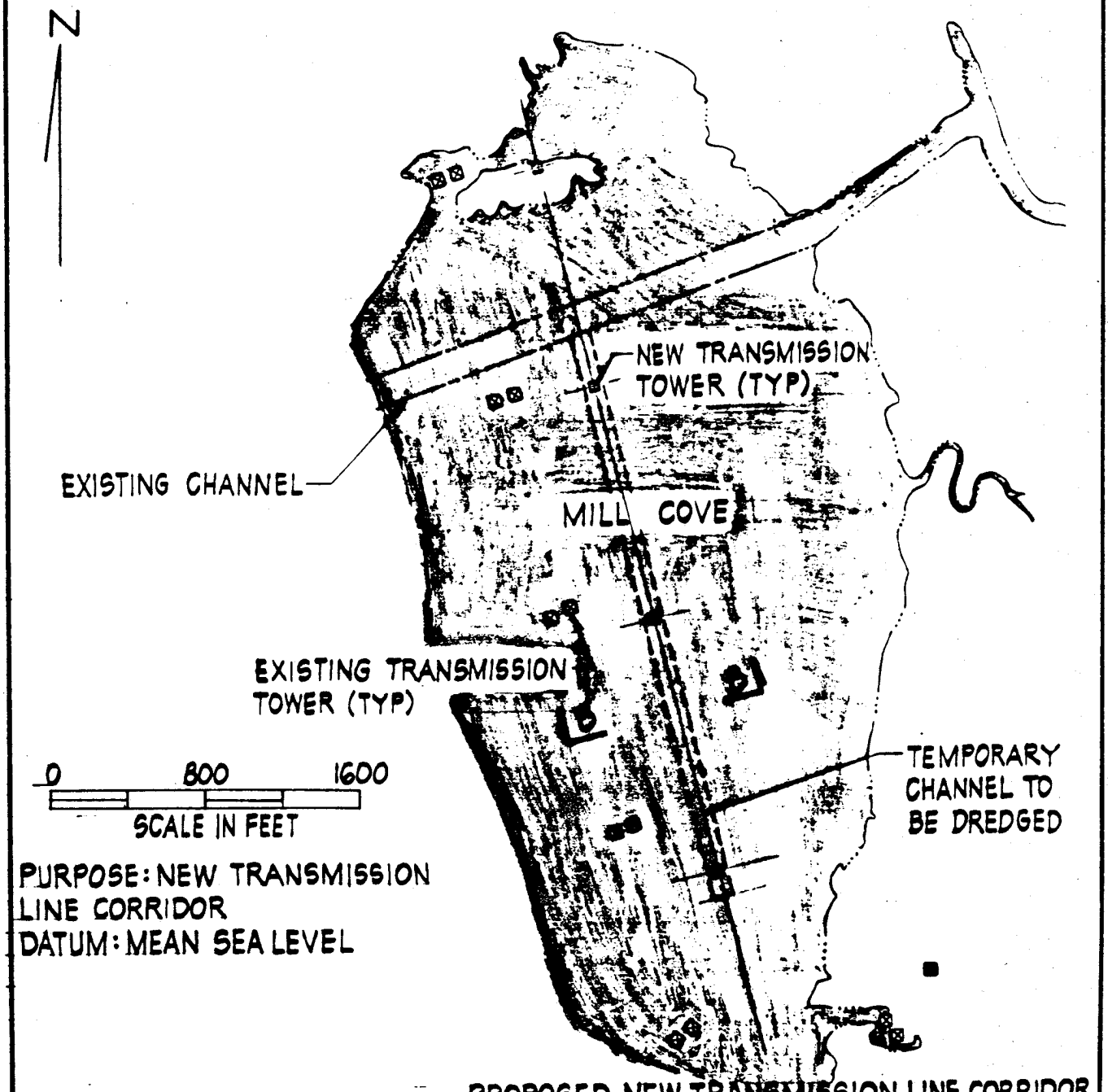


PLAN
(NOT TO SCALE)

PURPOSE: MAKE-UP WATER INTAKE STRUCTURE
DATUM: MEAN SEA LEVEL

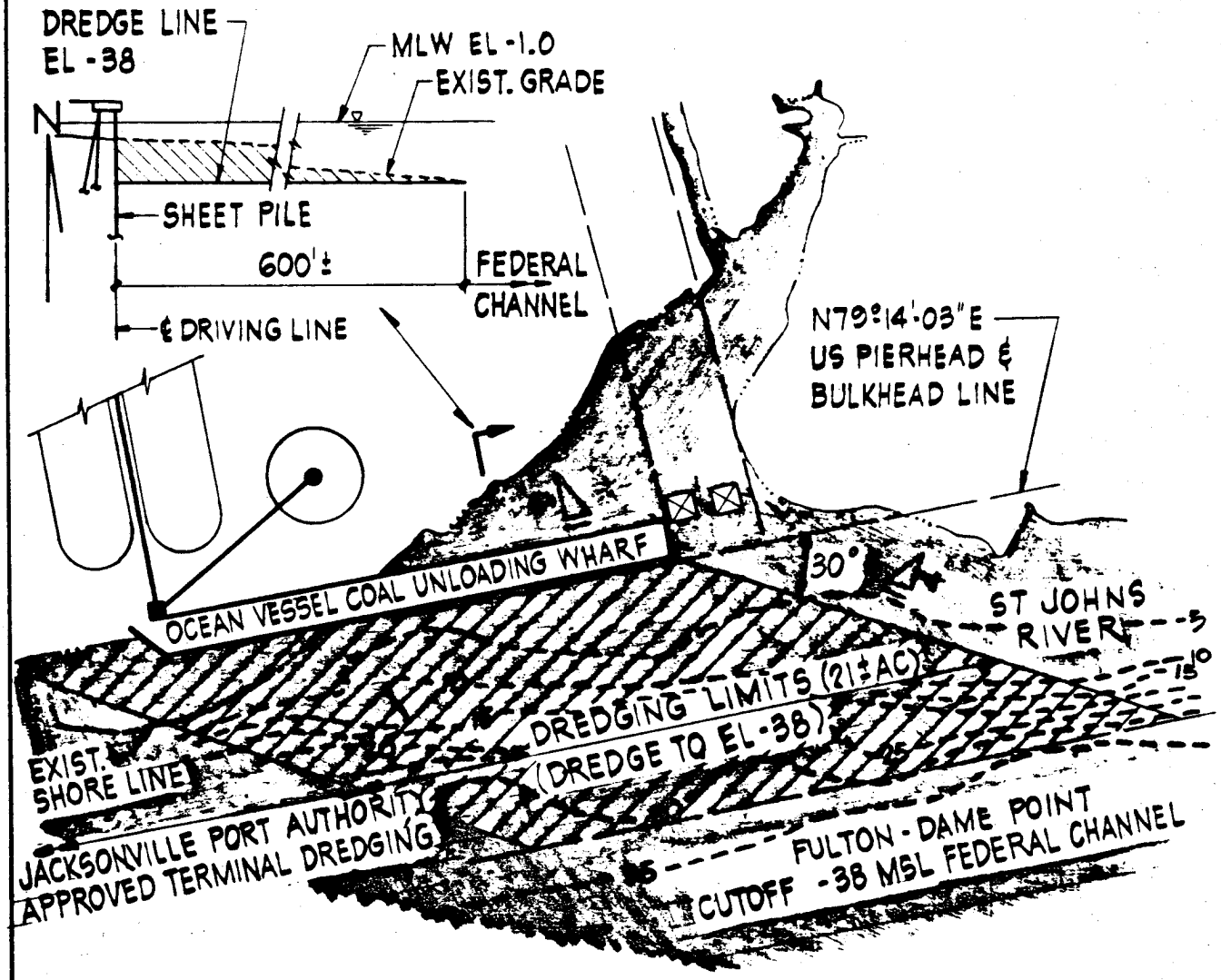
PROPOSED MAKE-UP WATER INTAKE FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY.

SHEET 6 OF 20 DATE FEB 18 1981



PROPOSED NEW TRANSMISSION LINE CORRIDOR FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA, APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 7 OF 20 DATE FEB 18 1981



PLAN

0 400 800

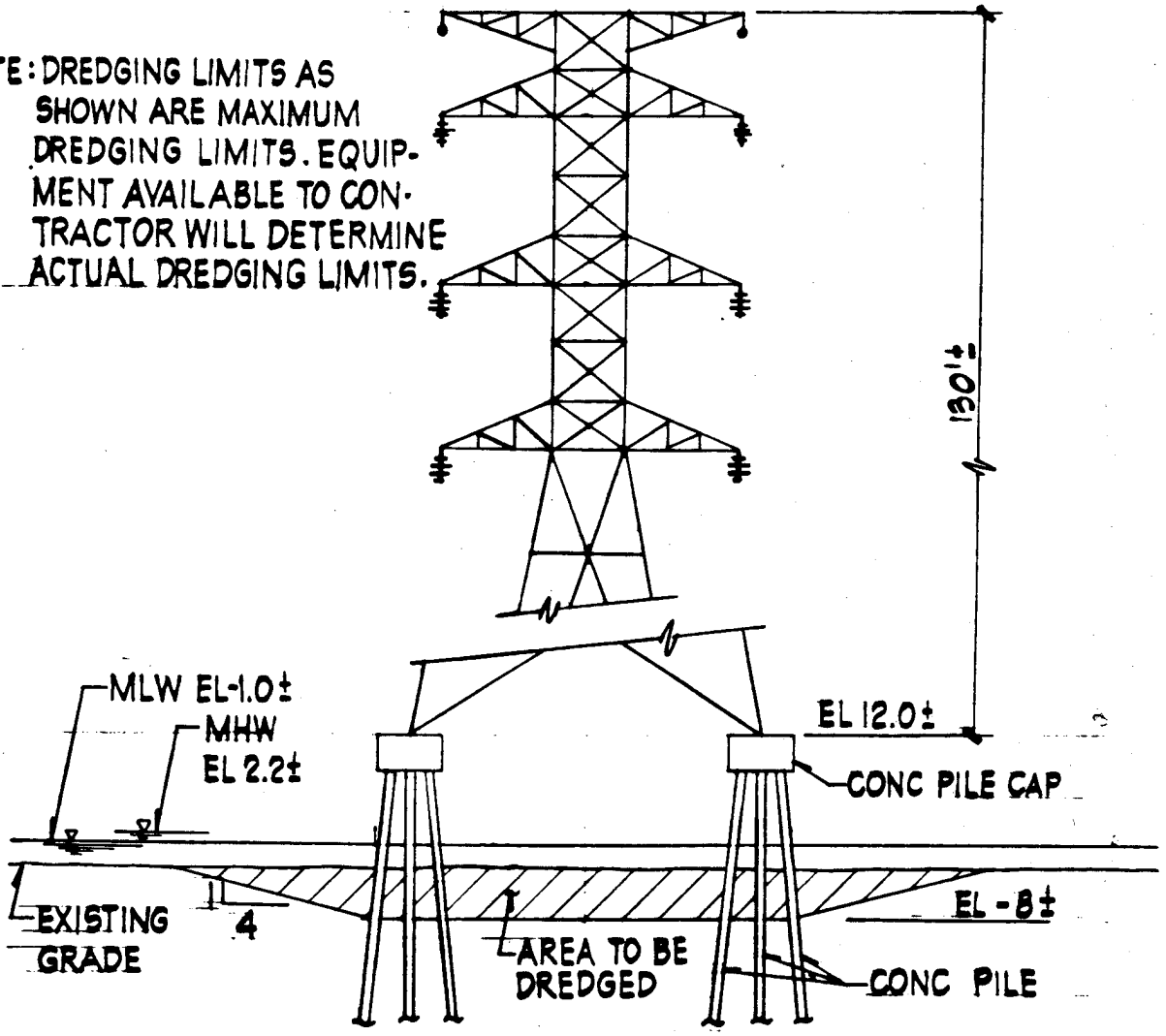
1"=400

PURPOSE: DREDGING IN ST JOHNS RIVER FOR OCEAN VESSEL COAL UNLOADING FACILITY
DATUM: MEAN SEA LEVEL
381,000 CU YD - SUITABLE FILL MATERIAL
170,000 CU YD - SPOIL MATERIAL
551,000 CU YD - TOTAL DREDGED MATERIAL

PROPOSED DREDGING IN THE ST JOHNS RIVER
AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 8 OF 20 DATE: FEB 18 1981

NOTE: DREDGING LIMITS AS SHOWN ARE MAXIMUM DREDGING LIMITS. EQUIPMENT AVAILABLE TO CONTRACTOR WILL DETERMINE ACTUAL DREDGING LIMITS.

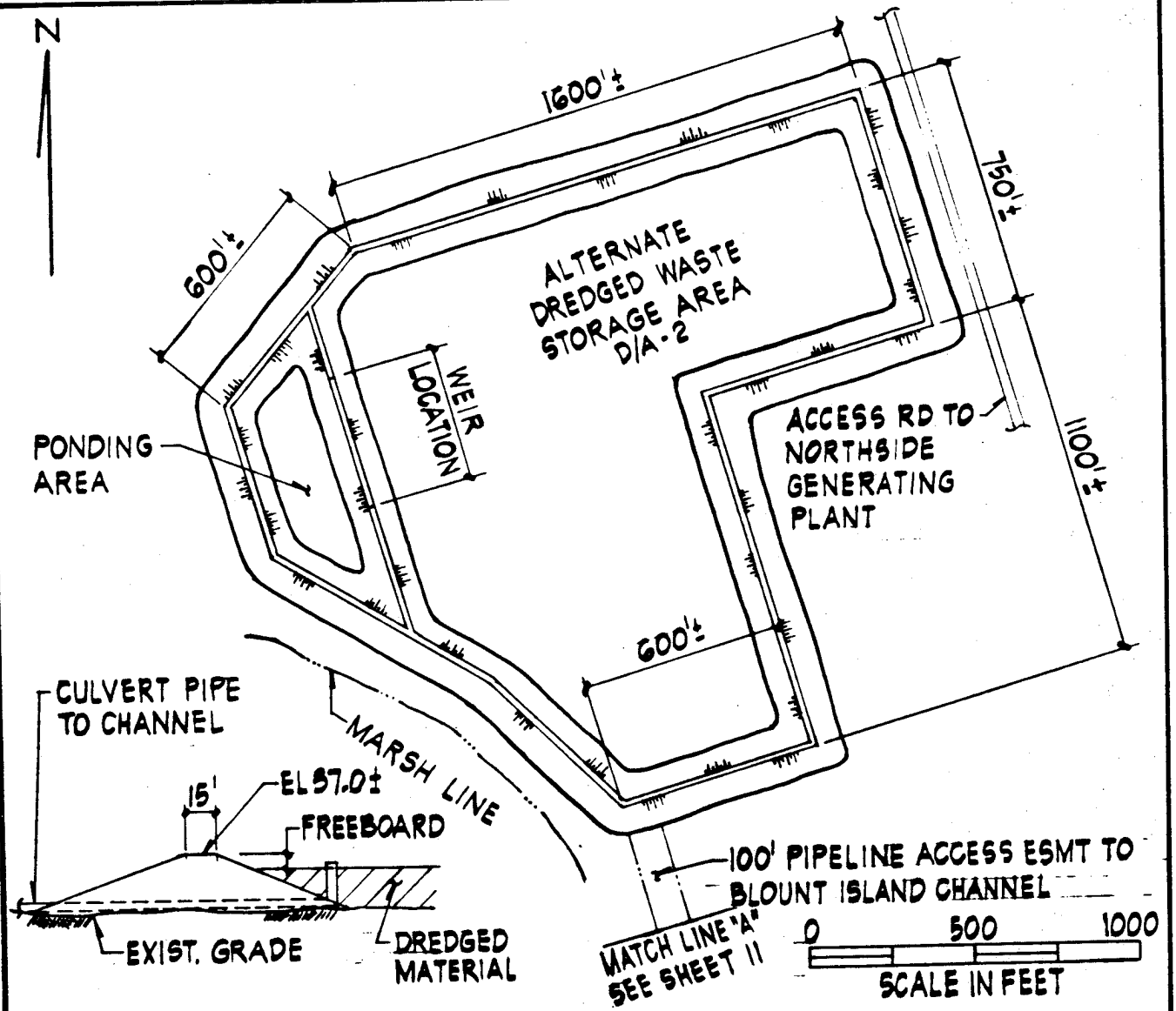


SECT B
(NOT TO SCALE)

PURPOSE: NEW TRANSMISSION LINE CORRIDOR
DATUM: MEAN SEA LEVEL
45,000 CUYD MAXIMUM DREDGING VOLUME

PROPOSED NEW TRANSMISSION LINE CORRIDOR FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA, APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

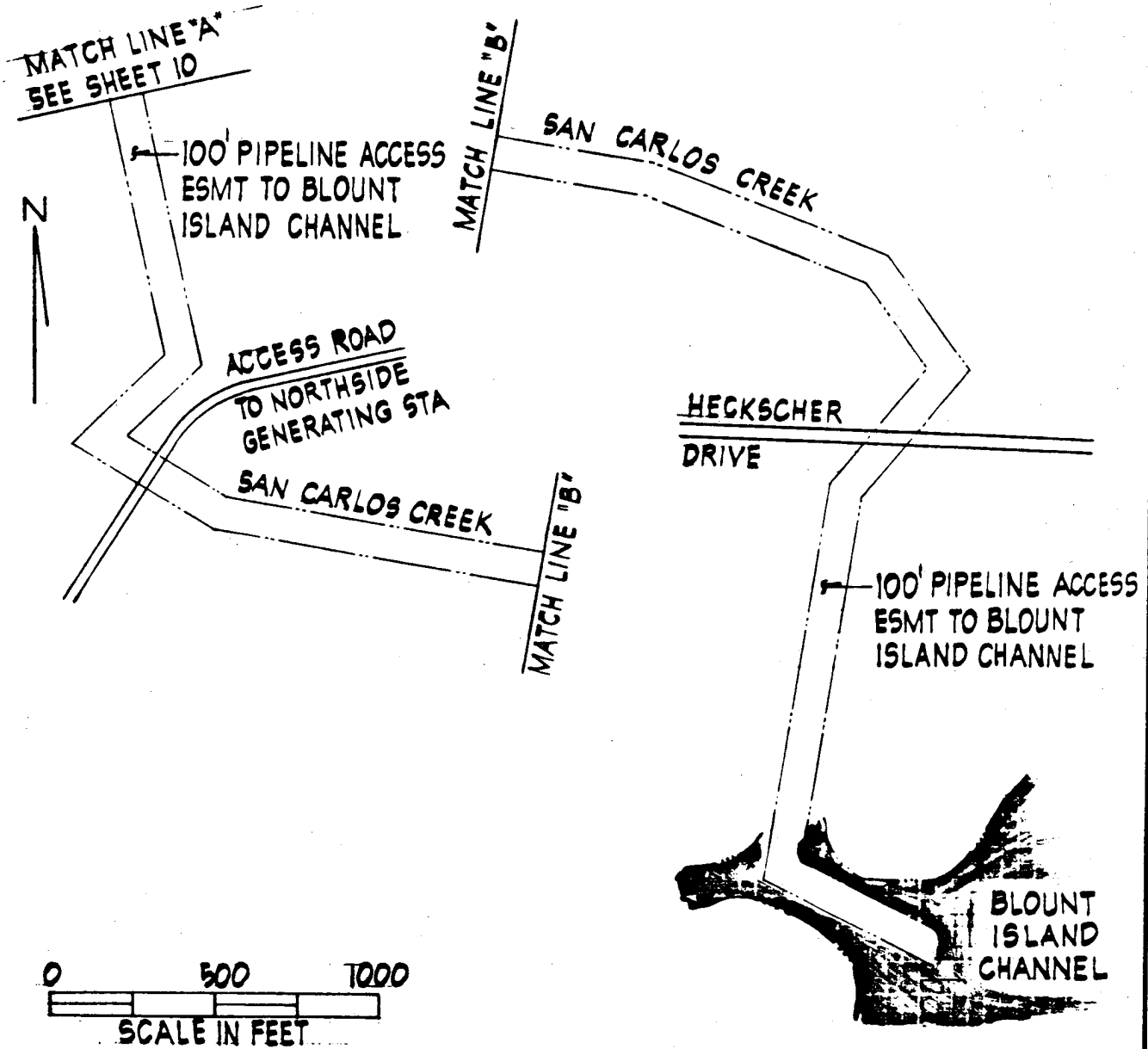
SHEET 9 OF 20 DATE: FEB 18 1981



PURPOSE: SPOIL AREA FOR DREDGED MATERIAL
DATUM: MEAN SEA LEVEL

PROPOSED SPOIL AREA FOR MAINTAINANCE DREDGING (ALT)
ST JOHNS RIVER POWER PARK
AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

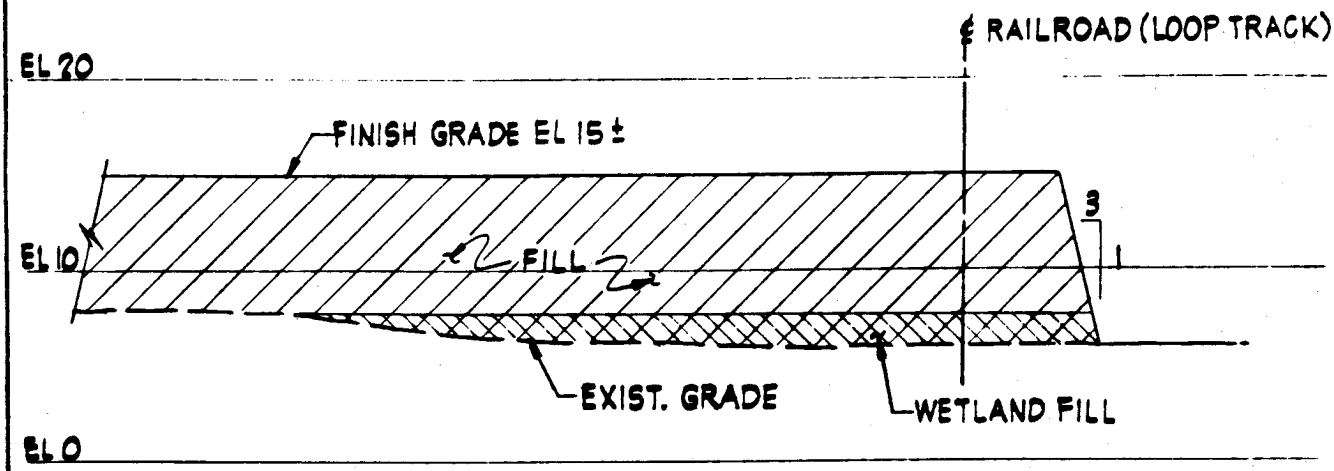
SHEET 10 OF 20 DATE FEB 18 1981



PURPOSE: PIPELINE ACCESS ESMT TO SPOIL AREA FOR DREDGED MAT.
DATUM: MEAN SEA LEVEL

PROPOSED 100' PIPELINE ACCESS ESMT TO DREDGED MAT. SPOIL AREA FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 11 OF 20 DATE: FEB 18 1982



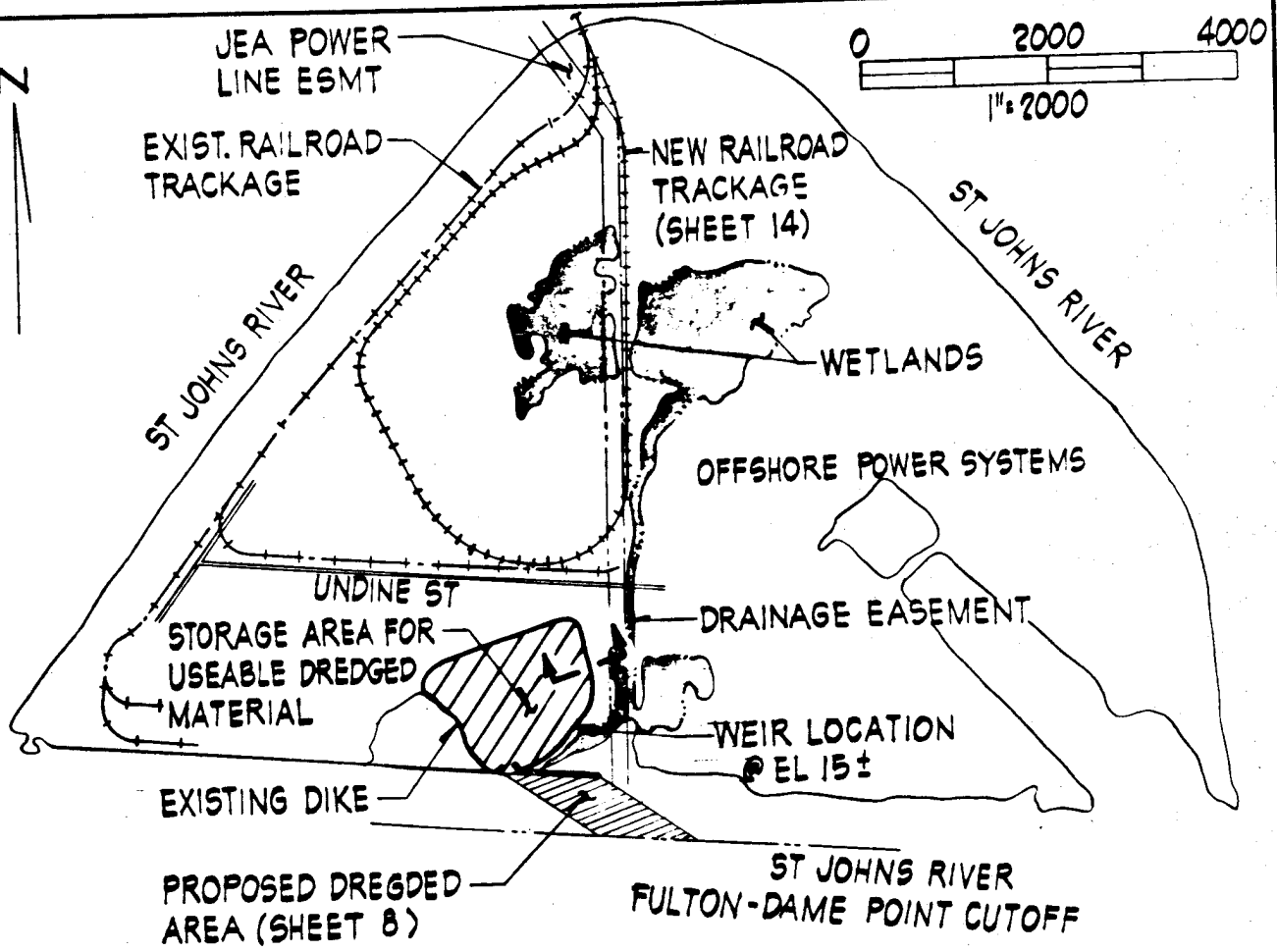
SECT A

SCALE 1"=10' VERT
1"=300' HOR

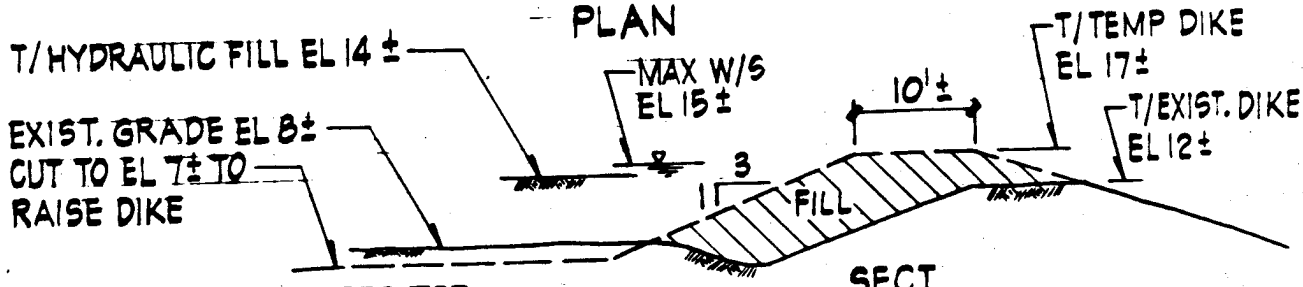
PURPOSE: WET LAND FILLING
FOR SITE PREPARATION
DATUM: MEAN SEA LEVEL
TYPE OF FILL: FINE TO MEDIUM SAND

PROPOSED WET LAND FILLING FOR
ST JOHNS RIVER POWER PARK
AT THE CITY OF JACKSONVILLE, COUNTY
OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE
ELECTRIC AUTHORITY

SHEET 12 OF 20 DATE: FEB 18 1981



PLAN

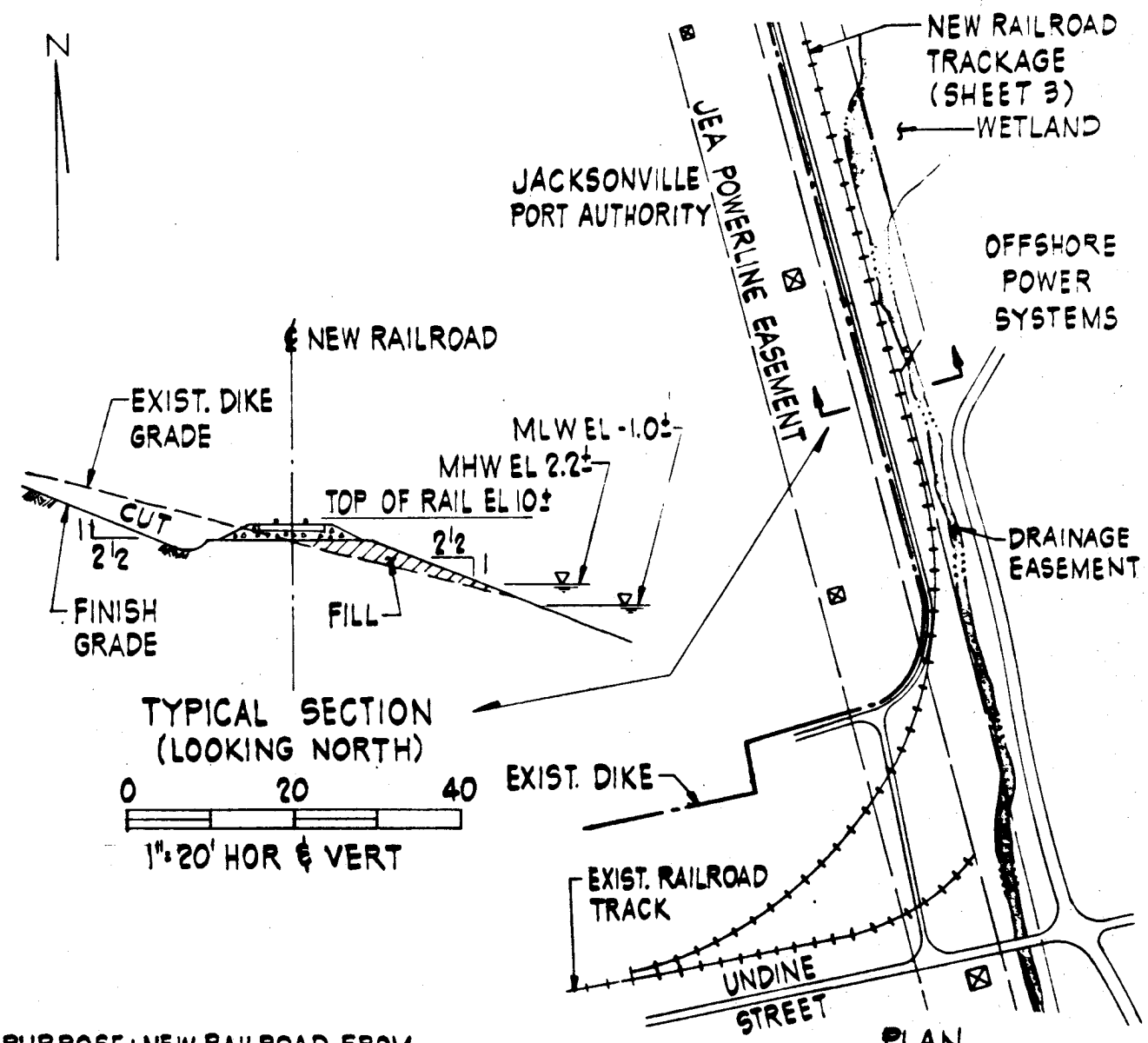


SECT

PURPOSE: STORAGE AREA FOR USEABLE DREGDED MATERIAL
DATUM: MEAN SEA LEVEL
STORAGE CAPACITY=400,000 C Y

PROPOSED STORAGE AREA FOR USEABLE DREGDED MATERIAL AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

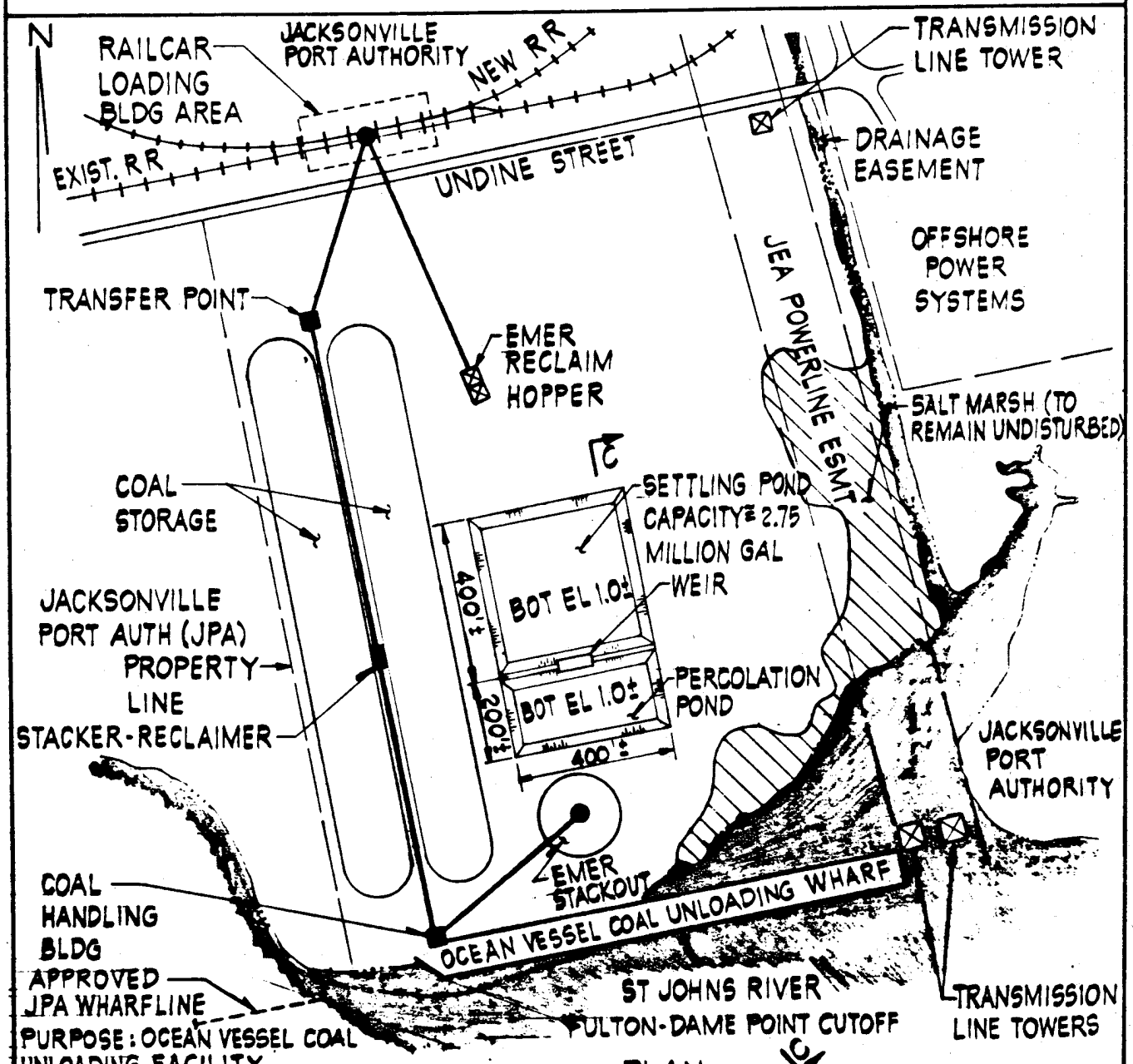
SHEET 13 OF 20 DATE: FEB 18 1981



PURPOSE: NEW RAILROAD FROM COAL UNLOADING FACILITY TO ST JOHNS RIVER POWER PARK
DATUM: MEAN SEA LEVEL

PROPOSED NEW RAILROAD LAYOUT FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 14 OF 20 DATE: FEB 18 1981

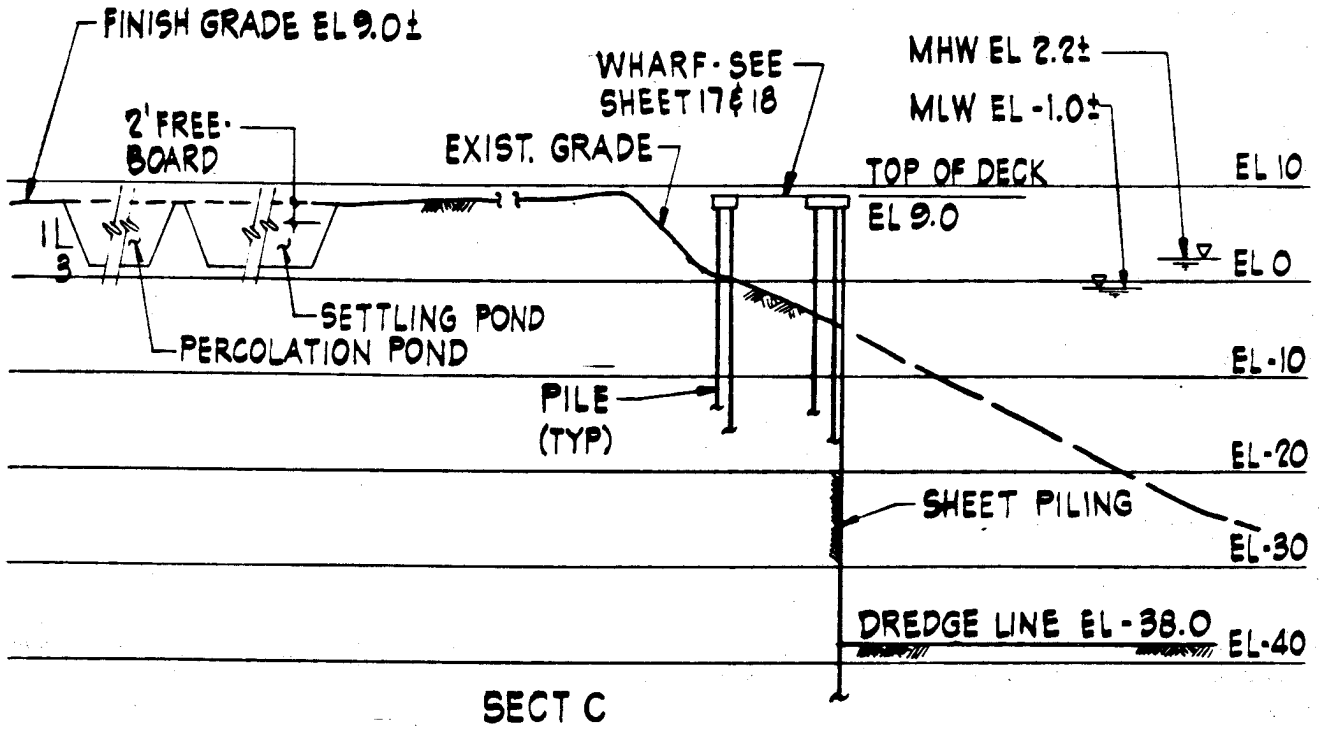


PROPOSED COAL UNLOADING & STORAGE FACILITY FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA

APPLICATION BY: JACKSONVILLE ELEC AUTHORITY

SHEET 15 OF 20

DATE: FEB 18 1981



SECT C

SEE SHEET 5

1" = 200' HOR; 1" = 20' VERT

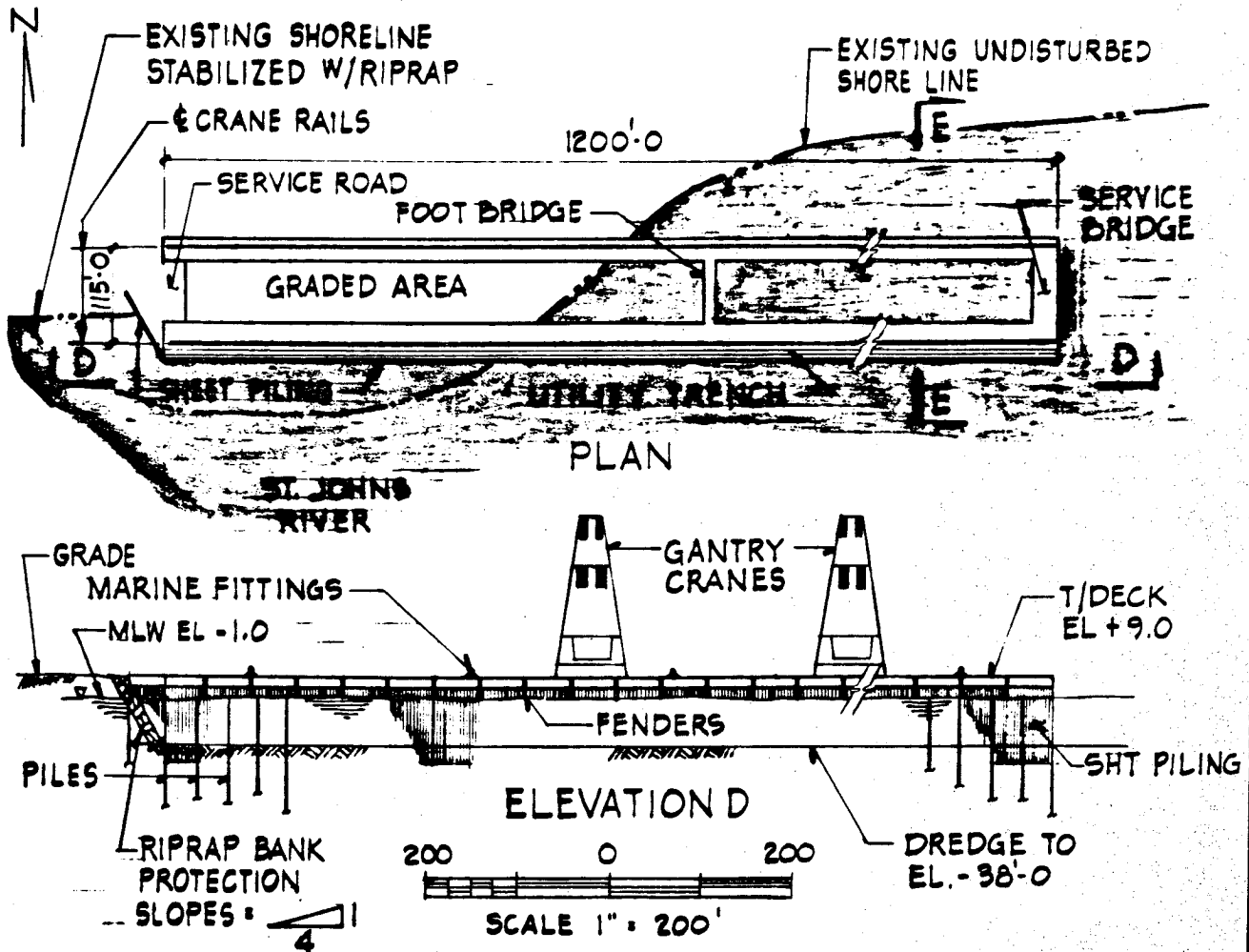
PURPOSE: OCEAN VESSEL COAL UNLOADING FACILITY DEVELOPMENT

DATUM: MEAN SEA LEVEL

PROPOSED COAL UNLOADING FACILITY FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA

APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 16 OF 20 DATE: FEB 18 1981

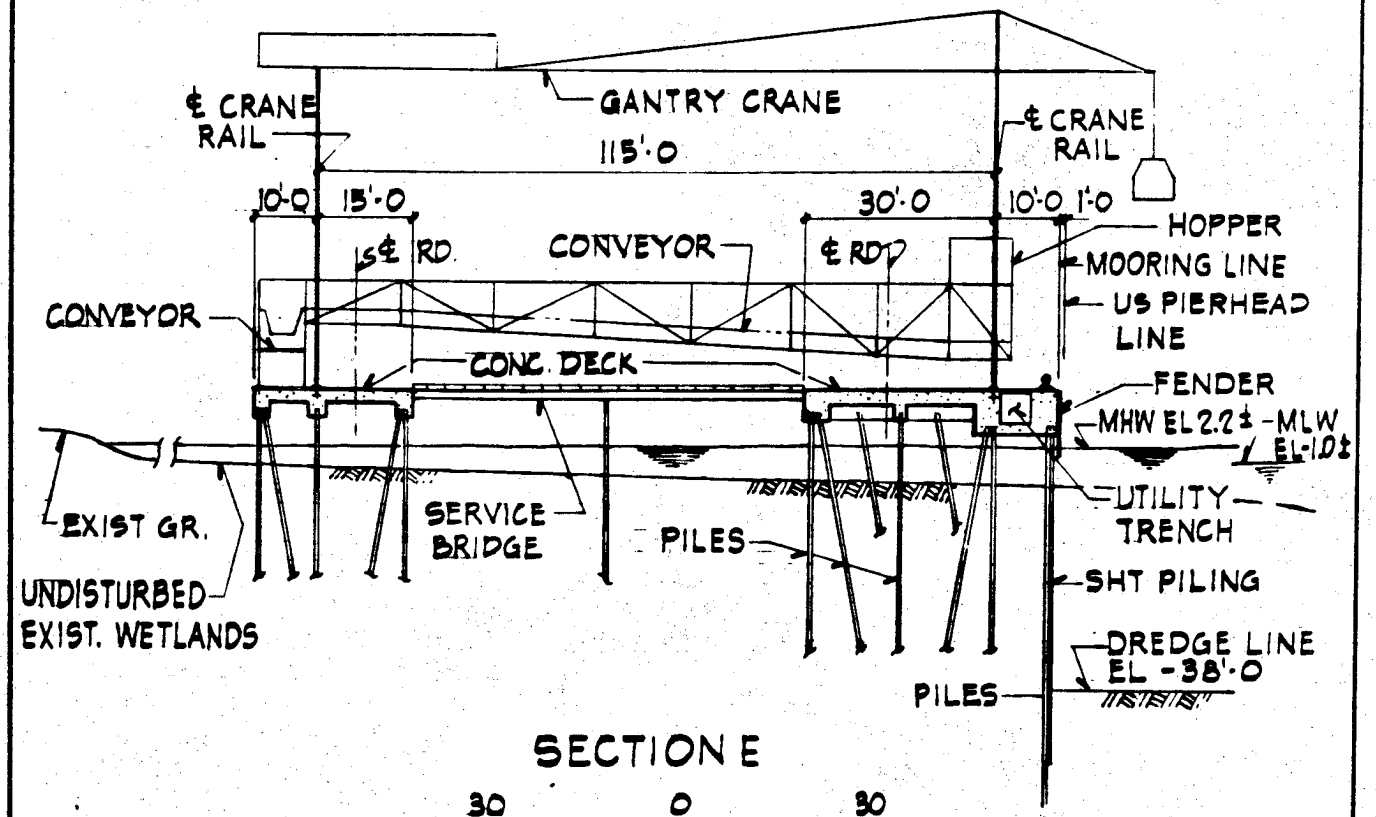


OCEAN VESSEL COAL UNLOADING FACILITY

PURPOSE: OCEAN VESSEL
COAL UNLOADING FACILITY
DATUM: MEAN SEA LEVEL

PROPOSED OCEAN VESSEL COAL UNLOADING WHARF FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE COUNTY OF DUVAL, STATE OF FLORIDA. APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY.

SHEET 17 OF 20 DATE FEB 18 1981



SECTION E

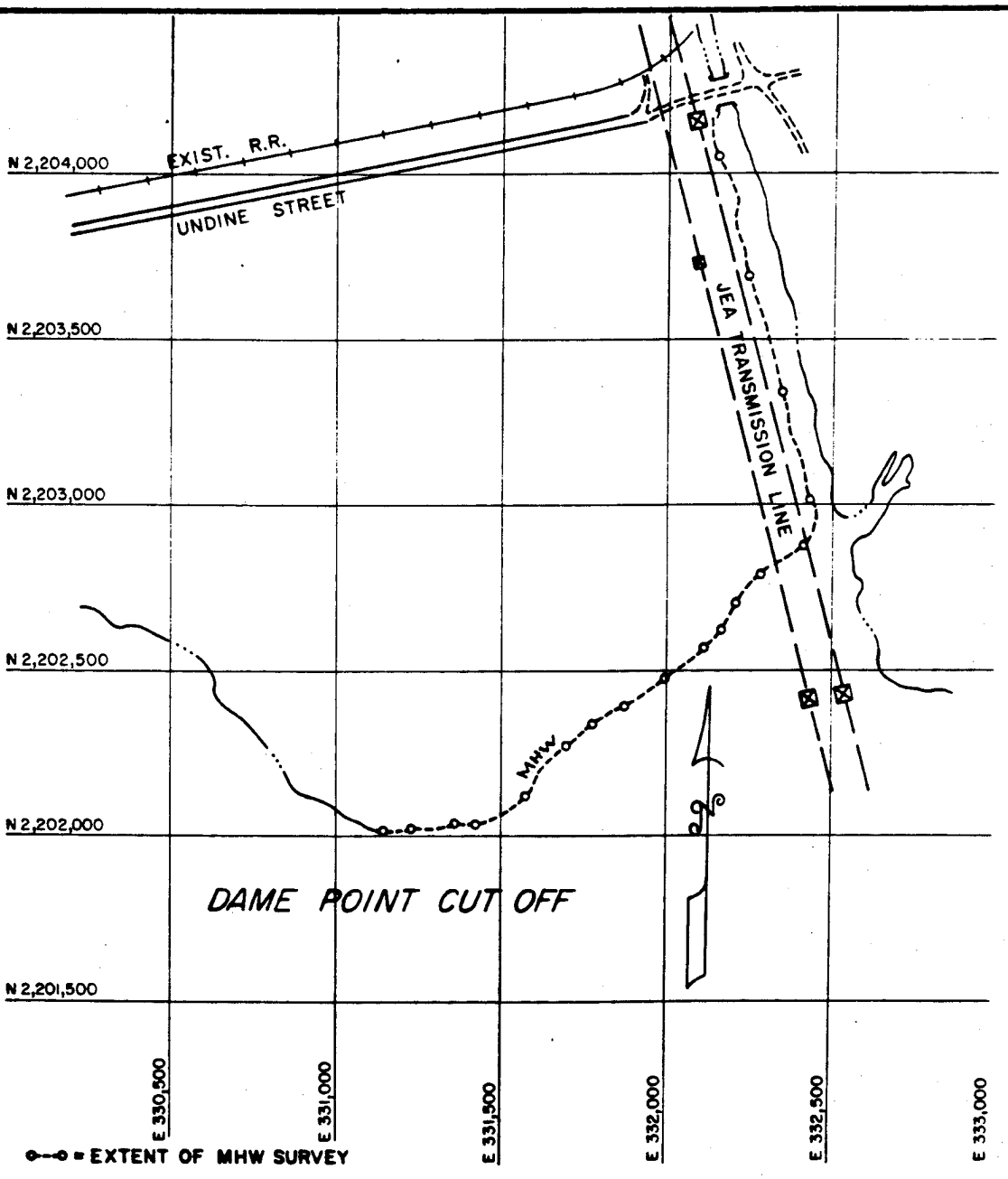
30 0 30

SCALE 1" = 30'

ALL DIMENSIONS ARE APPROXIMATE

PURPOSE : OCEAN VESSEL COAL UNLOADING FACILITY
DATUM : MEAN SEA LEVEL

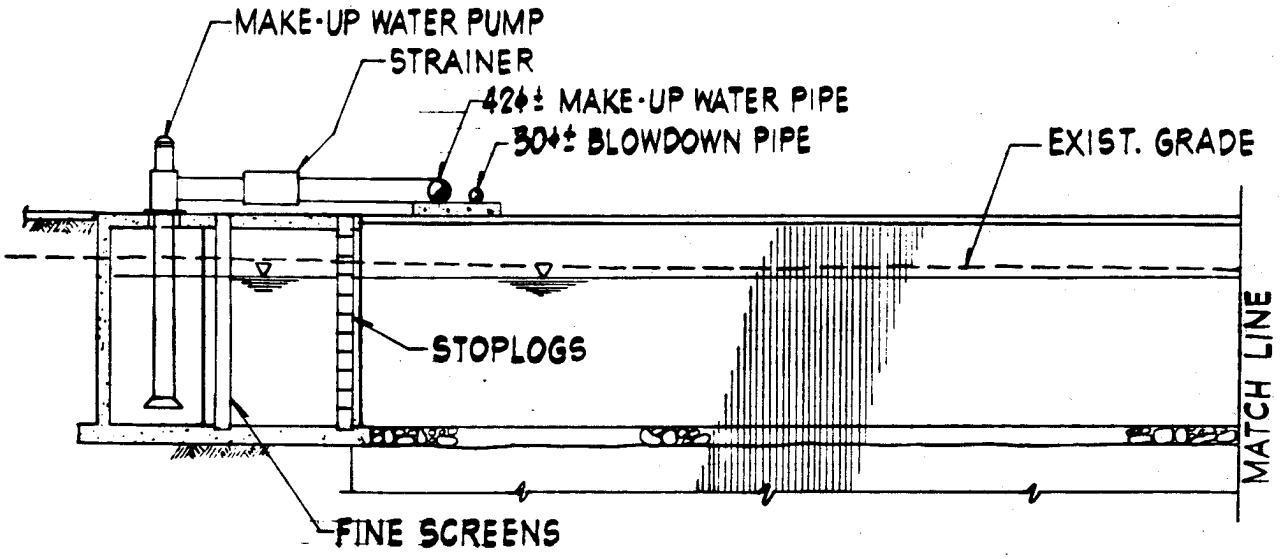
PROPOSED OCEAN VESSEL COAL UNLOADING WHARF FOR ST JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE COUNTY OF DUVAL, STATE OF FLORIDA. APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY.



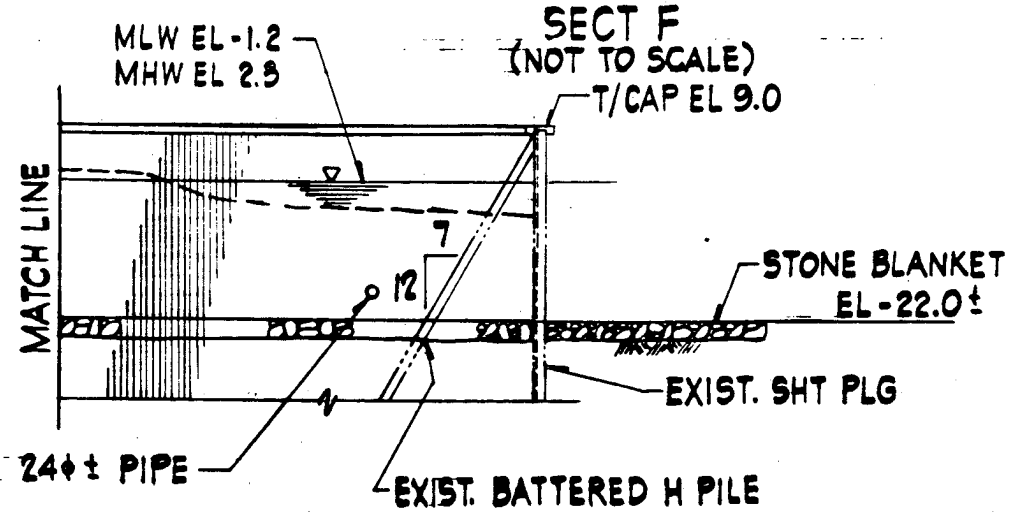
PURPOSE: BLOUNT ISLAND COAL UNLOADING FACILITY MEAN HIGH WATER LINE (MHW) SURVEY (PERFORMED BY: SOUTHERN RESOURCES MAPPING COMPANY)

PROPOSED ST. JOHNS RIVER POWER PARK AND OCEAN VESSEL COAL UNLOADING FACILITY AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA.
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 19 OF 20 DATE: FEB 18 1981



SECT F
(NOT TO SCALE)



PURPOSE: MAKE-UP WATER INTAKE STRUCTURE
DATUM: MEAN SEA LEVEL

PROPOSED MAKE-UP WATER INTAKE FOR ST. JOHNS RIVER POWER PARK AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELECTRIC AUTHORITY

SHEET 20 OF 20 DATE: FEB 18 1981

INFORMATION NEEDED ON AFFIDAVIT OF OWNERSHIP OR CONTROL

1. The affidavit of ownership or control should be signed by at least one owner of the property, lessee, or easement holder.
2. If subdivided, the property should be described by lot number, block number (if any), name of subdivision, and plat book number and page where recorded.
3. If unplatted, the property should be described by section, township, and range, and subdivision of section.
4. If the description is based on courses and distances not following the plane coordinates, the point of beginning should be identified.

Please contact this office should clarification or further instructions be necessary.

AFFIDAVIT OF OWNERSHIP OR CONTROL

TO THE DEPARTMENT OF ENVIRONMENTAL REGULATION:

I hereby certify that I am the (check one):

record owner _____

lessee _____

record easement holder _____

applicant to record owner for easement _____

of the below described property situated in Duval County, Florida; and that said property is all the property that is contiguous to and landward of the area in which the work proposed in the permit application is to be conducted. Furthermore, I certify that as record owner, lessee, or record easement holder I have or will have prior to undertaking the work all necessary approvals or permission from all other persons with a legal interest in said property to conduct the work proposed in the permit application.

LEGAL DESCRIPTION

INFORMATION TO FOLLOW THIS FILING

_____

_____

Sworn to and subscribed before me at _____

_____ County, _____, this _____ day

of _____, 19____.

_____

NOTARY PUBLIC

My commission expires:

DISCHARGE SERIAL NUMBER

001

FOR AGENCY USE

d. Chemical composition of these additives (see instructions). | 219d | _____

Complete items 20-25 if there is a thermal discharge (e.g., associated with a steam and/or power generation plant, steel mill, petroleum refinery, or any other manufacturing process) and the total discharge flow is 10 million gallons per day or more. (see instructions)

20. Thermal Discharge Source Check the appropriate item(s) indicating the source of the discharge. (see instructions) | 220

- ☐ Boiler Blowdown — BLBD
- ☐ Boiler Chemical Cleaning — BCCL
- ☐ Ash Pond Overflow — APOF
- ☐ Boiler Water Treatment — Evaporator Blowdown — EPBD
- ☒ Oil or Coal Fired Plants — Effluent from Air Pollution Control Devices — OCFP
- ☐ Condense Cooling Water — COND
- ☒ Cooling Tower Blowdown — CTBD
- ☐ Manufacturing Process — MFPR
- ☐ Other — OTHR

21. Discharge/Receiving Water Temperature Difference

Give the maximum temperature difference between the discharge and receiving waters for summer and winter operating conditions. (see instructions)

Summer | 221a | 14.7 °F.

Winter | 221b | 33.0 °F.

22. Discharge Temperature, Rate of Change Per Hour | 222 | 25.2 °F./hour

Give the maximum possible rate of temperature change per hour of discharge under operating conditions. (see instructions)

23. Water Temperature, Percentile Report (Frequency of Occurrence)

In the table below, enter the temperature which is exceeded 10% of the year, 5% of the year, 1% of the year and not at all (maximum yearly temperature). (see instructions)

Frequency of occurrence		10%	5%	1%	Maximum
a. Intake Water Temperature (Subject to natural changes)	223a	83.5 °F	84.6 °F	86.1 °F	88 °F
b. Discharge Water Temperature	223b	89.5 °F	91.0 °F	92.0 °F	93.0 °F

24. Water Intake Velocity (see instructions) | 224 | 0.25 feet/sec.

25. Retention Time Give the length of time, in minutes, from start of water temperature rise to discharge of cooling water. (see instructions) | 225 | NA minutes (Recirculating cooling system)

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DISCHARGE SERIAL NUMBER

001

FOR AGENCY USE

26. Additional Information

226

Item	Information
1	The following numbered discharges combine to form the main plant discharge, serial number 001: 003 Sanitary wastewater treatment facility effluent (operating phase) 005 Cooling tower blowdown 006 Central wastewater treatment facility effluent (continuous operation) 007 Central wastewater treatment facility effluent during metal cleaning operations only 008 Oily wastewater collection pond effluent
3	The Site Certification Application/Environmental Information Document (SCA/EID) being submitted separately and the Water and Waste Management Study for the St. Johns River Power Park (attached) are parts of this application.
14-b	Units of energy production are in 1,000 Mega Watts-Day. The facility will consist of two nominal 600 MW units.
16	The parameters indicated are expected to be present in the final discharge based on the analysis of the influent St. Johns River water. Parameters not checked were not analyzed for.
17	Effluent concentrations presented are estimated values at the point of discharge into the Northside Generating Station discharge channel and are based on individual waste stream characteristics. A detailed discussion is included in the Water and Waste Management Study. Minimum values reported for the effluent are minimum observed values in the St. Johns River. Influent flows include 49.5 MGD surface water, 3.8 MGD groundwater and 0.2 MGD rainfall runoff. Only observed surface water quality and groundwater quality data were used in determining the anticipated total influent quality, based on flow weighted averages.

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STANDARD FORM C – MANUFACTURING AND COMMERCIAL

FOR AGENCY USE

SECTION II. BASIC DISCHARGE DESCRIPTION

Complete this section for **each** discharge indicated in Section I, Item 9, that is to surface waters. This includes discharges to municipal sewerage systems in which the wastewater does not go through a treatment works prior to being discharged to surface waters. Discharges to wells must be described where there are also discharges to surface waters from this facility. **SEPARATE DESCRIPTIONS OF EACH DISCHARGE ARE REQUIRED EVEN IF SEVERAL DISCHARGES ORIGINATE IN THE SAME FACILITY.** All values for an existing discharge should be representative of the twelve previous months of operation. If this is a proposed discharge, values should reflect best engineering estimates.

ADDITIONAL INSTRUCTIONS FOR SELECTED ITEMS APPEAR IN SEPARATE INSTRUCTION BOOKLET AS INDICATED. REFER TO BOOKLET BEFORE FILLING OUT THESE ITEMS.

1. Discharge Serial No. and Name

a. **Discharge Serial No.** (see instructions) — 201a: 002 (See Additional Information Item 26 Page II-9 for this Discharge Serial Number)

b. **Discharge Name** Give name of discharge, if any. (see instructions) — 201b: CONSTRUCTION RUNOFF SEDIMENT CONROL POND EFFLUENT

c. **Previous Discharge Serial No.** If previous permit application was made for this discharge (see Item 4, Section I), provide previous discharge serial number. — 201c: NA

2. Discharge Operating Dates

a. **Discharge Began Date** If the discharge described below is in operation, give the date (within best estimate) the discharge began. — 202a: NA (YR) (MO)

b. **Discharge to Begin Date** If the discharge has never occurred but is planned for some future date, give the date (within best estimate) the discharge will begin. — 202b: 82 (YR) 2 (MO)

c. **Discharge to End Date** If discharge is scheduled to be discontinued within the next 5 years, give the date (within best estimate) the discharge will end. — 202c: 87 (YR) 6 (MO)

3. Engineering Report Available Check if an engineering report is available to reviewing agency upon request. (see instructions) — 203: ☒

4. Discharge Location Name the political boundaries within which the point of discharge is located.

			Agency Use	
State	204a	FLORIDA	204d	
County	204b	DUVAL	204e	
(if applicable) City or Town	204c	JACKSONVILLE	204f	

5. Discharge Point Description Discharge is into (check one): (see instructions)

Stream (includes ditches, arroyos, and other intermittent watercourses)	205a	☒STR
Lake		☐LKE
Ocean		☐OCE
Municipal Sanitary Wastewater Transport System		☐MTS
Municipal Combined Sanitary and Storm Transport System		☐MCS

DISCHARGE SERIAL NUMBER

002

FOR AGENCY USE

Municipal Storm Water Transport System ☐ STS

Well (Injection) ☐ WEL

Other ☐ OTH

If 'other' is checked, specify 205b

6. **Discharge Point — Lat/Long** Give the precise location of the point of discharge to the nearest second.

Latitude 206a 30 DEG 25 MIN 30 SEC

Longitude 206b 81 DEG 32 MIN 10 SEC

7. **Discharge Receiving Water Name** Name the waterway at the point of discharge.(see instructions) 207a ST. JOHNS RIVER VIA BROWN'S CREEK

If the discharge is through an outfall that extends beyond the shoreline or is below the mean low water line, complete Item 8.

207b

For Agency Use			207c	For Agency Use
Major	Minor	Sub		303e

8. **Offshore Discharge**

a. **Discharge Distance from Shore** 208a NA feet

b. **Discharge Depth Below Water Surface** 208b _____ feet

9. **Discharge Type and Occurrence**

a. **Type of Discharge** Check whether the discharge is continuous or intermittent. (see instructions) 209a (see note, Item 26)

☐ (con) Continuous

☒ (int) Intermittent

b. **Discharge Occurrence Days per Week** Enter the average number of days per week (during periods of discharge) this discharge occurs. 209b ___ days per week

c. **Discharge Occurrence** —Months If this discharge normally operates (either intermittently, or continuously) on less than a year-around basis (excluding shutdowns for routine maintenance), check the months during the year when the discharge is operating. (see instructions) 209c

☐ JAN ☐ FEB ☐ MAR ☐ APR

☐ MAY ☐ JUN ☐ JUL ☐ AUG

☐ SEP ☐ OCT ☐ NOV ☐ DEC

:omplete Items 10 and 11 if "inter-ittent" is checked in Item 9.a.)therwise, proceed to Item 12.

10. **Intermittent Discharge Quantity** State the average volume per discharge occurrence in thousands of gallons. 210 Variable (see note, Item 26) thousand gallons per discharge occurrence.

11. **Intermittent Discharge Duration and Frequency**

a. **Intermittent Discharge Duration Per Day** State the average number of hours per day the discharge is operating. 211a (see note, Item 26) ___ hours per day

b. **Intermittent Discharge Frequency** State the average number of discharge occurrences per day during days when discharging. 211b ___ discharge occurrences per day

12. **Maximum Flow Period** Give the time period in which the maximum flow of this discharge occurs. 212 (see note, Item 26) From ___ (month) to ___ (month)

DISCHARGE SERIAL NUMBER

002

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13. **Activity Description** Give a narrative description of activity producing this discharge.(see instructions)

213a This discharge is the final effluent from the primary construction phase runoff sediment control pond, located southeast of the plant railroad loop. The effluent consists of rainfall runoff from the site, treated effluent from the sanitary waste treatment plant, and discharges from smaller runoff control ponds and the concrete truck washing area sedimentation pond.

14. **Activity Causing Discharge** For each SIC Code which describes the activity causing this discharge, supply the type and maximum amount of either the raw material consumed (Item 14a) or the product produced (Item 14b) in the units specified in Table I of the instruction Booklet. For SIC Codes not listed in Table I, use raw material or production units normally used for measuring production.(see instructions)

Construction of the St. Johns River Power Park Units 1 & 2

a. **Raw Materials**

	SIC Code (1)	Name (2)	Maximum Amount/Day (3)	Unit (See Table I) (4)	Shared Discharges (Serial Number) (5)
214a					

b. **Products**

	SIC Code (1)	Name (2)	Maximum Amount/Day (3)	Unit (See Table I) (4)	Shared Discharges (Serial Number) (5)
214b					

DISCHARGE SERIAL NUMBER

002

FOR AGENCY USE

15. **Waste Abatement**

a. **Waste Abatement Practices** Describe the waste abatement practices used on this discharge with a brief narrative. (See instructions)

215a

Narrative: Rainfall runoff from the site area during construction is intercepted in a system of grassed drainage channels and directed to construction phase runoff sediment control ponds for suspended solids removal. These ponds discharge to the primary pond prior to discharge into Brown's Creek. Sanitary wastes are treated in two extended aeration package plants prior to discharge into the primary runoff sediment control pond. Water from washing concrete trucks will be collected in separate sedimentation ponds for suspended solids removal. Effluent from these ponds will be directed to the primary construction runoff sediment control pond prior to discharge.

b. **Waste Abatement Codes** Using the codes listed in Table II of the Instruction Booklet, describe the waste abatement processes for this discharge in the order in which they occur if possible.

215b

(1) ESEGRG, (2) LOCALS, (3) PSEDIM,
(4) BACTIV, (5) CCLDIS, (6) _____,
(7) _____, (8) _____, (9) _____,
(10) _____, (11) _____, (12) _____,
(13) _____, (14) _____, (15) _____,
(16) _____, (17) _____, (18) _____,
(19) _____, (20) _____, (21) _____,
(22) _____, (23) _____, (24) _____,
(25) _____.

DISCHARGE SERIAL NUMBER

002

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16. Wastewater Characteristics (See Note Item 26)

Check the box beside each constituent which is present in the effluent (discharge water). This determination is to be based on actual analysis or best estimate.(see instructions)

Parameter 216	Present	Parameter 216	Present
Color 00080		Copper 01042	
Ammonia 00610		Iron 01045	
Organic nitrogen 00605		Lead 01051	
Nitrate 00620		Magnesium 00927	
Nitrite 00615		Manganese 01055	
Phosphorus 00665		Mercury 71900	
Sulfate 00945		Molybdenum 01062	
Sulfide 00745		Nickel 01067	
Sulfite 00740		Selenium 01147	
Bromide 71870		Silver 01077	
Chloride 00940		Potassium 00937	
Cyanide 00720		Sodium 00929	
Fluoride 00951		Thallium 01059	
Aluminum 01105		Titanium 01152	
Antimony 01097		Tin 01102	
Arsenic 01002		Zinc 01092	
Beryllium 01012		Algicides* 74051	
Barium 01007		Chlorinated organic compounds* 74052	
Boron 01022		Pesticides* 74053	
Cadmium 01027		Oil and grease 00550	
Calcium 00916		Phenols 32730	
Cobalt 01037		Surfactants 38260	
Chromium 01034		Chlorine 50060	
Fecal coliform bacteria 74055		Radioactivity* 74050	

*Specify substances, compounds and/or elements in Item 26.

Pesticides (insecticides, fungicides, and rodenticides) must be reported in terms of the acceptable common names specified in *Acceptable Common Names and Chemical Names for the Ingredient Statement on Pesticide Labels*, 2nd Edition, Environmental Protection Agency, Washington, D.C. 20250, June 1972, as required by Subsection 162.7(b) of the Regulations for the Enforcement of the Federal Insecticide, Fungicide, and Rodenticide Act.

DISCHARGE SERIAL NUMBER

002

FOR AGENCY USE

17. Description of Intake and Discharge

For each of the parameters listed below, enter in the appropriate box the value or code letter answer called for.(see instructions)

In addition, enter the parameter name and code and all required values for any of the following parameters if they were checked in Item 16; ammonia, cyanide, aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc, phenols, oil and grease, and chlorine (residual).

Parameter and Code 217a	Influent		Effluent					
	Untreated Intake Water (Daily Average) (1)	In-Plant Treated Intake Water (Daily Average) (2)	Daily Average (3)	Minimum Value Observed or Expected During Discharge Activity (4)	Maximum Value Observed or Expected During Discharge Activity (5)	Frequency of Analysis (6)	Number of Analyses (7)	Sample Type (8)
Flow* MGD 50050			4.5	0	32.3			
pH Units 00400			X	6	9			
Temperature (winter) ° F 74028				UNABLE TO PREDICT				
Temperature (summer) ° F 74027				UNABLE TO PREDICT				
Biochemical Oxygen Demand (BOD 5-day) mg/l 00310				UNABLE TO PREDICT				
Chemical Oxygen Demand (COD) mg/l 00340				UNABLE TO PREDICT				
Total Suspended (nonfilterable) Solids mg/l 00530			50	0	100			
Specific Conductance micromhos/cm at 25° C 00095			X	UNABLE TO PREDICT				
Settleable Matter (residue) ml/l 00545				UNABLE TO PREDICT				

*Other discharges sharing intake flow (serial numbers).(see instructions)

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17. (Cont'd.)

Parameter and Code 217a	Influent		Effluent					
	Untreated Intake Water (Daily Average) (1)	In-Plant Treated Intake Water (Daily Average) (2)	Daily Average (3)	Minimum Value Observed or Expected During Discharge Activity (4)	Maximum Value Observed or Expected During Discharge Activity (5)	Frequency of Analysis (6)	Number of Analyses (7)	Sample Type (8)

18. **Plant Controls** Check if the following plant controls are available for this discharge. 218

Alternate power source for major pumping facility. ☒ APS

Alarm or emergency procedure for power or equipment failure ☐ ALM

Complete item 19 if discharge is from cooling and/or steam water generation and water treatment additives are used.

19. **Water Treatment Additives** If the discharge is treated with any conditioner, inhibitor, or algicide, answer the following:

a. Name of Material(s) 219a _____

b. Name and address of manufacturer 219b _____

c. Quantity (pounds added per million gallons of water treated). 219c _____

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d. Chemical composition of these additives (see instructions). | 219d | _____

Complete items 20-25 if there is a thermal discharge (e.g., associated with a steam and/or power generation plant, steel mill, petroleum refinery, or any other manufacturing process) and the total discharge flow is 10 million gallons per day or more. (see instructions)

20. Thermal Discharge Source Check the appropriate item(s) indicating the source of the discharge. (see instructions) | 220 | NA

- Boiler Blowdown ☐ BLBD
- Boiler Chemical Cleaning ☐ BCCL
- Ash Pond Overflow ☐ APOF
- Boiler Water Treatment — Evaporator Blowdown ☐ EPBD
- Oil or Coal Fired Plants — Effluent from Air Pollution Control Devices ☐ OCFP
- Condense Cooling Water ☐ COND
- Cooling Tower Blowdown ☐ CTBD
- Manufacturing Process ☐ MFPR
- Other ☐ OTHR

21. Discharge/Receiving Water Temperature Difference | | NA

Give the maximum temperature difference between the discharge and receiving waters for summer and winter operating conditions. (see instructions)

Summer | 221a | _____ °F.

Winter | 221b | _____ °F.

22. Discharge Temperature, Rate of Change Per Hour | 222 | _____ °F./hour NA

Give the maximum possible rate of temperature change per hour of discharge under operating conditions. (see instructions)

23. Water Temperature, Percentile Report (Frequency of Occurrence) | | NA

In the table below, enter the temperature which is exceeded 10% of the year, 5% of the year, 1% of the year and not at all (maximum yearly temperature). (see instructions)

Frequency of occurrence		10%	5%	1%	Maximum
a. Intake Water Temperature (Subject to natural changes)	223a	°F	°F	°F	°F
b. Discharge Water Temperature	223b	°F	°F	°F	°F

24. Water Intake Velocity (see instructions) | 224 | _____ feet/sec. NA

25. Retention Time Give the length of time, in minutes, from start of water temperature rise to discharge of cooling water. (see instructions) | 225 | _____ minutes NA

DISCHARGE SERIAL NUMBER

002

FOR AGENCY USE

26. Additional Information

226

Item	Information
1	Discharges numbered 003, sanitary wastewater treatment facility effluent, and 004, sedimentation ponds for concrete truck washing, also combine with this discharge, serial number 002.
3	The SCA/EID, submitted separately, and the Water and Waste Management Study (attached), are parts of this application.
9, 10, 11 & 12	This discharge is caused primarily by rainfall runoff and will therefore depend on intensity and duration of rainfall events.
16	This discharge is caused primarily by rainfall runoff. Therefore, presence of constituents in the discharge cannot be predicted at this time.
17	Since the primary source of influent water is rainfall, influent characteristics have not been predicted.

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FOR AGENCY USE

NOT APPLICABLE

STANDARD FORM C – MANUFACTURING AND COMMERCIAL

SECTION III. WASTE ABATEMENT REQUIREMENTS & IMPLEMENTATION (CONSTRUCTION) SCHEDULE

This section requires information on any uncompleted implementation schedule which may have been imposed for construction of waste abatement facilities. Such requirements and implementation schedules may have been established by local, State, or Federal agencies or by court action. In addition to completing the following items, a copy of an official implementation schedule should be attached to this application. IF YOU ARE SUBJECT TO SEVERAL DIFFERENT IMPLEMENTATION SCHEDULES, EITHER BECAUSE OF DIFFERENT LEVELS OF AUTHORITY IMPOSING DIFFERENT SCHEDULES (Item 1a.) AND/OR STAGED CONSTRUCTION OF SEPARATE OPERATION UNITS (Item 1c), SUBMIT A SEPARATE SECTION III FOR EACH ONE.

FOR AGENCY USE
SCHED. NO. _____

1. Improvements — 300

   a. Discharge Serial Number Affected List the discharge serial numbers, assigned in Section II, that are covered by this implementation schedule. — 301a — _____, _____, _____ / _____, _____, _____

   b. Authority Imposing Requirements Check the appropriate item indicating the authority for implementation schedule. If the identical implementation schedule has been ordered by more than one authority, check the appropriate items. (see instructions) — 301b

   - Locally developed plan — ☐ LOC
   - Areawide Plan — ☐ ARE
   - Basic Plan — ☐ BAS
   - State approved implementation schedule — ☐ SQS
   - Federal approved water quality standards implementation plan. — ☐ WQS
   - Federal enforcement procedure or action — ☐ ENF
   - State court order — ☐ CRT
   - Federal court order — ☐ FED

   c. Facility Requirement. Specify the 3-character code of those listed below that best describes in general terms the requirement of the implementation schedule and the applicable six-character abatement code(s) from Table II of the instruction booklet. If more than one schedule applies to the facility because of a staged construction schedule, state the stage of construction being described here with the appropriate general action code. Submit a separate Section III for each stage of construction planned.

   3-character (general) — 301c — _____

   6-character (specific) (see Table II) — 301d — _____ / _____ / _____

New Facility	NEW
Modification (no increase in capacity or treatment)	MOD
Increase in Capacity	INC
Increase in Treatment Level	INT
Both Increase in Treatment Level and Capacity	ICT
Process Change	PRO
Elimination of Discharge	ELI

FOR AGENCY USE

2. Implementation Schedule and 3. Actual Completion Dates

Provide dates imposed by schedule and any actual dates of completion for implementation steps listed below. Indicate dates as accurately as possible. (see instructions)

Implementation Steps		2. Schedule (Yr./Mo./Day)		3. Actual Completion (Yr./Mo./Day)
a. Preliminary plan complete	302a	___/___/___	303a	___/___/___
b. Final plan submission	302b	___/___/___	303b	___/___/___
c. Final plan complete	302c	___/___/___	303c	___/___/___
d. Financing complete & contract awarded	302d	___/___/___	303d	___/___/___
e. Site acquired	302e	___/___/___	303e	___/___/___
f. Begin action (e.g., construction)	302f	___/___/___	303f	___/___/___
g. End action (e.g., construction)	302g	___/___/___	303g	___/___/___
h. Discharge Began	302h	___/___/___	303h	___/___/___
i. Operational level attained	302i	___/___/___	303i	___/___/___

JACKSONVILLE ELECTRIC AUTHORITY

ST. JOHNS RIVER POWER PARK

UNITS 1 AND 2

WATER AND WASTE MANAGEMENT STUDY

(AUGUST 1981)

EBASCO SERVICES INCORPORATED
145 TECHNOLOGY PARK/ATLANTA
NORCROSS, GEORGIA 30092

WATER AND WASTE MANAGEMENT STUDY

SUMMARY

PURPOSE AND SCOPE

The Jacksonville Electric Authority (JEA) contracted with Ebasco Services Incorporated to perform engineering services for two (2) 600 MW coal-fired generating units. As a part of this project, conceptual engineering studies for development of a plant "water balance" and "wastewater management" plan were required. This Water and Waste Management Study fulfills these requirements by providing a water management plan and a solid waste management plan for the proposed station, the St. Johns River Power Park, Units 1 and 2. The plans developed include both the construction and operational phases of the project and satisfy applicable environmental regulations.

The water and waste management study addresses the following:

- Identifies applicable water and solid waste regulations;
- Identifies plant systems requiring water;
- Identifies sources of liquid and solid discharges from the station;
- Establishes, by system, influent and effluent water quality and quantity;
- Characterizes station solid wastes in terms of quantity and quality; and,
- Recommends a water management plan and a solid waste disposal plan for the operational and construction phases of the proposed station.

The recommendations provided in this study are consistent with existing environmental regulations. However, anticipated new and revised environmental regulations have been considered in making the recommendations.

RESULTS AND CONCLUSIONS

Water Management

The two sources of water for the proposed plant will be surface water from the St. Johns River and groundwater from the Floridan aquifer. Surface water, withdrawn from the existing JEA Northside Generating Station (NGS) discharge channel, will be used as makeup to the recirculating cooling water system. Groundwater, from on-site deep wells, will be used for the

plant potable water supply, demineralized water systems, fire protection system, the flue gas desulfurization (FGD) system, and plant service water.

Plant effluents will be reused where feasible and treated, if necessary, prior to reuse. A system of sedimentation ponds and a retention basin will collect all plant effluents unsuitable for direct discharge. Groundwater resources will be protected by the use of impervious liners in certain sedimentation ponds and the retention basin. Most plant discharges will require treatment by a chemical wastewater treatment facility using physical/chemical processes.

All plant discharges will be directed to the discharge channel of the existing NGS, and will ultimately discharge into the St. Johns River through the existing NGS discharge structure.

Estimated water requirements for the two units are as follows:

	Gallons per Minute (gpm)	
Plant Makeup/Withdrawls	Average	Maximum
Surface Water From Northside Generating Station's (NGS)	34,400	34,400
Groundwater from Deep Wells	2,600	5,400
Consumptive Use	11,300	12,800
Plant Discharge to NGS Discharge	25,900	28,100

For the sake of clarity, water requirements listed above are approximated to the nearest 100 gpm. Also, consumptive use is the sum of water lost through evaporation, water contained in solid wastes and water used for coal dust suppression. Because of rainfall runoff contributions, plant discharge is not equal to surface water and groundwater makeup minus consumptive use.

Solid Waste Management

The high volume solid wastes (i.e. , coal ash and FGD waste) produced over the life of the station are expected to be generated in the following approximate quantities:

	Acre-Feet
Bottom Ash	1,140
Fly Ash	6,080
FGD Waste	12,400

The FGD process selected will produce a by-product gypsum of wallboard grade quality. All three coal combustion by-products will then be available as recoverable resources. It is anticipated that fly ash, bottom ash, and gypsum will be removed off-site for use in nearby potential markets, primarily the construction industry.

On-site disposal of the solid wastes will be necessary should markets for the by-products not materialize or demand cease due to temporary market interruptions. A two phase disposal program will be implemented to thoroughly assess environmental effects of on-site disposal. This program will consist of a solid waste landfill with both "active" and "test cell" areas, designed to provide information currently unavailable due to the absence of specific coal and leachate characteristics. The test cell will aid in the characterization of the structural stability and physical and chemical properties of fly ash, bottom ash, and gypsum mixtures, and monitoring for leachate will be conducted. The test program, approximately five years in duration, also will develop criteria for establishing an environmentally acceptable and cost effective long term disposal plan. During this period, the waste material not directly associated with the test cell will be placed into a secure, monitored landfill. The landfill will be developed in active cells of approximately 10 acres each.

RECOMMENDATIONS

Considering the results and conclusions identified above, the water and waste management plans outlined in Section IV of this study should be implemented to ensure compliance with applicable environmental regulations. These plans include the following:

1. Coal pile, coal pile runoff sedimentation pond, flow equalization basin, and metal cleaning waste retention basin should be lined with impervious material to protect groundwater resources at the main plant site.

2. Metal cleaning wastes should be treated in the central chemical wastewater treatment facility in lieu of off-site disposal by contractor. Solid wastes settled in the metal cleaning waste retention basin should be disposed of off-site within 90 days by RCRA permitted contractor.

3. The bottom ash system should be a recirculating system producing a dry bottom ash for marketing and/or landfill.

4. Potable water and fire protection systems both should be separate from other plant service water systems.

5. Water should be reclaimed and reused wherever feasible, such as utilizing boiler blowdown as makeup to the FGD system.

6. The central wastewater treatment facility should be designed to remove suspended solids and iron and to adjust pH to acceptable neutral levels.

7. The FGD system should produce a potentially marketable resource, gypsum. Non-marketable solid by-products should be commingled and disposed of in a monitored landfill on-site. A market analysis should be performed for using FGD gypsum, bottom ash, and fly ash in both segregated and commingled states. This analysis should emphasize utilizations having the greatest market potential and allowing maximum reduction of on-site land use requirements.

8. A test program should be implemented to determine the most appropriate long term solid waste disposal alternative.

9. Recirculating cooling water should be treated with chlorine and sulfuric acid to prevent biofouling and scaling.

Other recommendations include:

1. A continuing effort should be made to investigate the possibility of further recycle of plant wastewaters as makeup to plant systems. Emphasis should be on minimizing groundwater use.

2. A chlorine minimization program should be initiated soon after plant start-up to determine the optimal chlorination schedule for Units 1 and 2.

3. The regulatory process should be closely monitored to assess the impacts of new and revised water pollution control and solid waste regulations on the proposed plant design.

4. The central wastewater treatment facility should be designed with provisions for expansion to accommodate future revisions to the effluent limitations.

5. An accurate water balance for the flue gas desulfurization (FGD) system should be established as soon as the FGD system is selected.

6. A monitoring program should be developed to determine the suitability of direct discharge of active landfill and solid wastes handling and temporary storage area rainfall runoff instead of treatment.

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INTRODUCTION

This plan is a revised version of the February 1981 Water and Waste Management Study which was prepared as a part of the conceptual engineering phase of the Jacksonville Electric Authority's (JEA) proposed St. Johns River Power Park (SJRPP), Units 1 and 2. Under the JEA-Ebasco Contract, Sections 7.3.1a V and 7.3.1.a VI call for conceptual engineering studies on "Water Balance" and "Wastewater Management", respectively. This revised Water and Waste Management Study will fulfill the requirements of the "Water Balance" and "Wastewater Management" studies. In addition, solid waste management has been included in this study.

The results of the report provide an integral input into the licensing process of the SJRPP as optimum wastewater treatment and solid waste handling systems are developed to ensure plant compliance with federal and state discharge and water quality regulations. This study identifies pertinent federal and state wastewater and solid waste regulations, plant makeup water quality, plant water requirements, plant wastewater and solid waste quantities and characteristics, and recommended plant management plans.

It is emphasized that the flow quantities in this study are based on the present conceptual design of the power plant and are primarily meant to be used to illustrate the wastewater and solid waste management concepts.

I GENERAL PLANT DATA

The proposed SJRPP, Units 1 and 2, will consist of two 600 MW coal-fired generating units located at a site near the bank of the St. Johns River north of Blount Island. The proposed site is located in the northeast corner of Jacksonville, Duval County, Florida, east of New Berlin Road, and adjacent to the north boundaries of the Northside Generating Station (NGS). The site plan and plot plan for the proposed plant are presented in Figures I and II, respectively. Major plant facilities include active and inactive coal storage areas, electrostatic precipitators, SO_2 removal system, central wastewater treatment facility, ash and flue gas desulfurization disposal facilities and active and inactive limestone storage areas.

Commercial operation is planned for the SJRPP Unit 1 in late 1985 and for Unit 2 in mid-1987. The units will be base-loaded at an average load factor of 62 percent over the 40 year nominal plant life. The power plant will utilize bituminous and subbituminous coal from a yet to be determined source, though most likely from Tennessee, Kentucky and Ohio. Analyses of coals from these areas resulted in the following ranges of characteristics:

Heating value	10,500 to 13,250 Btu/lb
Ash content	6.0 to 18.0 (wt.%)
Sulfur content	0.5 to 4.0 (wt.%)
Moisture	4.0 to 15.0 (wt.%)

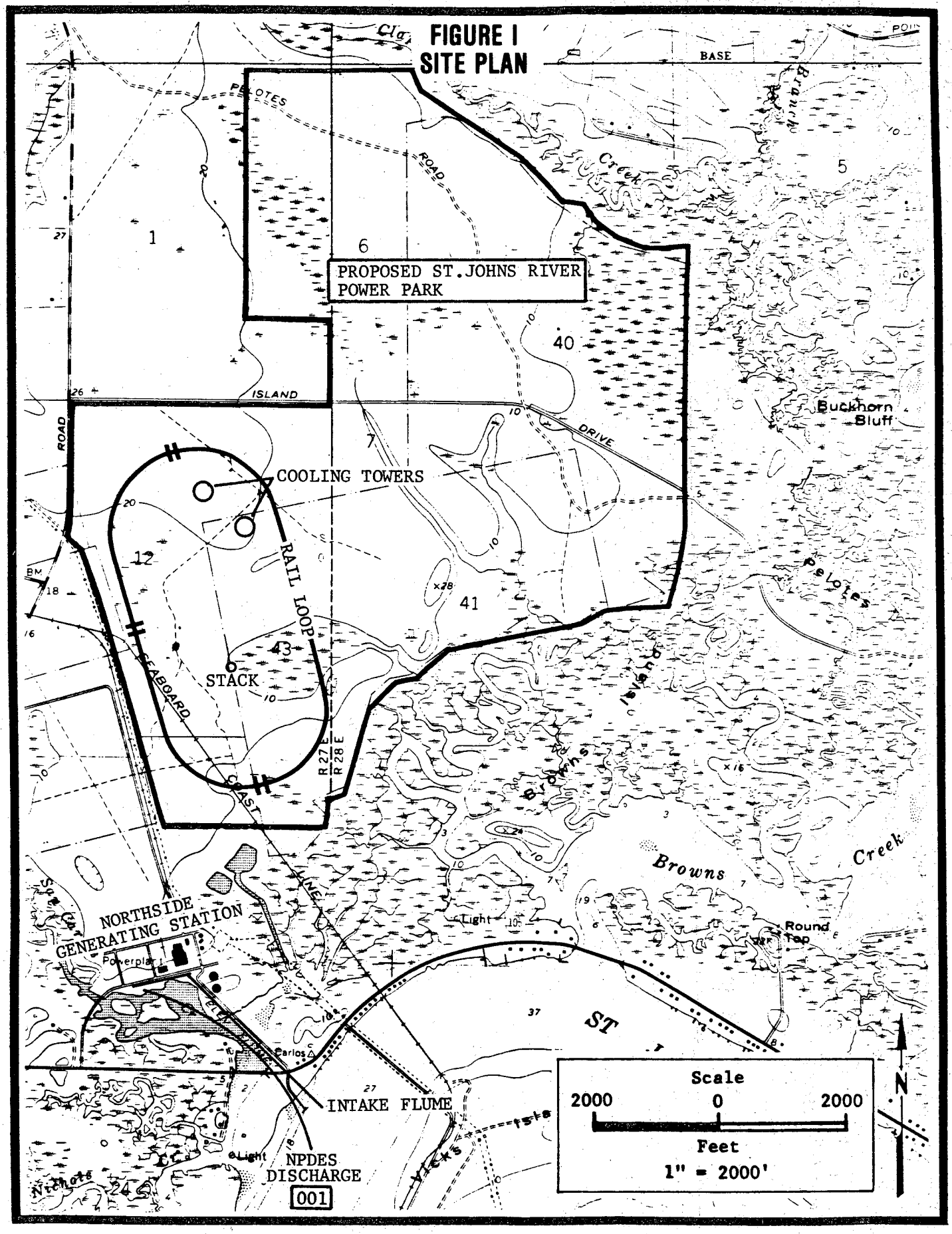
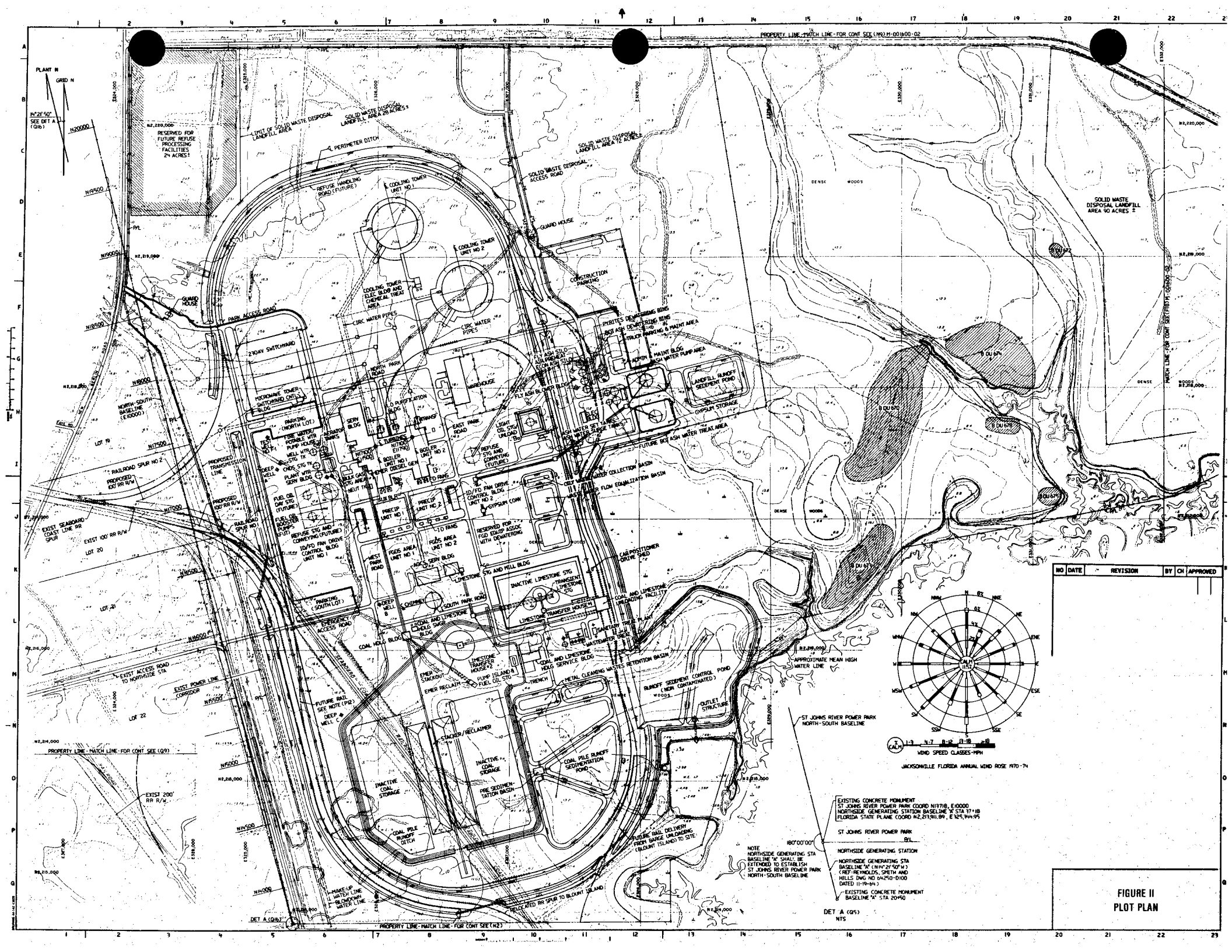


FIGURE I
SITE PLAN
PROPOSED ST. JOHNS RIVER POWER PARK
COOLING TOWERS
STACK
RAIL LOOP
SEABOARD
COAST
NORTHSIDE GENERATING STATION
INTAKE FLUME
NPDES DISCHARGE
001
ISLAND
ROAD
DRIVE
Buckhorn Bluff
Pelotes
Browns Creek
Round Top
Scale
2000 0 2000
Feet
1" = 2000'
N


PROPERTY LINE - MATCH LINE - FOR CONT SEE (MD) M-001600-02
PLANT N
GRID N
N 21° 50' W
SEE DET A (Q16)
RESERVED FOR FUTURE REFUSE PROCESSING FACILITIES 24 ACRES ±
LIMIT OF SOLID WASTE DISPOSAL LANDFILL AREA
SOLID WASTE DISPOSAL LANDFILL AREA 20 ACRES ±
SOLID WASTE DISPOSAL LANDFILL AREA 12 ACRES ±
SOLID WASTE DISPOSAL LANDFILL AREA 90 ACRES ±
PERIMETER DITCH
REFUSE HANDLING ROAD (FUTURE)
SOLID WASTE ACCESS ROAD
GUARD HOUSE
COOLING TOWER UNIT NO 1
COOLING TOWER UNIT NO 2
COOLING TOWER ELEC BLDG AND CHEMICAL TREAT AREA
CIRC WATER PIPES
CONSTRUCTION PARKING
PYRITES DEWATERING BINS
BOTTOM ASH DEWATERING BINS
TRUCK PARKING & MAINT AREA
MAINT BLDG
ASH WATER PUMP AREA
LANDFILL RUNOFF SEDIMENT POND
GYPSUM STORAGE
FUTURE BOT ASH WATER TREAT AREA
ASH WATER SURGE TANKS
FLY ASH SILO AIR PRESHEATER AND ASH SURGE BIN
FLY ASH & LIMER BLDG
WAREHOUSE
230KV SWITCHYARD
MICROWAVE TOWER SWITCHYARD CNTL'S BLDG
NORTH PARK ROAD
EAST PARK ROAD
WEST PARK ROAD
SOUTH PARK ROAD
PARKING (NORTH LOT)
PARKING (SOUTH LOT)
FIRE WATER/ POTABLE WTR PUMP HOUSE
WELL WTR STG TK
PLANT WTR SERV BLDG
AERATOR TANKS
SERV BLDG
H2O PURIFICATION BLDG
TURBINES
BOILER UNIT NO 1
BOILER UNIT NO 2
EMER DIESEL GEN
ID/FD FAN DRIVE & CONTROL BLDG UNIT NO 2
GYPSUM CONV
RESERVED FOR FGD EDISON ASSOC WITH DEWATERING
PRECIP UNIT NO 1
PRECIP UNIT NO 2
FGDS AREA UNIT NO 1
FGDS AREA UNIT NO 2
LTD PANS
ADD SERV BLDG
LIMESTONE STG AND MILL BLDG
INACTIVE LIMESTONE STG
TRANSIENT LIMESTONE STG
LIMESTONE TRANSFER HOUSE #1
LIMESTONE TRANSFER HOUSE #2
COAL AND LIMESTONE UNLOADING FACILITY
CARPOSITIONER DRIVE SHED
COAL AND LIMESTONE HDLG SERVICE BLDG
COAL HDLG BLDG
COAL HDLG SWGR BLDG
WASTEWATER TREAT PLANT
METAL CLEANING WASTES RETENTION BASIN
RUNOFF SEDIMENT CONTROL POND (NON CONTAMINATED)
OUTLET STRUCTURE
APPROXIMATE MEAN HIGH WATER LINE
PUMP ISLAND & FUEL OIL STG
EMER STACKOUT
EMER RECLAIM
STACKER/RECLAIMER
INACTIVE COAL STORAGE
PRE SEDIMENTATION BASIN
COAL PILE RUNOFF SEDIMENTATION POND
COAL PILE RUNOFF DITCH
FUTURE RAIL DELIVERY FROM BARGE UNLOADING (BLOUNT ISLAND) TO SITE
RELOCATED RR SPUR TO BLOUNT ISLAND
MAKE-UP & BLOWDOWN WATER LINE
DEEP WELL A
DEEP WELL B
DEEP WELL C
RAILROAD SPUR NO 1
RAILROAD SPUR NO 2
PROPOSED 100' RR R/W
EXIST 100' RR R/W
EXIST SEABOARD COAST LINE RR SPUR
EXIST ACCESS ROAD TO NORTHSIDE STA
EXIST POWER LINE CORRIDOR
EXIST 200' RR R/W
PROPOSED TRANSMISSION LINE
FAIRFIELD RD
LOT 19
LOT 20
LOT 21
LOT 22
DENSE WOODS
8 DU 6/A
ST JOHNS RIVER POWER PARK NORTH-SOUTH BASELINE
EXISTING CONCRETE MONUMENT ST JOHNS RIVER POWER PARK COORD N19718, E10000 NORTHSIDE GENERATING STATION BASELINE "A" STA 37+18 FLORIDA STATE PLANE COORD N2,219,911.89, E325,944.95
ST JOHNS RIVER POWER PARK
180°00'00"
NORTHSIDE GENERATING STATION
NORTHSIDE GENERATING STA BASELINE "A" (N 21° 50' W) (REF REYNOLDS, SMITH AND HILLS DWG NO 64250-D100 DATED 11-19-64)
EXISTING CONCRETE MONUMENT BASELINE "A" STA 20+50
NOTE NORTHSIDE GENERATING STA BASELINE "A" SHALL BE EXTENDED TO ESTABLISH ST JOHNS RIVER POWER PARK NORTH-SOUTH BASELINE
DET A (Q5) NTS
CALM (1.5%)
WIND SPEED CLASSES-MPH
1-3 4-7 8-12 13-18 ≥18
JACKSONVILLE FLORIDA ANNUAL WIND ROSE 1970-74
NO DATE REVISION BY CH APPROVED
FIGURE II
PLOT PLAN

II ENVIRONMENTAL REGULATIONS

A. Water Pollution Control

1. Federal

The proposed SJRPP will be subject to the U.S. Environmental Protection Agency (USEPA) Effluent Guidelines and Standards for Steam Electric Power Generating, Standards of Performance for New Sources (40 CFR Part 423.15, October 8, 1974, as amended). These standards are summarized in Table I.

Proposed revisions to the guidelines and standards were published by the U.S. EPA in the Federal Register, October 14, 1980. It is anticipated that these proposed regulations will be finalized in their present form in late 1981. Major changes from the existing regulations include a more stringent limit for chlorine discharges and a relaxation of the bottom ash transport water requirements.

The proposed SJRPP's water management plan is based on existing regulations. Should the effluent regulations be revised as proposed, the water management plan will be revised, if necessary, to comply with the final regulations, particularly in the area of meeting chlorine standards.

2. State

Chapter 17-3 of the Florida Administrative Code (FAC), March, 1979, classifies the St. Johns River in the plant vicinity as a predominantly marine, Class III water and describes the minimum water quality criteria to be met in this area. The criteria for Class III waters designated for fish and wildlife propagation and management are listed in Table II. Also included in this table are general water quality criteria applicable to all surface waters of the state. In addition to the criteria listed in Table II, the FAC also lists criteria for nutrients, phenolic compounds, pesticides and herbicides, and radioactive substances. The criteria specify the concentrations of pollutants which are allowed beyond a designated mixing zone in the river. The mixing zone for the proposed plant will be defined based on present and future river flow conditions and the expected nature and volume of the plant discharge, but are not anticipated to exceed the established area limit for estuaries of 125,600 square meters (FAC, Section 17-4.244(1)(g)).

Florida statutes allow for variances or other relief from water quality criteria if ambient levels of constituents in state waters are greater than specified in the water quality standards.

B. Solid Waste Management

1. Federal

The solid wastes generated by the combustion of coal (i.e., fly ash, bottom ash and flue gas desulfurization waste) have been determined to be non-hazardous, at the federal level, as defined by Subtitle C of the Resource Conservation and Recovery Act (RCRA) of 1976, and are, therefore, subject to the provisions of Subtitle D of this act. The regulations promulgated under Subtitle D establish guidelines for state solid waste programs and set certain criteria for solid waste disposal facilities. However, Subtitle D of RCRA has not been adopted by the state of Florida and is not currently applicable to the wastes from the SJRPP.

2. State

The disposal of combustion ash, scrubber sludge and other lesser volume solids is governed by a Florida State Solid Waste Plan, as outlined in Chapter 17-7 of the Florida Administrative Code (FAC), effective March 25, 1979. Requirements under Chapter 17-7 are modified on a case-by-case basis to account for the differences in the waste material involved.

Based on the classification criteria in the regulations, the proposed plant's ash disposal facility would be considered a Class I sanitary landfill and would be subject to certain provisions pertaining to such landfills. Siting requirements for sanitary landfills which affect the waste disposal area include location, pre-operational hydrogeological and soils characterization, and post-operational monitoring and treatment of surface runoff and leachate to meet the water quality standards at the site boundary.

Chapter 17-7 of the FAC requires Class I sanitary landfills to have three monitoring wells installed prior to the disposal of waste material. Locations of these wells are designated as upgradient and downgradient of the landfill site, and downstream of the first section of the site to be filled. In addition, the regulations require that the solid waste may not be disposed of:

- In an area subject to frequent or periodic flooding, unless drainage provisions are installed;
- In an area immediately adjacent to or within 500 feet of an existing or approved shallow water supply well;
- In any natural or artificial body of water including groundwater;

- Within 200 feet of any natural or artificial body of water;
- In any area open to public view from any major thoroughfare; and
- On the right-of-way of any public highway, road, or alley.

3. Local

The proposed site is in Duval County which is authorized to develop its own solid waste and resource recovery plan. The Sanitary Engineering Branch of the Jacksonville Public Health Division has enforcement responsibility over all solid waste facilities in Duval County. Although no permit is required for the construction or operation of a private, environmentally sound solid waste disposal facility, county officials would expect the facility to be operated in an appropriate manner and would reserve the right to inspect the facility frequently. There are no specific county regulations pertaining to the design of this type of facility nor to subsequent monitoring procedures.

TABLE I

USEPA STANDARDS OF PERFORMANCE FOR NEW SOURCES
STEAM ELECTRIC POWER GENERATING

Waste Streams and Pollutants (a) (d)	Maximum mg/l	Average mg/l
All waste streams;		
pH (except once-through cooling)	6.0-9.0(St'd Units)	
PCB's	No Discharge	
Low volume waste streams:		
Total Suppended Solids(TSS)	100	30
Oil and grease	20	15
Bottom ash transport water (b)		
TSS	100	30
Oil and grease	20	15
Fly ash transport water:		
TSS	No Discharge	
Oil and grease	No Discharge	
Metal cleaning wastes:		
TSS	100	30
Oil and grease	20	15
Copper (total)	1	1
Iron (total)	1	1
Boiler blowdown:		
TSS	100	30
Oil and grease	20	15
Copper (total)	1	1
Iron (total)	1	1
Once-through cooling water:		
Free available chlorine (c)	0.5	0.2
Cooling tower blowdown:		
Free available chlorine (c)	0.5	0.2
Corrosion inhibitors	Case by Case Limit	
Area runoff subcategory:		
TSS	50	
pH	6.0-9.0	

Source: 40 CFR 423, 1974.

(a) - Except where specified otherwise, the allowable discharge equals flow multiplied by the concentration limitation.

(b) - Allowable discharge equals flow multiplied by concentration divided by 20.0.

(c) - Neither free available chlorine nor total residual chlorine may be discharged from any unit for more than 2 hours in any one day; and not more than one unit in any plant may discharge free available or total residual chlorine at any one time, unless the utility can demonstrate, through a chlorine minimization study, that the units in a particular location cannot operate at or below this level of chlorination.

(d) - When waste streams with dissimilar effluent limitations are combined, the appropriate effluent limitations for the individual waste streams must be met prior to combination.

TABLE II

FLORIDA WATER QUALITY CRITERIA FOR CLASS III,
PREDOMINANTLY MARINE WATERS

Parameter	Allowable Level
Aluminum	1.5 mg/l
Antimony	0.2 mg/l
Arsenic	0.05 mg/l
Beryllium	1.10 mg/l
Bromates	100 mg/l
Bromine (molecular)	0.1 mg/l
Cadmium	5.0 ug/l
Chlorides	10% increase above ground background levels
Chlorine (total residual)	0.01 mg/l
Chromium, hexavalent	0.50 mg/l (in effluent)
total	1.0 mg/l (in effluent)
	0.05 mg/l (after mixing)
Copper	0.015 mg/l
Cyanide	5.0 ug/l
Fluorides	5.0 mg/l
Iron	0.3 mg/l
Lead	0.05 mg/l
Mercury	0.1 ug/l
Nickel	0.1 mg/l
Phosphorous (elemental)	0.1 ug/l
Polychlorinated Biphenyls	0.001 ug/l
Selenium	0.025 mg/l
Silver	0.05 ug/l
Zinc	1 mg/l
BOD	Appropriate D.O. must be maintained
Detergents	0.5 mg/l
Dissolved gases	110% of saturation value at the existing atmospheric and hydrostatic pressures
Dissolved oxygen	minimum 4 mg/l; 24 hr. avg. 5 mg/l
Oil & Grease (dissolved and emulsified)	5.0 mg/l
Turbidity	50 Jackson units above background levels
Fecal coliform	200/100 ml (monthly avg) 800/100 ml (daily max.)
Total coliform	1000/100 ml (monthly avg.) 2400/100 ml (maximum)
pH	6.5 - 8.5 (also the discharge may not cause the ambient pH to vary by more than one pH unit)

III SOURCE AND QUALITY OF PLANT MAKEUP WATER

A. Surface Water

Surface water will serve as the source of water for the main condenser cooling systems of Units 1 and 2. Surface water makeup for the proposed plant will be withdrawn from the discharge channel of the existing NGS, which uses water from the St. Johns River. Thus, the ultimate source of surface water for the proposed plant is the Blount Island Channel of the St. Johns River. Table III presents existing water quality in this portion of the river. The concentrations of the parameters listed are average and maximum concentrations observed in samples collected during the period November 1979 through October 1980. These data were obtained during a water quality monitoring program conducted in the vicinity of the proposed site by Envirosphere Company, a division of Ebasco Services, Inc.

B. Groundwater

Deep wells tapping the Floridan aquifer will serve as the source of makeup water to the following plant water systems:

- Boiler Feedwater Makeup
- Boiler Tube Cleaning Rinse
- Potable Water
- Flue Gas Desulfurization
- Bottom Ash Sluice Water
- Bottom Ash Hopper Cooling and Sealing
- Circulating Pump Lubrication
- Equipment Cleaning
- Fire Protection
- Miscellaneous Service Water

Present groundwater quality is presented in Table IV. These data are analyses of samples taken from a test well drilled on the plant site.

TABLE III

ST. JOHNS RIVER WATER QUALITY IN BLOUNT ISLAND CHANNEL

Parameter	Concentration Mean	Maximum
Chlorides, mg/l	13,000	20,400
Sulfates, mg/l	1,740	2,600
Calcium, mg/l	272	395
Iron, mg/l	0.801	2.7
Magnesium, mg/l	843	1,200
Potassium, mg/l	267	365
Sodium, mg/l	7,150	9,150
Cyanide, ug/l	10	90
Aluminum, ug/l	488	3,630
Antimony, ug/l	0.19	0.95
Arsenic, ug/l	0.69	1.0
Beryllium, ug/l	0.09	0.19
Boron, ug/l	3.11	4.7
Cadmium, ug/l	0.29	2.2
Chromium, ug/l	1.59	5.0
Copper, ug/l	69.5	275
Lead, ug/l	0.37	10
Manganese, ug/l	27.3	90
Mercury, ug/l	0.24	0.6
Nickel, ug/l	3.34	16.5
Selenium, ug/l	0.5	0.75
Silver, ug/l	0.16	0.35
Zinc, ug/l	46.2	149

TABLE IV

DEEP WELL GROUNDWATER QUALITY AT PROPOSED SITE

Parameter	Concentration
Chlorides, mg/l	15.2
Sulfates, mg/l	89
Nitrates, mg/l	0.53
Calcium, mg/l	50.2
Iron, mg/l	0.21
Magnesium, mg/l	23.7
Potassium, mg/l	1.2
Sodium, mg/l	13.2
Total Dissolved Solids, mg/l	347
Alkalinity (as $CaCO_3$), mg/l	154.4
Hardness (as $CaCO_3$), mg/l	231.7
Turbidity, mg/l	0.40
Aluminum, ug/l	Less than 37
Arsenic, ug/l	Less than 2
Boron, ug/l	410
Cadmium, ug/l	0.8
Copper, ug/l	4.0
Lead, ug/l	21
Manganese, ug/l	2.0
Mercury, ug/l	Less than 0.2
Nickel, ug/l	Less than 7
Selenium, ug/l	Less than 10
Silver, ug/l	0.4
Zinc, ug/l	7

IV OPERATIONAL PHASE

A. Introduction

Water and waste management plans for the operational phase of the proposed station are developed in this section. Plant water requirements are identified, wastewaters generated are characterized, and a water management plan is presented. Solid wastes generated during plant operation are also quantified and a solid waste management plan is presented.

The following assumptions have been made in preparing this section:

1. The two units are identical in design and operation, and are operating at steady state conditions.

2. The average water flows presented are annual averages based on continuous operation at full load.

3. High volume solid waste generation estimates are based on average coal characteristics and an average (not levelized) capacity factor of 60 percent expected over the 40 year life of the plant. (Estimating the total quantities of high volume solid waste based on the expected average station capacity factor rather than at 100 percent capacity factor is considered realistic.)

B. Water Requirements

1. Introduction

Water requirements for various plant systems are discussed in the following sections. Unless otherwise noted, the flow quantities are total flows for both Units 1 and 2. As discussed in Section III, the St. Johns River will serve as the water source for the main condenser cooling system. All other plant water systems will use groundwater or reclaimed service water.

2. Recirculating Cooling Water

A recirculating cooling system will be employed to remove waste heat from the steam cycle. Two evaporative natural draft cooling towers will be utilized to dissipate heat from the main condenser and auxiliary cooling water systems. Approximately 425,000 gpm of surface water will be recirculated through the main condensers of both units. The annual average evaporation rate is expected to be approximately 10,500 gpm, and the maximum rate will be about 11,500 gpm.

Due to the highly saline nature of the makeup water, a maximum of 1.5 cycles of concentration has been established for the proposed plant, a typical level for saline water systems. At this level, the water may have a tendency toward scale formation. Therefore, provisions will be made for addition of sulfuric acid to the makeup water to reduce the level of

bicarbonate alkalinity and minimize the potential for calcium carbonate scale formation. Preliminary calculations indicate that approximately 25 to 50 ppm sulfuric acid may be required in the cooling tower makeup water for alkalinity removal.

Chlorine also will be added to the main condenser cooling systems to prevent biological fouling. Control is achieved by adding sufficient chlorine to obtain a biocidal residual which must be maintained throughout the system long enough to control microorganisms. To comply with EPA regulations, an intermittent chlorination system will be used. Alternative chlorination operating schemes to determine the optimal chlorine levels for each unit will be studied when the plant becomes operational.

To limit the cycles of concentration at 1.5 with a maximum evaporation rate of 11,500 gpm, a makeup of 34,400 gpm and a blowdown of 24,000 gpm will be required. Average blowdown will be approximately 23,900 gpm based on an average evaporation rate of about 10,500 gpm. Cooling tower makeup will be maintained at 34,400 gpm.

Auxiliary cooling water prevents excess operating temperatures in the auxiliary equipment. Major auxiliary equipment includes main turbine lube oil coolers, boiler feed pump turbine lube oil coolers, condenser vacuum pump coolers, duplex alternator air coolers, soot blower air compressor inter and after coolers, and hydrogen coolers. Cooling this equipment is accomplished by a completely closed system utilizing heat exchangers. Stored condensate water (closed cooling water) cools the equipment and heat exchangers cool this water using main condenser cooling water, which is returned to the cooling tower, thus completing the cooling loop.

Because this system is completely closed and utilizes the same circulating water as the main condenser cooling system, there are no additional water usage requirements.

3. Demineralized Water

The boiler makeup water supply system produces high quality water for use in the steam generating cycle. Because the boiler operates at high-pressures and temperatures, certain constituents in the makeup water, such as dissolved salts (mainly calcium and magnesium), must be maintained at very low levels to prevent scaling of the boiler tubing. Demineralized water is required for initial boiler fill, boiler fill after routine cleaning operations, demineralizer and condensate polisher regeneration, and makeup for small losses through boiler blowdown and evaporation.

The makeup demineralizer trains will consist of two separate trains rated at 340 gpm each. These trains will consist of cation exchangers followed by anion exchangers, and mixed-bed polishing demineralizers. Water from deep wells will be demineralized and stored in condensate storage tanks. Average groundwater requirements are expected to be approximately 91 gpm

for the boiler/steam cycle and an additional 64 gpm for boiler soot blowing. The 64 gpm is lost to the atmosphere through evaporation. The 91 gpm boiler blowdown will be reused in the FGD system. An average of 22 gpm will be required for demineralizer and condensate polisher regeneration. Acid and caustic are required for regeneration, as well. Makeup demineralizer regeneration will occur approximately once every three days for each train. Condensate polisher regeneration will be infrequent, occurring primarily during startup.

4. Coal Handling

Reclaimed water from other plant systems will be used for dust suppression at the coal handling facilities. Average requirements are expected to be about 50 gpm, with some consumptive loss occurring. An instantaneous maximum demand of up to 350 gpm is anticipated.

5. Ash Handling

Fly ash will be collected dry and pneumatically transported to temporary storage silos. Should a market exist for fly ash as a recoverable resource, trucks or railroad cars will transport the fly ash, from the silo area, off-site. On-site disposal is provided, however, should a market not materialize.

Recommended disposal practices are discussed in detail in Section IV, Part E. Water requirements for fly ash should be minimal as only small quantities of water will be required for dust suppression at the on-site disposal area. This water will be supplied from the bottom ash system.

Bottom ash produced from the combustion of coal is collected continuously in a water impounded bottom ash hopper located directly beneath the boiler. To reduce water requirements, the bottom ash sluicing system has been designed to be a recirculating system. A continuous source of low-pressure water will be required for cooling as well as for makeup to the water impounded equipment. Intermittent high-pressure water flow of about 400 gpm will be required for equipment sprays and flushes and for sluicing pyrites from the pyrites pulverizing hoppers to the pyrites storage tank. Pyrites from the storage tank and bottom ash from the bottom ash hoppers periodically will be sluiced separately to dewatering bins for dewatering at an average rate of 650 gpm. In addition, bottom ash hopper cooling and sealing flow of about 1200 gpm also will be conveyed to the dewatering bins.

Despite the high system flow rates, a fresh water demand of only 200 gpm groundwater will be needed because this is a recirculating system. An average of approximately 2250 gpm sluice water will be recirculated from the dewatering system. Approximately 100 gpm of the groundwater flow will

be used as makeup, as some water is lost through evaporation and by binding to the ash particles. The "dry" bottom ash produced is actually about 20 percent water. In addition, about 100 gpm will be drawn from the dewatering system for wetting fly ash which must be disposed of on-site.

6. Flue Gas Desulfurization

Water used in the flue gas desulfurization (FGD) system to remove sulfur dioxide and hydrogen chloride from the hot gases is expected to average 2150 gpm with a maximum of 3150 gpm. Although the system will recycle quench water, makeup water will be needed continually to replace that lost through evaporation, approximately 1000 gpm. In addition, water will be periodically blown down at an average rate of about 1000 gpm to remove excess chlorides from the system. The chloride concentration of water circulating in the FGD system is critical because chlorides are highly corrosive. Acceptable chloride levels for reliable system operation can be maintained with the aforementioned quantity of fresh water available. Higher chloride concentrations would require use of yet to be developed technology, including exotic metallurgy to prevent corrosion. The FGD system has been designed to produce wallboard grade gypsum for which chloride concentration also must be made fairly low. Too high chloride and total dissolved solids concentrations in the gypsum cake wash water creates an inferior quality product. Approximately 50 to 180 gpm of makeup water will be removed from the FGD system with the gypsum by-product.

7. Miscellaneous Plant Service Water

Miscellaneous service water uses at the SJRPP include pump bearing cooling, pump seals, air preheater washing, equipment maintenance cleaning, and other miscellaneous plant uses. Groundwater will supply the service water system serving these uses with an estimated average flow of 113 gpm and a maximum flow of approximately 3000 gpm.

8. Potable Water System

Potable water for domestic and sanitary use will be supplied from deep wells via the main plant storage tanks at an average rate of 11 gpm. Maximum demand is expected to be 140 gpm. These figures are based on a total plant staff of 375 people and an average potable water requirement of 40 gallons per capita per day. All lines leading from the storage tanks for uses other than potable water will be provided with backflow preventers to prevent return flow into the storage tanks and eliminate potential contamination of the potable water source. Potable water receives secondary chlorination treatment prior to distribution, in accordance with state requirements.

9. Fire Protection System

Large quantities of water must be available for fire protection at the plant. Although average demand is zero, maximum instantaneous demand can be as high as 2500 gpm. Approximately 600,000 gallons of water will be stored on site for fire protection, with a maximum makeup rate of 625 gpm

required during actual use. The fire protection system will be a closed-loop system except during actual use in extinguishing fires. The system will be tested periodically to ensure proper operation. Water will be pumped through the main system pumps and recirculated back to the storage tanks without circulating through the entire system. Thus, no consumptive use of water will occur. After installation of the system, a small amount of water, about 30 gpm for several minutes, will be released during the initial test of the sprinkler system. Water released through the system cannot return to the storage tanks since backflow preventers will be installed in the fire protection lines. Sprinkler valves and other components throughout the fire protection loop will be tested locally at regular intervals during plant operation, without the use of water.

10. Ocean Vessel Coal Unloading Facility

Water requirements at the ocean vessel coal unloading facility located on Blount Island will be potable water and service water. Water supply will be from existing Jacksonville Port Authority (JPA) facilities on the island. Approximately 400 gpd of potable water and an average of 20 gpm (200 gpm maximum) service water will be required. Service water uses include coal dust suppression and occasional equipment washing. Water from the treatment facility to be constructed on the island will be reused whenever available for coal dust suppression.

11. Water Use Variations

Depending on varying conditions at the plant, there will be variations in the water use requirements of plant systems. All water requirements discussed in the preceding sections are either average or maximum requirements for the plant operating at full load. When the plant operates at less than full load, the evaporative losses from the cooling tower will decrease in direct proportion to the plant load. Since the cooling tower's makeup remains constant, the blowdown will increase. However, when the cooling towers are shut down because of prolonged plant shutdown, no makeup or blowdown will be necessary, eliminating the withdrawal of surface water. With one unit shut down, fresh water requirements also will be reduced as one FGD system will not be operating. In addition, variations in the amount of FGD system blowdown will occur due to varying chloride concentrations in the coals burned. Other plant water requirements are not expected to change significantly with plant load variations. Some maximum service water uses will not occur concurrently with others. For example, during an air preheater fire, the generating unit will be shut down; thus, although water will be required for fire control, normal unit water requirements will not be present.

In summary, total plant water requirements are not expected to change significantly with variations in plant load except in the case of prolonged plant shutdown. During these shutdown periods, no surface water requirements are anticipated. Although no groundwater makeup will be

required by the FGD system during shutdowns, other systems' (i.e., demineralizer, equipment cleaning, etc.) water usages will increase. Therefore, overall groundwater use is not expected to change significantly during plant shutdown.

C. Wastewater Sources and Characterization

1. Introduction

Wastewaters generated by various plant systems and operations and runoff from certain areas are discussed in this section. These wastewaters are described with respect to their source, flow or volume, quality, and degree of compliance with applicable discharge regulations. Table V presents anticipated wastewater quality from major contributing effluent streams generated by Units 1 and 2.

2. Recirculating Cooling Water

Effluent from the recirculating cooling water systems will be in the form of cooling tower blowdown discharged into the existing NGS discharge channel and ultimately into the St. Johns River. Expected blowdown flow is about 23,900 gpm, based on a constant makeup flow of 34,400 gpm and an annual average evaporation of approximately 10,500 gpm. Both blowdown quantity and quality will depend somewhat on meteorological conditions, but quality will be more strongly influenced by the river water quality. Cooling tower blowdown will vary directly with makeup water quality and the operating cycles of concentration. Table V indicates the anticipated cooling tower blowdown quality for both units. These predictions are based on 1.5 cycles of concentration and average and worst case river water quality.

The only contaminants expected to be added to the blowdown are thermal energy, chlorine, and perhaps sulfate. The increases in temperature (16.4°F average in winter and 5.3°F average in summer) will be dissipated in a designated mixing zone in the river beyond the NGS's point of discharge (POD). As described in the previous section, chlorine will be added to the cooling water system to control biological fouling. The concentration of free available chlorine in the blowdown is not expected to exceed 0.2 mg/l for more than two hours per day per unit, in accordance with existing EPA regulations. Chlorination will be carefully controlled at the minimum levels necessary for efficient operation through a chlorine minimization study to be initiated after the plant goes into commercial operation. Sulfate concentration in the cooling tower blowdown may increase slightly as a result of acid addition for scale control. The addition of 25 to 50 mg/l of sulfuric acid may increase sulfate (SO_4) levels by 24 to 48 mg/l and decrease bicarbonate levels (as $CaCO_3$) by 25

TABLE V

PLANT EFFLUENT CHARACTERISTICS

Parameter	Cooling Tower Blowdown		FGDS Blowdown	Demin. Regen.	Landfill Area Runoff
	Avg.	Max.	Avg.	Avg.	Avg.
Chlorides, mg/l	18740	30390	6905	149	59
Sulfates, mg/l	2500	3873	10000	8000	766
Calcium, mg/l	391	588	3000	394	130
Iron, mg/l	1.1	4.0	8.1	.178	1.2
Magnesium, mg/l	1215	1788	2750	162	4.3
Potassium, mg/l	385	544	32	8.17	---
Sodium, mg/l	10300	13630	2400	2200	---
Cyanide, mg/l	.01	.13	---	---	< 0.01
Aluminum, mg/l	.703	5.4	0.3	.131	.9
Antimony, ug/l	.27	1.4	2300	---	---
Arsenic, ug/l	.99	1.5	300	7.1	15
Beryllium, ug/l	.13	.28	140	---	< 7
Boron, mg/l	4.5	7.0	46	2.91	---
Cadmium, ug/l	.42	3.3	110	5.68	1.8
Chromium, ug/l	2.3	7.4	500	---	< 10
Copper, ug/l	100	410	200	28.4	23
Lead, ug/l	0.5	15	400	149	12
Manganese, ug/l	39.3	134.1	2500	14.2	---
Mercury, ug/l	.35	.89	70	.71	.46
Nickel, ug/l	4.8	25	1500	24.9	64
Selenium,ug/l	.72	1.1	2200	35.5	10
Silver, ug/l	.23	.52	60	2.84	< 10
Zinc, ug/l	66.6	222	350	49.7	50

to 50 mg/l. Th pH of the water may decrease slightly but will be maintained above 6.0 pH units. It is not anticipated that additional chemicals, such as corrosion inhibitors, will be required in the cooling tower flow.

3. Demineralizer Regeneration

Regeneration wastes result from the operation of the demineralizer trains. The regeneration cycle consists of backwashing, acid and caustic regeneration, and rinsing of the demineralizer beds. The ion exchange beds must be periodically regenerated to strip adsorbed ions from the resin surface and replace them with hydrogen and hydroxyl ions from the cation and anion exchangers, respectively. This process is achieved by adding the regenerating chemcials (e.g., H_2SO_4 and NaOH) in quantities in excess of the exchange capacity of the bed. Thus, demineralizer wastes are characterized by extremes in pH (i.e., from 2 to 12 pH units) and a high dissolved solids concentration. Suspended solids may also be present due to inefficient pretreatment or precipitation reactions. Average total dissolved solids levels in the neighborhood of 12,000 mg/l would be typical, composed of anions and cations in nearly the same proportion as the influent raw water. Estimated discharge loadings of various parameters resulting from demineralizer regeneration are shown in Table V.

The volume of regeneration wastes is estimated to be 44,000 gallons per train per regeneration, including rinse water. Average flow rate will be about 15 gpm and maximum instantaneous flow may be 350 gpm. It is anticipated that one demineralizer train will be regenerated every three to four days, depending on demineralized water usage.

4. Boiler Blowdown

Boiler blowdown will be fairly continuous to control the buildup of dissolved constituents in the boiler/steam cycle and is expected to average 91 gpm with a maximum flow of about 510 gpm. The blowdown will be very low in dissolved and suspended solids and will be slightly alkaline. The estimated range of boiler blowdown water quality characteristics is as follows:

Parameter	Concentration (mg/l)
pH	9.4 - 9.6
Total suspended solids	1 - 10
Oil and Grease	0 - 5
Iron	0.01 - 2.0
Phosphate, PO_4	2 - 10

Hydrazine will be added as needed to the boiler/steam cycles of Units 1 and 2 for oxygen removal. Hydrazine reduces any oxygen introduced into the

system water. Oxygen can enter the system through the makeup water and by air infiltration in the condensate system. Excess hydrazine is decomposed by heat to ammonia and nitrogen. Because the boiler blowdown quality is quite high, this water will be reused as makeup to the FGD system, unless its use adversely affects the quality of gypsum produced.

5. Metal Cleaning Wastes

Metal cleaning wastes will result from scheduled periodic maintenance cleaning of Units 1 and 2 air preheaters, boiler firesides, and boiler watersides.

Boiler fireside cleaning will be accomplished by using air operated soot blowers to remove accumulated material. Air preheater cleaning is required periodically to remove accumulated soot and fly ash on surfaces. Preheaters will be cleaned by hosing them down with high-pressure water. Resulting wastes may be acidic and normally should contain sulfates, fly ash and soot, and metallic ions such as iron and copper. Air preheater washing is expected to occur about twice a year per unit, with approximately 100,000 gallons of water required per washing. Maximum flow rate is estimated to be 3000 gpm, averaging 32 gpm on an annual basis.

Boiler waterside cleaning to remove corrosion products and scale will be required every three to five years for each unit to maintain normal operating performance. Corrosion products would be characteristic of the boiler tube material and would contain primarily iron oxide. Boiler scale consists of precipitated salts and may include calcium and/or magnesium phosphates, and silica, depending on boiler feed water and materials of construction.

The chemicals used in boiler cleaning specifically depend on the requirements of the boiler system, based on analysis of boiler scale. The chemicals are generally highly acidic and alkaline and considerable quantities of water are required for flushing. The total volume of wastes per event is estimated to be between 0.5 to 1.5 million gallons, averaging 1 gpm on an annual basis. Preoperational boiler cleaning is also required. This operation is discussed in detail in Section V of this report.

Both air preheater and boiler waterside cleaning wastes will require treatment for iron removal, pH adjustment, and suspended solids removal.

6. Coal Handling

A portion of the water used for dust suppression during coal handling will be retained in the coal. The remainder will drain, producing a wastewater

with a suspended solids concentration in excess of 30 mg/l and showing wide variations in pH. This flow is expected to average about 30 gpm with a maximum of approximately 100 gpm. Treatment will be required to reduce suspended solids and adjust pH to acceptable levels.

7. Ash Handling

As fly ash is collected in a dry state, there will be no wastewater associated with its handling.

The recirculating bottom ash handling system recycles an average sluice water flow of 2250 gpm. A makeup flow of 200 gpm is required, as this quantity of system water is lost by binding to bottom ash particles and in the wetting of fly ash for on-site disposal. Bottom ash system water balance calculations indicate that sufficient dissolved solids will be removed in the water bound to the dewatered ash to eliminate the need for blowdown. However, provisions have been made to incorporate a future blowdown should the solids content in the recirculating sluice water exceed acceptable operating levels. Blowdown from the bottom ash system could be as much as five percent of the daily average recirculating flow and would require treatment for suspended solids removal.

8. Flue Gas Desulfurization

The FGD system will require a blowdown of approximately 1000 gpm to remove dissolved solids from the system. Chloride concentrations must be maintained at about 4,000 mg/l for reliable system operation as described in Section IV.B.6. The blowdown will contain the same constituents as those present in the makeup water; concentrations of these constituents will vary in direct proportion to the makeup flow plus contributions from the flue gas and limestone processed. Table V presents estimated FGD system blowdown characteristics. Depending on which FGD system is selected, makeup water requirements might increase to 3150 gpm and blowdown flow may increase to 2000 gpm. Blowdown quality should remain essentially the same, however.

9. Sanitary Wastes

Wastes from plant locker rooms, showers, and toilets, estimated at an average daily flow of 11 gpm, should be similar in character to municipal sanitary wastewater. Five-day biochemical oxygen demand (BOD_5) is expected to be about 26 pounds per day, based on a loading of 0.07 pound BOD_5 per capita per day. General composition of the plant sanitary wastes is as follows:

Constituent	Range of Concentration (mg/l)
Solids, Total	700 - 1,500
Dissolved	500 - 1,000
Suspended	200 - 500
Biochemical Oxygen Demand (5-day, 20°C)	200 - 400
Chemical Oxygen Demand (COD)	500 - 1,200
Nitrogen (Total as N)	40 - 100
Phosphorus (Total as P)	10 - 25
Oil and Grease	10 - 200

10. Miscellaneous Wastes

Wastes resulting from miscellaneous service water uses include those from routine equipment cleaning, laboratory drains, sampling streams, floor drains, pump sealing and bearing cooling, etc. Collectively, these wastes are expected to average about 81 gpm. Maximum instantaneous flow may be as high as 485 gpm. Of both these flows, about 50 gpm is used for pump sealing and bearing cooling. Waste generated from this use is of nearly identical quality as the service water utilized. The quality of wastes generated from the other miscellaneous uses will vary considerably depending on their source. Some of this wastewater will be reused in other plant systems without prior treatment. The remaining wastes will require treatment for solids removal, pH adjustment, oil and grease removal, or some combination of these treatments.

11. Area Runoff

Rainfall water runoff from certain plant areas will require treatment to maintain compliance with federal regulations and policies. These areas include coal handling and storage, limestone handling and storage, main transformer area, oil storage and unloading, solid waste handling and temporary storage, and the solid waste landfill areas. Runoff quantities have been estimated based on the area involved and expected rainfall. Average runoff is based on an average annual rainfall of 54.5 inches. Maximum flows have been calculated using a 10-year, 24-hour design storm of 7.6 inches, with maximum intensity of 5.2 inches occurring within a six hour period.

The following table indicates average and maximum expected runoff from various plant areas and the estimated size of each area. A runoff coeffieient of one (1) has been assumed for all areas except the active and test cell solid waste landfills. For these areas, a runoff coefficient of 0.6 has been assumed. The table also indicates the parameters for which treatment will be necessary.

Area	Size	Average Runoff(gpm)	Maximum Runoff(gpm)	Treatment Necessary
Coal Handling and Storage	42 acres	119	6047	pH, TSS, Iron
Limestone Handling and Storage	6 acres	17	861	pH, TSS
Landfill (Active)	10 acres	6	140	pH, TSS
Landfill (Test Cell)	5 acres	2	70	pH, TSS
Solid Waste Handling and Temporary Storage	3 acres	9	70	pH, TSS
Light Oil Storage and Truck Unloading	1 acre	3	200	Oil and Grease
Coal and Limestone Service	16,553 ft^2	1	150	Oil and Grease
ID and FD Transformer Area	14,000 Ft^2	1	100	Oil and Grease
Main Transformer Area	5,000 ft^2	1	100	Oil and Grease

The major contributor to runoff quantity is the coal pile storage area. Assuming the proposed SJRPP will burn coal from regions of east Kentucky and east Tennessee, the table below is presented to indicate estimated coal pile runoff quality, based on available data.

Parameter	Concentration (mg/l) Average	Maximum
Arsenic	0.15	0.36
Barium	0.17	0.5
Cadmium	0.001	0.001
Calcium	300	490
Chromium	0.005	0.011
Copper	0.9	1.4
Iron	200	1,800
Lead	0.01	0.01
Mercury	0.0005	0.0025
Selenium	0.005	0.030
Zinc	6.5	16.6
Total Dissolved Solids	7,500	16,000
Chloride	10	20
Sulfate	5,000	9,600
Manganese	30	45

12. Ocean Vessel Coal Unloading Facility

Wastewater generated at the coal unloading facility will consist of sanitary wastes, rainfall runoff, and area drainage resulting from coal dust suppression and equipment washing operations.

Area drainage is expected to average 5 gpm with a maximum flow of 50 gpm. This wastewater will be similar to that generated at the main plant's coal handling area and will require treatment for solids removal and pH adjustment. Oil and grease concentrations may be above acceptable levels due to contributions from equipment washing, in which case oil/water separation would be required.

Sanitary wastes generated at the unloading facility will average approximately 400 gallons per day (gpd). Characteristics of these wastes are the same as those for sanitary wastes generated at the main plant location, as described in Part 9 of this section. These wastes will require secondary sewage treatment as a minimum.

Rainfall runoff requiring treatment will be primarily from the lined coal pile. Average runoff is expected to be about 100 gpm, based on a total area of 35 acres, an annual rainfall average of 54.5 inches, and a runoff coefficient of 1.0. Total runoff quantity produced will be approximately 22.2 acre feet, determined from a 10-year, 24-hour design storm of 7.6 inches. The wastewater produced from draining off the coal pile will be similar in character to that generated at the main plant coal storage area (see Part 11 above).

D. Water Management Plan

1. Introduction

This section presents the water management plan developed for the St. Johns River Power Park, including provisions for the required treatment of wastewater discharge. Figure III illustrates in detail the conceptual water management plan for Units 1 and 2. The plan integrates water requirements and effluents of the various systems to minimize total plant water usage and discharges while complying with applicable regulations.

2. General Description

To summarize the preceding sections, applicable environmental regulations, plant water sources, system water requirements, and wastewaters to be generated have been identified. Surface water from the St. Johns River will be withdrawn from the discharge channel of the existing JEA NGS and will be used as makeup to the recirculating cooling water system. Blowdown from the cooling towers of this system will be discharged back into the NGS discharge channel, downstream of the proposed plant intake. Groundwater from the Floridan aquifer will be used for potable water, fire protection, demineralized condensate makeup, and plant service water. All groundwater is pumped first to one of two 750,000 gallon storage tanks, then pumped as required by various plant systems. Both the potable water system and the fire protection system have separate pumps servicing only those uses. These systems withdraw well water from different storage tanks. Plant service water is drawn by suction pumps off the main storage tanks for use in remaining plant systems. The condensate system has separate smaller storage tanks, holding treated water from the demineralizer trains.

Plant systems' effluents will be reused where feasible, within operating or regulatory constraints. Those effluents unsuitable for reuse, other than cooling tower blowdown, will be directed to one of several wastewater treatment facilities, including sedimentation ponds, oil/water separators, retention basins, or a central wastewater treatment facility. These facilities are described in detail in Part D.4 of this section; briefly, the facilities have been designed to produce an effluent in compliance with existing effluent limitations for steam electric generating stations. All plant effluents will be discharged via the common cooling tower blowdown line to the NGS discharge channel.

The recommended treatment and reuse approaches for each plant effluent previously identified will be discussed first, then each wastewater facility will be described in terms of the treatment afforded.

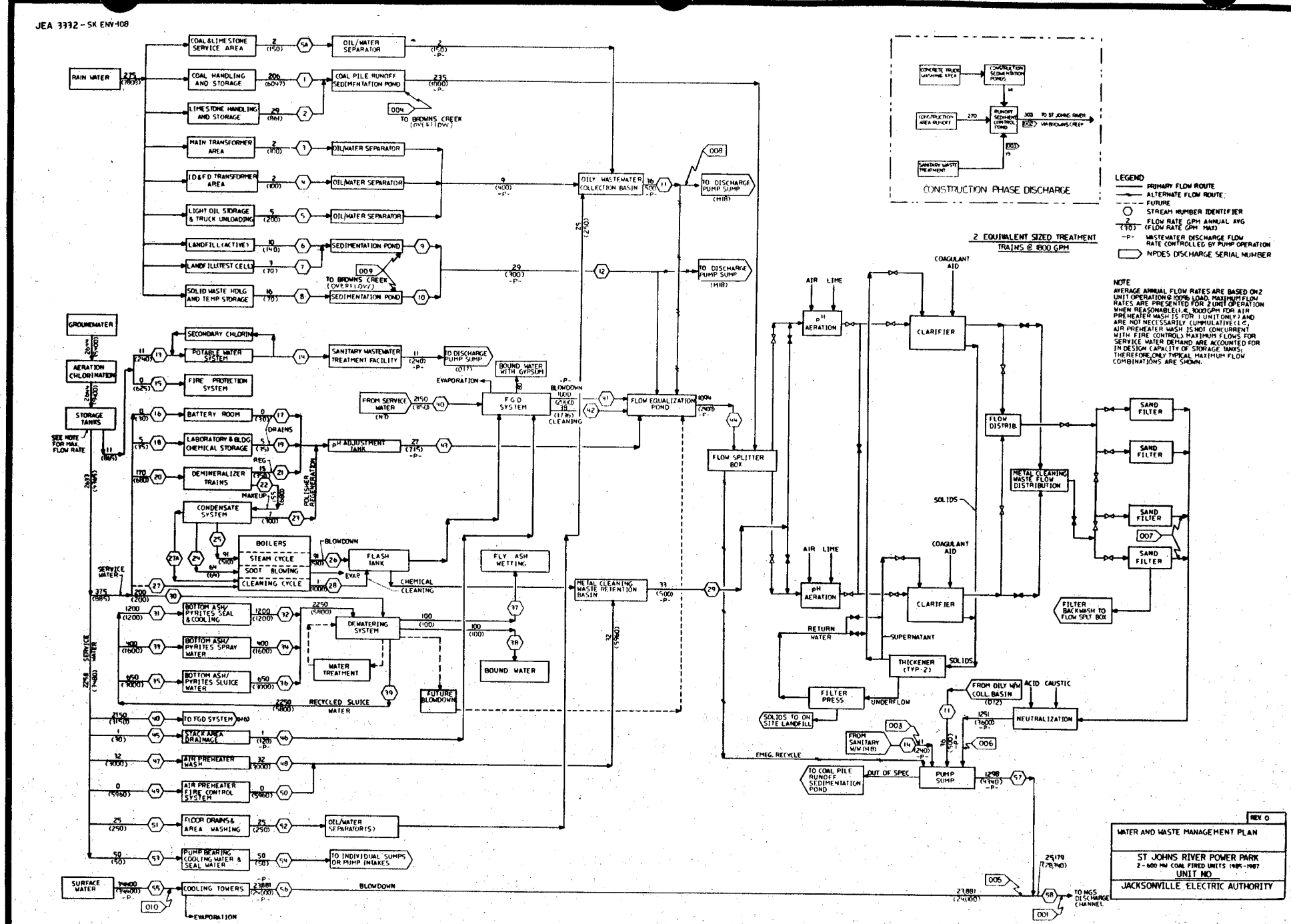


FIGURE III WATER MANAGEMENT PLAN - TWO UNIT OPERATION AT FULL LOAD

3. Wastewater Treatment and Reuse

A summary of the various SJRPP water system discharges and their anticipated control requirements are presented in the following table. No controls are noted for those effluents being reused.

Water System	Average Flow Rate (gpm)	Discharge to	Control Required For
Recirculating Cooling Water	23,881	NGS Discharge Channel	TRC, Scaling
Coal and Limestone Storage Area Runoff	136	Central Wastewater Treatment Facility	TSS, pH
Sanitary Wastewater	11	Package Sewage Treatment Facility	BOD, Coliform, TSS, pH
Boiler Blowdown	91	FGD System	
FGD System	1038	Central Wastewater Treatment Facility	TSS, pH
Demineralizer and Polisher Regenerants	22	Central Wastewater Treatment Facility	TSS, pH
Plant Drainage	31	Central Wastewater Treatment Facility	TSS, Oil and Grease, pH
Pump Bearing Cooling and Sealing Water	50	Individual Sumps or Pump Intakes	
Bottom Ash System		No Discharge	

a. Cooling Tower Blowdown

The recirculating cooling water will be chlorinated to control biological fouling and sulfuric acid will be added to control scaling. Although total residual chlorine levels will be maintained to provide efficient condenser operation, free available chlorine will be limited to the 0.2 mg/l intermittent discharge allowed by EPA. To establish potentially lower discharges, a chlorine minimization study will be implemented soon after plant start-up. Sulfuric acid additions are expected to be on the order of 25 to 50 mg/l, at which level, insignificant changes in cooling tower blowdown quality are anticipated. The blowdown will be discharged into the discharge channel of the NGS, downstream of the proposed SJRPP's intake location.

b. Demineralizer Regeneration Wastes

Regenerant wastes from Units 1 and 2 demineralizers and condensate polishers will be directed to a pH adjustment tank and then to a flow equalization pond serving the central wastewater treatment facility. The demineralizers will be operated such that the regeneration shows a net alkaline characteristic, reducing lime feed requirements in the central wastewater facility. Maximum flow rate from the pH adjustment tank, where regenerant wastes combine with laboratory drainage and battery room drainage, will be 715 gpm. From the flow equalization basin, the effluent is directed to a flow splitter box for distribution to the central wastewater treatment facility.

c. Boiler Blowdown

Boiler blowdown at a rate of 91 gpm will flow first to a flash tank, then will be routed to the FGD system for use as fresh water makeup.

d. Metal Cleaning Wastes

Boiler cleaning wastes also flow first to the flash tank, then are directed to the metal cleaning waste retention basin for equalization and storage prior to treatment. The basin will hold for several weeks the anticipated million plus gallons of chemicals, flush water, and scale and corrosion materials removed during boiler waterside cleaning operations. Floating mechanical agitators will be provided in the basin to prevent stratification of the cleaning wastes. The supernatant from the basin will be pumped directly into a line feeding the pH adjustment/aeration tank of the central wastewater facility. This facility has been designed to treat metal cleaning wastes in a train separate from one treating other plant wastewaters. Air preheater wash wastewater will be treated in the same manner.

Sludges generated from the metal cleaning operations which settle in the waste retention basin will be removed after drying. These sludges will be disposed of off-site by a RCRA permitted contractor if they are determined to be hazardous, or on-site if they are not hazardous.

e. Coal Handling

Wastewater generated by coal dust suppression activities will be collected in the coal pile runoff sedimentation pond and treated with the pond's effluent in the central wastewater treatment facility.

f. Ash Handling

Present design for both fly ash and bottom ash handling systems preclude generation of liquid discharges requiring treatment. There will be no discharge from the dry fly ash handling system. The bottom ash system will produce about 100 gpm water which will be used for fly ash wetting during on-site landfill disposal operations. Other water lost from the bottom ash

system is bound to the "dry" bottom ash produced after dewatering. Provisions have been made for future treatment of recycled supernatant from the dewatering system and for future blowdown from the system, if necessary to remove excess dissolved solids. Blowdown from the bottom ash system would be directed, if necessary, to the flow equalization pond for subsequent treatment in the central treatment facility.

g. Flue Gas Desulfurization

Blowdown from the FGD system and wastewater generated from system cleaning will be pumped to the flow equalization pond, the flow splitter box, and then to the central treatment facility for pH adjustment and suspended solids removal.

h. Sanitary Wastes

Plant sanitary wastes will be treated in an extended aeration package plant. Treatment will consist of aeration, sedimentation, aerobic sludge digestion, and chlorination. Effluent from the package plant will be pumped to the final effluent pump station for discharge into the NGS discharge channel.

i. Miscellaneous Wastes

Plant miscellaneous wastes will require varying treatment depending on their source. Some wastewater, such as that from equipment washing, will require oil and grease removal. These wastes will be treated in oil-water separators before being combined in an oily wastewater collection basin. The effluent from this basin ordinarily will be discharged directly through the final effluent pump station; however, an alternative route to the flow equalization pond has been provided, in the event monitors indicate noncompliance with EPA effluent limitations. Other wastes, e.g., laboratory drains, will require pH adjustment prior to combining with other wastewaters in the flow equalization pond for additional treatment in the central facility.

j. Area Runoff

Rainfall runoff from various plant areas will be collected by drainage ditches, piping, and catch basins and routed to appropriate sedimentation ponds prior to further treatment or discharge. Potentially oily runoff from certain areas will be treated for oil removal in oil-water separators prior to discharge into a central oily wastewater collection pond. The oil-water separators will be designed to produce an effluent with oil and

grease concentrations of less than 15 mg/l. Oil skimmers will be provided for the collection pond, if required. Disposal of the separated oil and grease is discussed in Section IV.E.3.

Runoff from the two active solid waste landfills north of the plant loop and from the solid waste handling and temporary storage areas will be collected in sedimentation ponds then pumped to the flow equalization pond. Treatment in the central facility will adjust the pH of the runoff, remove additional solids not removed in the pond, and reduce small concentrations of certain metal constituents. An alternate route for the runoff from the solid waste areas has been planned should the runoff quality be in compliance with guidelines for pH, total suspended solids, and other water quality criteria. This route will pump the effluent from the sedimentation pond directly to the final effluent discharge pump sump.

The largest rainfall runoff flow will be from the coal and limestone handling and storage areas due to the larger areas involved. This runoff will be collected in the coal pile runoff sedimentation pond, pumped to the flow splitter box, then treated in the central treatment facility for pH adjustment and solids and iron removal.

k. Ocean Vessel Coal Unloading Facility

Sanitary wastes generated at the coal unloading facility will be pumped to and treated at the existing Jacksonville Port Authority's sanitary waste treatment facility on Blount Island.

Area drainage and rainfall runoff from the lined coal pile will be directed to a lined sedimentation pond located at the unloading facility site. The pond will be designed to process the rainfall runoff from the 24-hour, ten year design storm. Wastewater treatment will provide pH adjustment of and solids and iron removal from these wastes. After treatment, the effluent from the sedimentation pond will be discharged into a percolation pond.

4. Wastewater Treatment Facilities

Plant wastewater treatment facilities will consist of sedimentation ponds for various wastewater flows, a retention basin for metal cleaning wastes, a flow equalization basin, a sanitary wastewater treatment facility, miscellaneous oil-water separators, an oily wastewater collection basin, and a central wastewater treatment facility. These facilities are discussed in this section.

a. Sedimentation Ponds

Several sedimentation ponds will be constructed at the SJRPP. The exact number of ponds to be constructed will depend on operational requirements and siting limitations, but will include two coal pile runoff sedimentation

ponds (one on the main plant site and one on Blount Island), a sedimentation pond treating runoff from the solid waste handling and temporary storage areas, and sedimentation ponds constructed to collect runoff from the active solid waste landfill area and the solid waste test cell area. Several sedimentation ponds are expected to be constructed over the life of the plant to treat active solid waste landfill area runoff, since a large portion of the plant site will be used for solid waste disposal. It is infeasible to pump this wastewater greater and greater distances to the flow equalization pond as the active landfill area moves farther from the major plant facilities; thus, several smaller sedimentation ponds will be constructed close to the currently active landfill area.

Of the sedimentation ponds, only the main plant and Blount Island coal pile runoff sediment control ponds will be lined. The coal piles also will be lined. The liners to be used will be high density polyethelene, which is a flexible, impervious synthetic material, or equal, designed to protect groundwater resources from industrial liquid wastes. Other plant facilities which will be lined with the same material include the metal cleaning waste retention basin and the flow equalization basin. The proposed liner system will be designed for the life of the project and will have had proven satisfactory service for at least five years under similar service conditions. All seams (joints) between individual liner sheets will overlap with at least two inches of weld seam, which will be tested to insure a strong, water-tight bond between the sheets. Liners will have resistance to wear and abrasion at points of contact with concrete structures and fittings.

The sedimentation ponds will be designed with sufficient capacity to satisfy the regulatory requirements for runoff control, to process the volume associated with the once in ten year, 24-hour rainfall event. Capacity will be provided in each pond, except the coal pile pond, to allow accumulation of settled soilds of up to 20 percent of total pond volume. At this level, solids will be removed. The coal pile runoff sediment control pond will be designed to provide for sludge accumulation of up to two feet averaged over the total pond area.

Effluent from the main plant coal pile runoff sedimentation pond will be directed to the flow splitter box for distribution to the central wastewater treatment facility. Effluent from the landfill and solid waste handling and temporary storage area runoff sedimentation ponds will be pumped first to the flow equalization pond, then through the central wastewater facility, as explained in the previous section. Effluent from the Blount Island coal pile runoff sedimentation pond will be treated prior to discharge into the percolation pond.

b. Metal Cleaning Waste Retention Basin

The retention basin will be designed in two cells with a capacity of between 1.5 and 2 million gallons, enough to contain the maximum expected discharge from a routine maintenance cleaning operation. All plant metal

cleaning wastes, including those from air preheater washing and boiler waterside chemical cleaning, will be directed to the retention basin for equalization and storage prior to treatment in the central facility. The basin will be lined with a synthetic material, as described in part (a) above, to protect groundwater from potential contamination. Floating mechanical agitators will be installed in each cell to produce a waste with uniform pH.

c. Flow Equalization Basin

A flow equalization basin will be constructed to contain widely varying wastewater flows from several plant sources, including the FGD system, solid waste handling and disposal areas, demineralizer regeneration system, and other systems generating low volume wastes. The pond will be designed in two cells, each containing approximately 2 million gallons, sufficient capacity to hold the aforementioned flows plus future blowdown from the bottom ash handling system, if required, and effluent from the oily wastewater collection basin, should the alternative treatment route provided for this wastewater be implemented. The flow equalization basin will be lined with synthetic material, similar to the coal pile runoff sedimentaton pond liner described in part (a) of this section.

d. Oil-Water Separators

Certain miscellaneous plant wastes and runoff from several potentially oily plant areas will be treated for oil removal in oil-water separators. The separators utilized for the various wastes will be designed to reduce oil and grease concentrations in the wastewaters to below the allowable average limit of 15 mg/l. The effluent from all oil-water separators will be directed to an oily wastewater collection basin, then pumped to the final effluent pump station for discharge. An alternate route to the flow equalization basin will be provided if further treatment of these wastes is required. Disposal of the separated oil and grease is discussed in Section IV.E.3.

e. Sanitary Waste Treatment Facility

The plant sanitary waste treatment facility will be designed to provide secondary treatment to some domestic wastes generated during construction and all domestic wastes generated once the SJRPP is operational. Two 15,000 gallon per day (gpd) extended aeration package plants will be erected. The two plants will operate together or separately and will have some common components. Both plants will be required during construction; however, after this phase is completed, one plant will provide treatment for the anticipated average flow of 15,000 gpd for the estimated operational staff of 375 people. The other plant will be maintained as a spare unit.

The extended aeration process to be used is a modification of the conventional activated sludge process which has been designed to minimize the amount of biological sludge produced. Treatment will consist of pre-screening, followed by aeration, sedimentation, aerobic sludge digestion, and finally chlorination. A 90 to 95 percent removal efficiency for BOD and suspended solids is anticipated. Characteristics of the treated effluent are estimated to be as follow:

Total Suspended Solids	20 mg/l
Biochemical Oxygen Demand (5 day)	20 mg/l
Oil and Grease	10 mg/l
Nitrogen as N	40 mg/l
Phosphorus as P	10 mg/l

This effluent will discharge directly into the NGS discharge channel via the final effluent pump station.

f. Central Chemical Wastewater Treatment Facility

The central wastewater treatment facility will treat plant wastewaters unsuitable for further reuse or direct discharge into the St. Johns River via the NGS discharge channel. A schematic diagram of the central facility is presented in Figure III. This figure also indicates the major wastewater sources to be treated in the central facility. The wastewater treatment system will be designed to treat contaminated rainfall runoff and miscellaneous plant effluents continuously at a maximum design flow rate of 3600 gpm total or 1800 gpm through each of two parallel treatment trains.

Both trains will operate at or near design capacity under conditions of increased flow such as may happen during electrostatic precipitator and air preheater washdowns and during periods of excessive rainfall.

The central treatment facility will be designed to remove suspended solids and iron from, and adjust the pH of, the plant effluent. Treatment methods consist of a combination of neutralization, precipitation, coagulation, gravity separation, and media filtration. To meet effluent standards for new sources, the final effluent will meet or surpass the following on a daily average basis:

Total suspended solids	30 mg/l
pH	6 to 8.5
Total iron	1.0 mg/l
Total copper	1.0 mg/l

Major components of the central wastewater treatment facility will include pH adjustment/aeration tanks, flocculator clarifiers, chemical feed equipment, dual media sand filters, a solids thickener, and a dewatering facility.

The two identical treatment trains allow segregated, yet concurrent, treatment of metal cleaning wastes and other plant wastes. As shown in Figure III, all plant wastes except those generated by metal cleaning operations first will be directed to a flow splitter box for distribution to the treatment facility. Metal cleaning wastes will enter the system through a separate line which can direct the wastewater to either of the two treatment trains. Whichever train is not being used to treat the metal cleaning wastes will treat all remaining plant wastewaters. This segregation of wastes will be maintained throughout the treatment system, including the sand filters, up to the point of final neutralization. Treatment of metal cleaning wastes generally will be accomplished at a time when other plant waste flows are relatively low.

Treated effluent from this facility will be reused when appropriate within the facility for reactor clarifier backflush water, line slurry makeup, and cooling of some pump bearings. Effluent reuse pumps will withdraw water from the final effluent pump sump and return it to a hydropneumatic tank at the treatment facility for use when required by the aforementioned systems. Service water will be interconnected with this system as a backup water supply.

g. Ocean Vessel Coal Unloading Facility Wastewater Treatment Plant

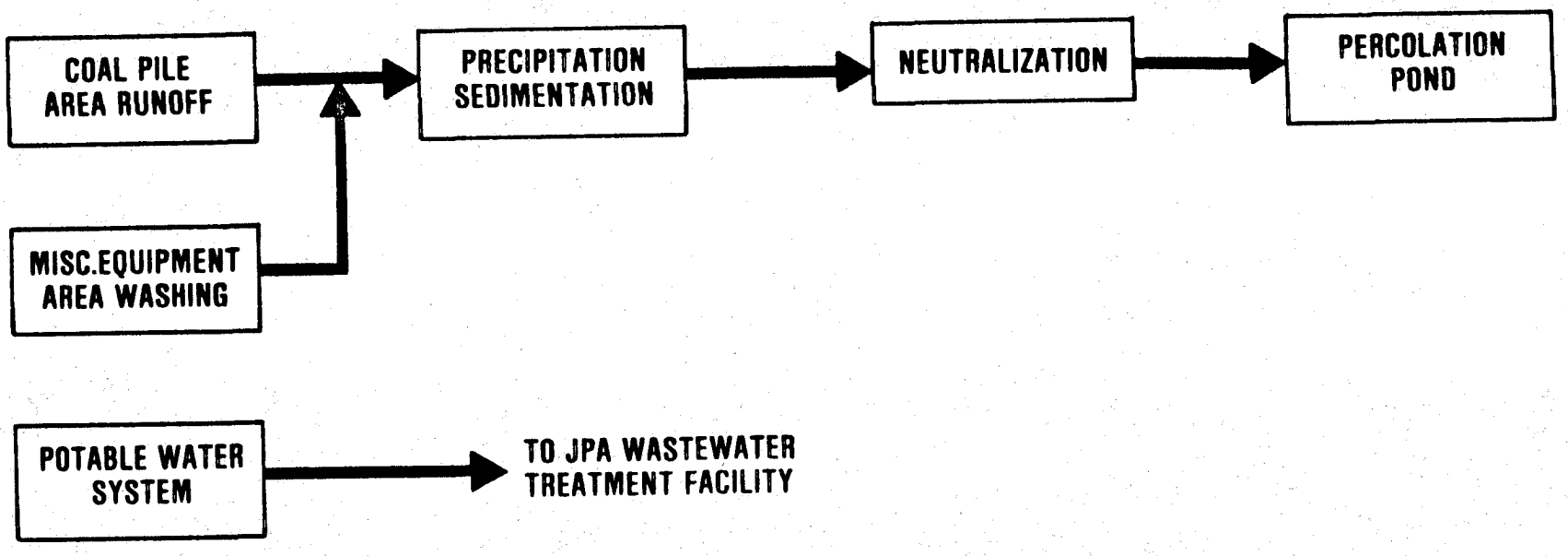
Wastewater treated at the Blount Island coal unloading facility will be designed to treat coal pile and area runoff. Treatment provided will process the ten year, 24-hour rainfall event and will include pH adjustment and iron and suspended solids removal. Treatment will consist of a combination of sedimentation, neutralization, and precipitation. Treated effluent then will be discharged into a two cell percolation pond, also designed to accomodate the maximum expected flow. Figure IV is a schematic of the planned wastewater treatment system.

E. Solid Waste Generation and Disposal

1. Introduction

The largest quantity of solid wastes produced by the operation of the plant will be generated by the flue gas desulfurization (FGD) system. Coal combustion ash, in the form of fly ash and bottom ash, will be the other major solid waste. Collectively, FGD waste and coal ash are referred to as "high volume solid wastes." Other comparatively small quantities of solid wastes generated by the operation of the plant include sludges from the sedimentation pond, retention basin, cooling towers, and wastewater treatment facilities.

FIGURE IV
WATER AND WASTE MANAGEMENT PLAN
AT BLOUNT ISLAND



2. High Volume Solid Wastes

Ash is the residue produced by the combustion of coal. It consists of the unburned organic matter and the inorganic mineral constituents present in the coal. The quantity and chemical characteristics of ash depend on the coal, boiler operating conditions, and air pollution control devices. Two types of ash are produced during combustion, fly ash and bottom ash. Fly ash consists of the finer particles that are entrained in the flue gas stream. Bottom ash is the coarser, heavier material that accumulates in the furnace bottom in the form of a loose ash or slag.

For the proposed wet limestone FGD scrubber, the sulfur dioxide in the flue gas reacts with the limestone slurry producing a waste. The principal constituent of the waste produced at the proposed plant will be calcium sulfate (gypsum) based on a forced oxidation system.

The following conditions have been used to estimate the quantities of high volume solid wastes:

Plant

Two 600 MW Units
Heat input rate = 5928 x 10^6 Btu/hour/unit
Plant life = 40 years
Average capacity factor = 60 percent (not levelized)

Coal

Heating value = 11,590 Btu/lb
Ash content = 9.2 percent
Sulfur content = 2.7 percent

Fly Ash

Removal efficiency = 100 percent
Percent of total ash produced = 80 percent
Bulk density at disposal site (dry) = 60 lbs/ft^3

Bottom Ash

Percent of total ash produced = 20 percent
Bulk density at disposal site (dry) = 80 lbs/ft^3

FGD System

Scrubber type = Wet limestone with forced oxidation
Waste composition = $CaSO_4.2H_2O$ (Gypsum)
Removal Efficiency = 100 percent
Excess sludge = 10 percent
Solid content = 80 percent
Bulk density at disposal site (dry) = 64 lbs/ft^3

Values used are estimated averages over the anticipated 40 year life of the plant. Removal efficiencies of 100 percent are assumed for the sake of conservatism.

a. Bottom Ash

Approximately 1.99 million tons of bottom ash are expected to be generated over the life of the plant. The total volume is estimated to be about 1140 acre-feet. Maximum rate of production of bottom ash is expected to be about 20 tons/hour for both units.

Bottom ash will be sluiced to a dewatering system for water removal. The water is recycled back to the bottom ash hopper and the dry ash is removed from the dewatering bins for reuse off-site or disposal on-site. Potential markets for bottom ash include sectors of the construction industry. Non-marketed bottom ash will be combined with the other combustion by-product solid wastes and disposed of in an on-site landfill.

b. Air Quality Control Systems Waste

The Air Quality Control Systems (AQCS) wastes consist of fly ash collected in the electrostatic precipitators and the FGD waste. Fly ash will be generated at the maximum rate of about 81 tons/hour from Units 1 and 2.

Approximately 7.95 million tons or 6,080 acre-feet of fly ash will be generated over the life of the plant. Fly ash will be pneumatically conveyed to temporary storage silos. The silos will provide a minimum of three days storage.

The maximum rate of production of dry gypsum for the two units is estimated at about 134 tons/hour. Total gypsum produced over the life of the plant will be approximately 17.2 million tons or 12,400 acre-feet. Temporary storage of up to seven days at full load generation will be provided for marketable gypsum.

Fly ash is a valuable, recoverable resource. Several alternatives are currently available for the use of fly ash. With the congressional encouragement of resource recovery activities through the passage of the Resource Conservation and Recovery Act of 1976, and with a potential nearby market for fly ash, it is anticipated that fly ash generated by the proposed plant will be sold as a by-product.

The gypsum produced by the FGD system will be of a commercial grade, comparable in quality to natural gypsum deposits. This quality can be achieved through special equipment design and quality control procedures. Wallboard manufacturing facilities exist in the vicinity of the proposed plant and it is anticipated that the gypsum produced at the proposed plant will be utilized in the manufacture of wallboard.

In the event markets for fly ash, bottom ash and gypsum do not materalize, or during temporary market interruptions, on-site storage will be necessary. Due to the conservative assumptions used in the solid waste area impacts assessment which have been necessary because of the absence of specific plant coal and leachate characteristics, a storage program having two elements will be implemented. These elements include an on-site solid waste disposal test program and an on-site landfilling operation for material not directly associated with the test program.

The test program will be designed to characterize the handleability, structural stability, and other physical and chemical properties of fly ash, bottom ash, and gypsum mixtures, and to develop criteria for establishing an environmentally acceptable and cost effective long term disposal plan.

During the testing period (approximately five years), the material not directly associated with the test program will be placed into a secure, on-site, monitored landfill. The landfill will be developed in cells of approximately 10 acres each. The base of the landfill will be above the seasonal high water table. The base material will be compacted to achieve a permeability of approximately 9×10^{-4} cm/sec and designed to minimize leachate caused by rainfall infiltration within the limitations of water quality standards in the area. The waste material will be placed and compacted in lifts (layers) up to a total height of about 60 feet. Compaction of this material further reduces infiltration of rainwater through the waste.

Before initial waste placement within each cell, diversion berms for diverting water runoff from surrounding areas will be constructed. In addition, a perimeter ditch inside the berm will collect the precipitation runoff from the landfill. Collected runoff will be treated as discussed in Section IV.C.11. During placement, drainage will be maintained toward perimeter ditches.

For closure of the landfill, the tops of completed cells will be sloped to enhance surface runoff while reducing infiltration. A cover consisting of a granular base (such as bottom ash) and topsoil will be placed on the sides of completed outside cells and on the landfill top surface. Interfacing side slopes of the cells will not be covered since they serve as initial sides for the next cell. The final step in closure will be to seed the covered landfill.

A system of groundwater monitoring wells will be installed prior to the disposal of the waste material and a monitoring program will be initiated. The system will include wells upgradient and downgradient of the disposal area. Water levels will be periodically monitored and water samples will be periodically collected for analysis of selected indicator parameters.

The solid waste mixture (fly ash, gypsum, and bottom ash) has a moisture content of approximately 20 percent; thus, fugitive dust emissions from the waste are expected to be minimal. The continual placement and compaction of new (moist) material over the old during construction of each landfill lift will also prevent the formation of dust should the surface be disturbed due to working. Covering the waste with soil and seeding will eliminate possible future dust emissions after closure of the cell.

3. Other Wastes

Compared to the high volume solid wastes, quantities of miscellaneous solid wastes generated by the operation of the plant are insignificant. These wastes include settled solids from various sedimentation ponds, the metal cleaning retention basin, and the cooling tower basin; separated oil and grease from oil-water separators; and, sludges from the santitary waste treatment facility and the central wastewater treatment facility. The quantities of the miscellaneous solid wastes generated will depend on a number of factors.

Solids which have accumulated in the various sedimentation basins will be removed periodically to maintain sufficient liquid holding capacity in the ponds. Solids build up will depend primarily on rainfall frequency and duration and the concentration of suspended solids in the influent to the ponds. Solids in these ponds will consist mainly of coal dust and ash. Material from the coal pile runoff sediment control ponds at the plant and on Blount Island will be removed and returned to their respective coal piles. Solids from the other runoff sedimentation ponds will be placed in the on-site landfill after removal. Frequency of solids removed from these ponds is estimated to be about once per year.

Removal of wastes from the metal cleaning waste retention basin will be required once every three to five years, corresponding with the frequency of one or two boiler cleaning operations. Because of the potentially corrosive nature of the liquid waste held in the basin, the settled solids remaining may be considered hazardous under the rules of RCRA. If the wastes are considered hazardous, a RCRA permitted contractor will remove the wastes from the basin in accordance with the applicable regulations and dispose of them off-site. Should these wastes not be determined to be hazardous, the RCRA permitted contractor requirement will be dropped and on-site disposal considered.

Solids accumulated in the flow equalization basin (primarily from the FGD system blowdown) will be removed for disposal in the on-site landfill for fly ash, gypsum, and bottom ash.

Suspended solids and particulates from the atmosphere will build up over time in the cooling tower basins. These basins will be cleaned once or twice a year and the accumulated solids will be removed and disposed of in an on-site landfill.

Sludge will be produced from operation of the central chemical wastewater treatment plant, generated during the solids clarification and iron precipitation processes. The quantity of sludges produced will depend on the influent wastewater characteristics and length of operation of the facility. The sludge will be removed when required, dewatered and disposed of in the landfill.

Although the extended aeration sanitary waste treatment facility is not expected to produce significant amounts of sludge, this waste material will be removed as necessary and disposed of off-site.

Oily waste removed from the oil-water separators will be collected for off-site disposal or reuse by licensed vendors. These wastes also may be incinerated in the boilers with the coal at selected times.

V CONSTRUCTION AND PREOPERATION WASTES

A. Introduction

Wastes generated during the constructon and pre-operational phases of the SJRPP Units 1 and 2 are discussed in this section. In addition, waste management plans during these periods are presented.

B. Wastewaters

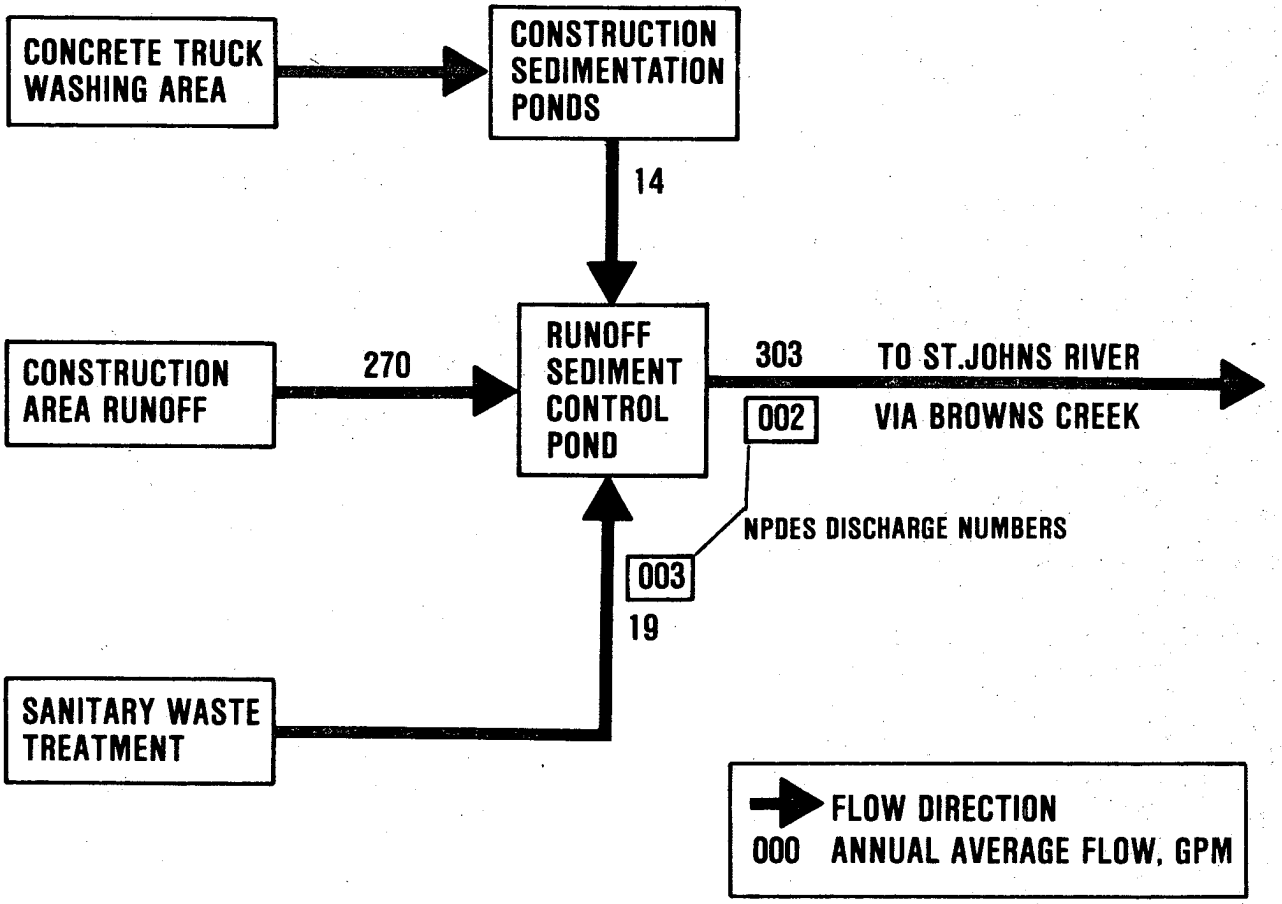
1. Area Runoff

Approximately 300 acres of land within the railroad loop will be cleared and grubbed. Of this, approximately 10 acres will be paved (construction building, roads, etc.) having an assumed 100 percent runoff. The runoff coefficient for the remaining 290 acres (a sandy type soil) is expected to be approximately 0.30. The average runoff coefficient for the cleared area is expected to be approximately 0.32. The total runoff from the 300 acre site is expected to be about 61 acre-feet, based on the 10 year, 24-hour design storm of 7.6 inches.

During construction, temporary sedimentation ponds will be located southeast of the railroad loop and within the area enclosed by the loop. All runoff waters generated within the general boundaries of the rail loop during construction will be directed to these ponds, where the majority of sedimentation will take place. The runoff collection system will consist of grassed drainage ditches, storm sewers, and a circumferential grassed main drainage ditch directing flow from the construction sedimentation ponds to the runoff sediment control pond. The runoff sediment control pond will provide 24-hour retention of the design storm and will be sized to retain accumulated solids. Effluent from this pond will overflow via a control pipe and follow existing drainage paths to the St. Johns River via Brown's Creek. The plot plan (Figure II) shows the on-site drainage plan during construction. A schematic diagram of the construction phase drainage is presented as Figure V.

The uncontaminated runoff is expected to contain little chemical contamination. However, until all construction is completed, there will be a potential for soil loss from uncovered areas. It is expected that some of the settleable material will be taken out of the runoff by filtering in the grass-covered drainage ditches. Additional settling will take place in the runoff sediment control pond prior to discharge to Brown's Creek. Total suspended solids are expected to be 50 mg/l on a daily average with a maximum of 100 mg/l. The runoff sediment control pond will be designed with sloping embankments, thus allowing growth of vegetation along the edges of the pond and facilitating biological uptake of nutrients and metals which may be contained in runoff entering the pond.

FIGURE V
CONSTRUCTION PHASE DRAINAGE-SCHEMATIC



2. Concrete Truck Washing

Concrete trucks leaving the construction site after delivery will be hosed down at a paved truck washing area. Washout from trucks will be directed to a 2.2 million gallon sedimentation pond. Overflow from this pond will be directed to the construction phase runoff sediment control pond. Peak drainage from the washing activity is expected to be approximately 20,000 gallons per day.

3. Heavy Equipment Refueling Area

One or more areas will be lined with gravel to serve as refueling areas for heavy construction equipment. These areas will include temporary fuel storage tanks. Rainfall runoff from these areas will be directed to gravity type oil-water separators designed to handle the 10 year, 24-hour storm. The effluent from the oil-water separators will be directed to the construction phase runoff sediment control pond.

4. Sanitary Wastes

During plant construction, the peak work force is expected to be approximately 2,000. Of these, approximately 650 people will use portable, self-contained facilities. Wastes from the portable facilities will be disposed off-site either by the facilities's supplier or by some contractor who would collect the wastes and transport them to the nearest municipal sanitary waste treatment facility with available capacity. Approximately 1,350 of the construction personnel will use permanent and temporary toilets, located in several site areas. The average wastewater generated is expected to be approximately 30,000 gpd at a rate of 22 gallons per capita per day. The biological oxygen demand is expected to be about 54 pounds per day, using a loading of 0.04 pounds per capita per day. Waste characteristics and treatment methods are the same as those for municipal sanitary wastes and are discussed in Section IV. During construction, the treated effluent from the sanitary waste treatment facility will be directed to the construction runoff sediment control pond, as indicated in Figure IV.

5. Metal Cleaning Wastes

There are two alternatives for treatment and/or disposal of pre-operational metal cleaning wastes; on-site treatment in the central wastewater treatment facility or off-site by disposal contractor. Pre-operational boiler and condensate systems cleaning wastes more than likely will be treated on-site after neutralization in the metal cleaning waste retention basin. Pre-operational cleaning consists of flushing the boiler system

with an alkaline detergent solution to remove oil and grease, dirt and other debris, then rinsing with water. Next, the boiler is acid cleaned to remove mill scale (iron oxide buildup), neutralized and rinsed with demineralized water.

The condensate system is cleaned in a similar manner. The waste cleaning solutions, flush waters, and associated debris are piped to the retention basin where the alkaline and acid solutions neutralize one another. Additional chemicals may be required to adjust the pH of the wastewater to precipitate the iron oxides in the basin. The supernatant will then be treated in the wastewater treatment facility for solids removal and final pH adjustment, as required. This approach to disposal of pre-operational metal cleaning wastes is preferred to disposal by contractor primarily due to the large volume of liquid involved.

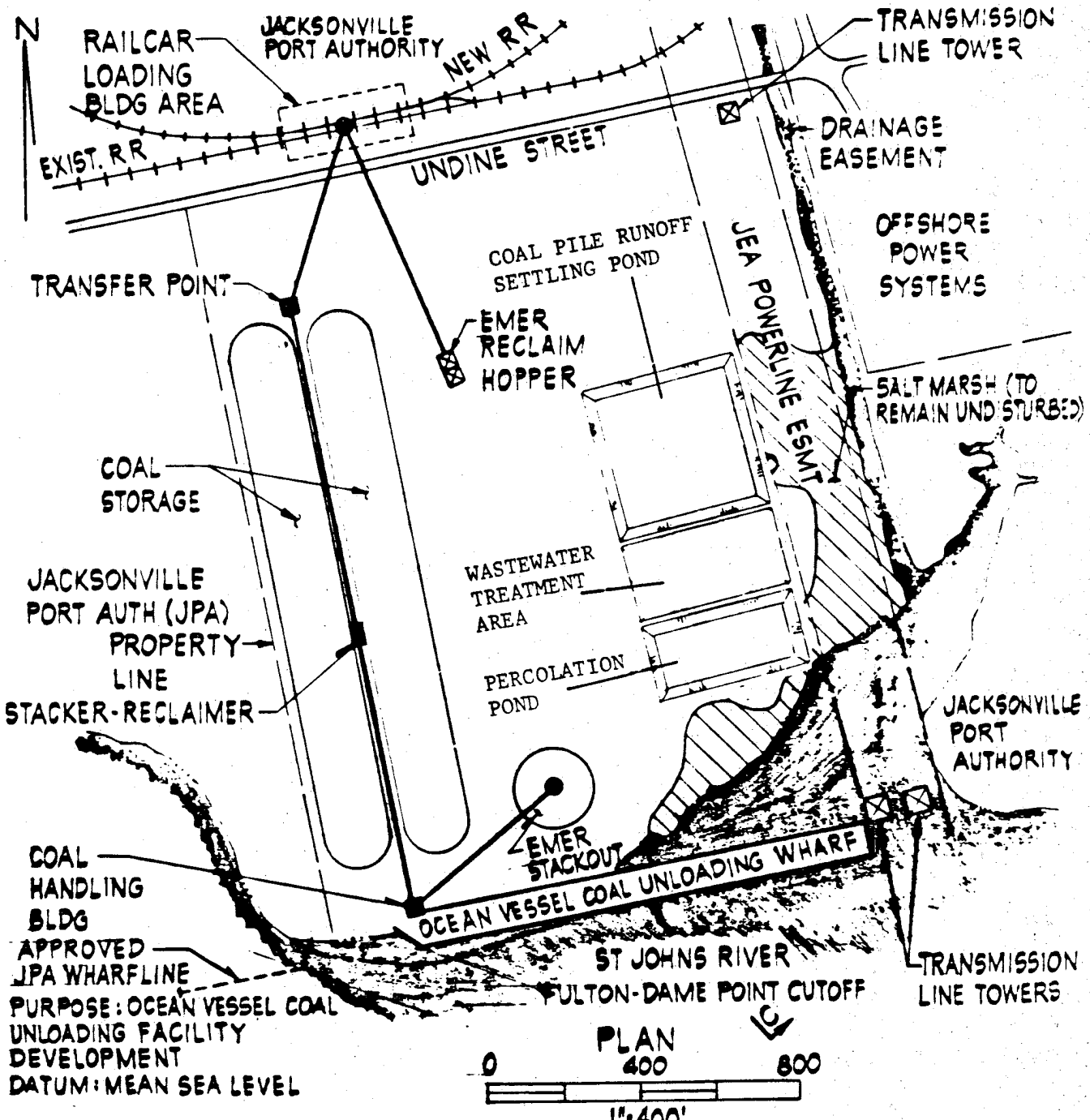
C. Solid Wastes

A pulpwood operation has already timbered much of the site for marketable pine pulpwood. After completing additional timber harvesting, the construction areas will be cleared and grubbed. Clearing and grubbing wastes will be disposed either by burning or burial. Burning operations will be conducted in accordance with local and state requirements.

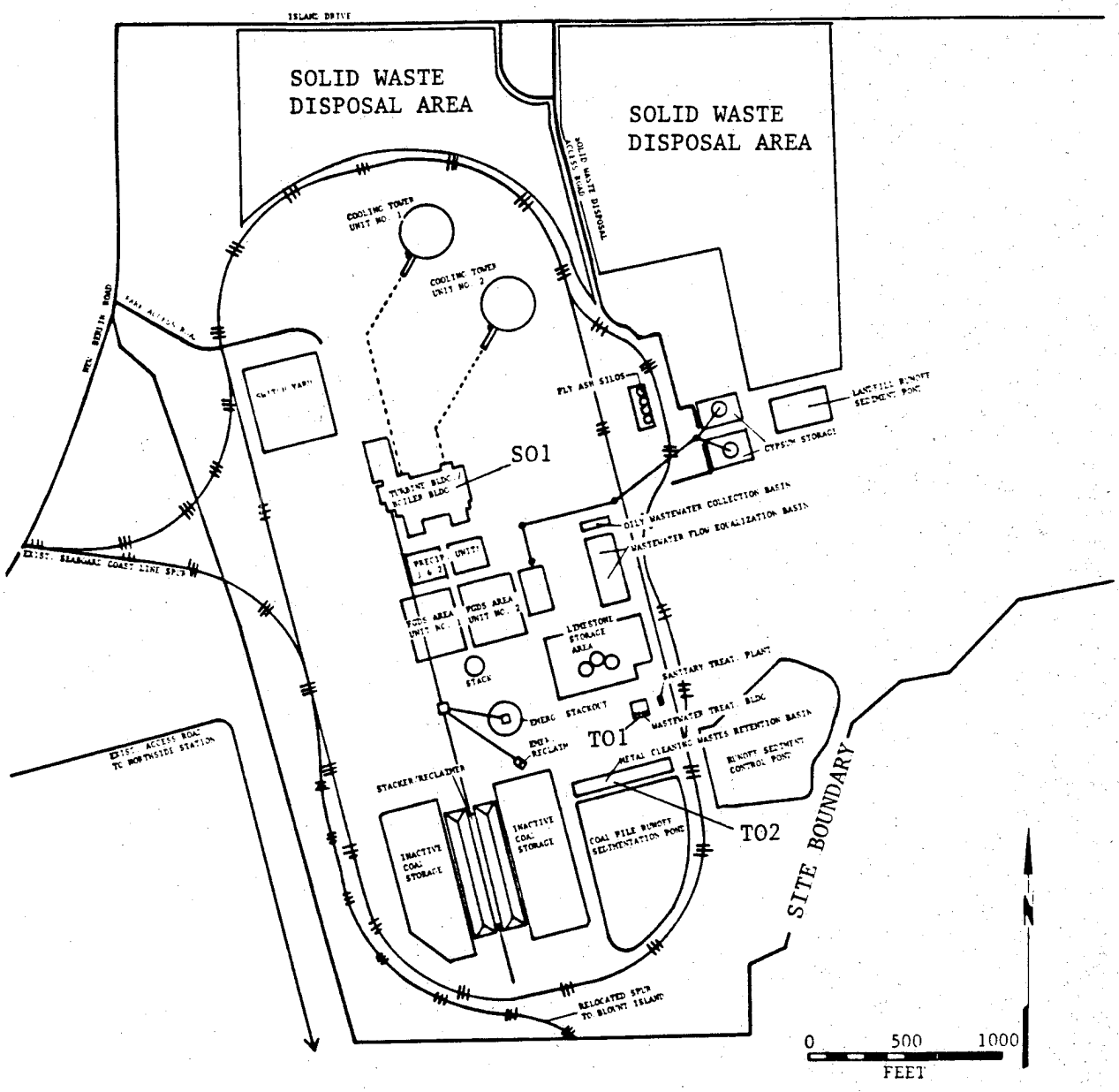
Construction waste material, such as scrap wood and iron, will be taken to a specified open area of the site where they will be separated and stock-piled for possible reuse or salvage.

Garbage generated by the construction work force will be deposited in designated containers and disposed in dumpsters for collection and disposal at the city landfill adjacent to the site.

Sludges generated from construction phase operation of the central wastewater treatment facility, sanitary wastewater treatment facility, and metal cleaning waste retention basin will be disposed of in the same manner as those similar sludges generated during the operational phase of the SJRPP. This subject is addressed in Section IV.E.3 of this study.



PROPOSED COAL UNLOADING & STORAGE FACILITY
FOR ST JOHNS RIVER POWER PARK
AT THE CITY OF JACKSONVILLE, COUNTY OF DUVAL, STATE OF FLORIDA
APPLICATION BY: JACKSONVILLE ELEC AUTHORITY
SHEET 15 OF 20
DATE: FEB 18 1981



NOTE: SO1 LOCATED INSIDE
TURBINE BUILDING

LOCATION OF HAZARDOUS WASTE TREATMENT AND STORAGE AREAS

0.3 USEPA HAZARDOUS WASTE PERMIT APPLICATION

Please print or type in the unshaded areas only
(fill—in areas are spaced for elite type, i.e., 12 characters/inch).

Form Approved OMB No. 158-R0175

FORM 1 GENERAL

U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERAL INFORMATION

Consolidated Permits Program

(Read the "General Instructions" before starting.)

I. EPA I.D. NUMBER

F

GENERAL INSTRUCTIONS

If a preprinted label has been provided, affix it in the designated space. Review the information carefully; if any of it is incorrect, cross through it and enter the correct data in the appropriate fill—in area below. Also, if any of the preprinted data is absent *(the area to the left of the label space lists the information that should appear)*, please provide it in the proper fill—in area(s) below. If the label is complete and correct, you need not complete Items I, III, V, and VI *(except VI-B which must be completed regardless)*. Complete all items if no label has been provided. Refer to the instructions for detailed item descriptions and for the legal authorizations under which this data is collected.

LABEL ITEMS

- II. EPA I.D. NUMBER
- III. FACILITY NAME
- V. FACILITY MAILING ADDRESS
- VI. FACILITY LOCATION

PLEASE PLACE LABEL IN THIS SPACE

II. POLLUTANT CHARACTERISTICS

INSTRUCTIONS: Complete A through J to determine whether you need to submit any permit application forms to the EPA. If you answer "yes" to any questions, you must submit this form and the supplemental form listed in the parenthesis following the question. Mark "X" in the box in the third column if the supplemental form is attached. If you answer "no" to each question, you need not submit any of these forms. You may answer "no" if your activity is excluded from permit requirements; see Section C of the instructions. See also, Section D of the instructions for definitions of bold—faced terms.

SPECIFIC QUESTIONS	MARK 'X' YES	NO	FORM ATTACHED
A. Is this facility a publicly owned treatment works which results in a discharge to waters of the U.S.? (FORM 2A)		X	
B. Does or will this facility *(either existing or proposed)* include a concentrated animal feeding operation or aquatic animal production facility which results in a discharge to waters of the U.S.? (FORM 2B)		X	
C. Is this a facility which currently results in discharges to waters of the U.S. other than those described in A or B above? (FORM 2C)		X	
D. Is this a proposed facility *(other than those described in A or B above)* which will result in a discharge to waters of the U.S.? (FORM 2D)	X		
E. Does or will this facility treat, store, or dispose of hazardous wastes? (FORM 3)	X		X
F. Do you or will you inject at this facility industrial or municipal effluent below the lowermost stratum containing, within one quarter mile of the well bore, underground sources of drinking water? (FORM 4)		X	
G. Do you or will you inject at this facility any produced water or other fluids which are brought to the surface in connection with conventional oil or natural gas production, inject fluids used for enhanced recovery of oil or natural gas, or inject fluids for storage of liquid hydrocarbons? (FORM 4)		X	
H. Do you or will you inject at this facility fluids for special processes such as mining of sulfur by the Frasch process, solution mining of minerals, in situ combustion of fossil fuel, or recovery of geothermal energy? (FORM 4)		X	
I. Is this facility a proposed stationary source which is one of the 28 industrial categories listed in the instructions and which will potentially emit 100 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)	X		
J. Is this facility a proposed stationary source which is NOT one of the 28 industrial categories listed in the instructions and which will potentially emit 250 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)		X	

III. NAME OF FACILITY

1 SKIP: ST. JOHNS RIVER POWER PARK UNITS 1 & 2

IV. FACILITY CONTACT

A. NAME & TITLE (last, first, & title)	B. PHONE (area code & no.)
2 MOEHLE D. A. DIV. CHF. FOSSIL GEN.	904 633 4513

V. FACILITY MAILING ADDRESS

A. STREET OR P.O. BOX: 3 P. O. BOX 53015

B. CITY OR TOWN	C. STATE	D. ZIP CODE
4 JACKSONVILLE	FL	32201

VI. FACILITY LOCATION

A. STREET, ROUTE NO. OR OTHER SPECIFIC IDENTIFIER: 5 NEW BERLIN RD & ISLAND DR.

B. COUNTY NAME: DUVAL

C. CITY OR TOWN	D. STATE	E. ZIP CODE	F. COUNTY CODE (if known)
6 JACKSONVILLE	FL	32226	

CONTINUE ON REVERSE

CONTINUED FROM THE FRONT

VII. SIC CODES (4-digit, in order of priority)

A. FIRST	B. SECOND
4911 (specify) Electric Generating Station	(specify)
C. THIRD	**D. FOURTH**
(specify)	(specify)

VIII. OPERATOR INFORMATION

A. NAME

JACKSONVILLE ELECTRIC AUTHORITY

B. Is the name listed in Item VIII-A also the owner? [X] YES [ ] NO

C. STATUS OF OPERATOR (Enter the appropriate letter into the answer box; if "Other", specify.)

F = FEDERAL; S = STATE; P = PRIVATE; M = PUBLIC (other than federal or state); O = OTHER (specify)

M (specify)

D. PHONE (area code & no.)

A 904 633 4513

E. STREET OR P.O. BOX

233 W DUVAL STREET

F. CITY OR TOWN

B JACKSONVILLE

G. STATE FL

H. ZIP CODE 32201

IX. INDIAN LAND

Is the facility located on Indian lands? [ ] YES [X] NO

X. EXISTING ENVIRONMENTAL PERMITS

A. NPDES (Discharges to Surface Water): 9 N	**D. PSD** (Air Emissions from Proposed Sources): 9 P
B. UIC (Underground Injection of Fluids): 9 U	**E. OTHER** (specify): 9 (specify)
C. RCRA (Hazardous Wastes): 9 R	**E. OTHER** (specify): 9 (specify)

XI. MAP

Attach to this application a topographic map of the area extending to at least one mile beyond property bounderies. The map must show the outline of the facility, the location of each of its existing and proposed intake and discharge structures, each of its hazardous waste treatment, storage, or disposal facilities, and each well where it injects fluids underground. Include all springs, rivers and other surface water bodies in the map area. See instructions for precise requirements.

XII. NATURE OF BUSINESS (provide a brief description)

Municipal electric utility which generates and distributes electricity to industrial, commercial, and residential customers in the Jacksonville, Florida area. The new generating station will have two 600 MW coal-fired units. Heat will be dissipated in natural draft cooling towers. Intake will be from discharge channel of existing power plant (shown on Form 3 map) and discharge will be into the St. Johns River via the existing Northside Generating Station's discharge pipe.

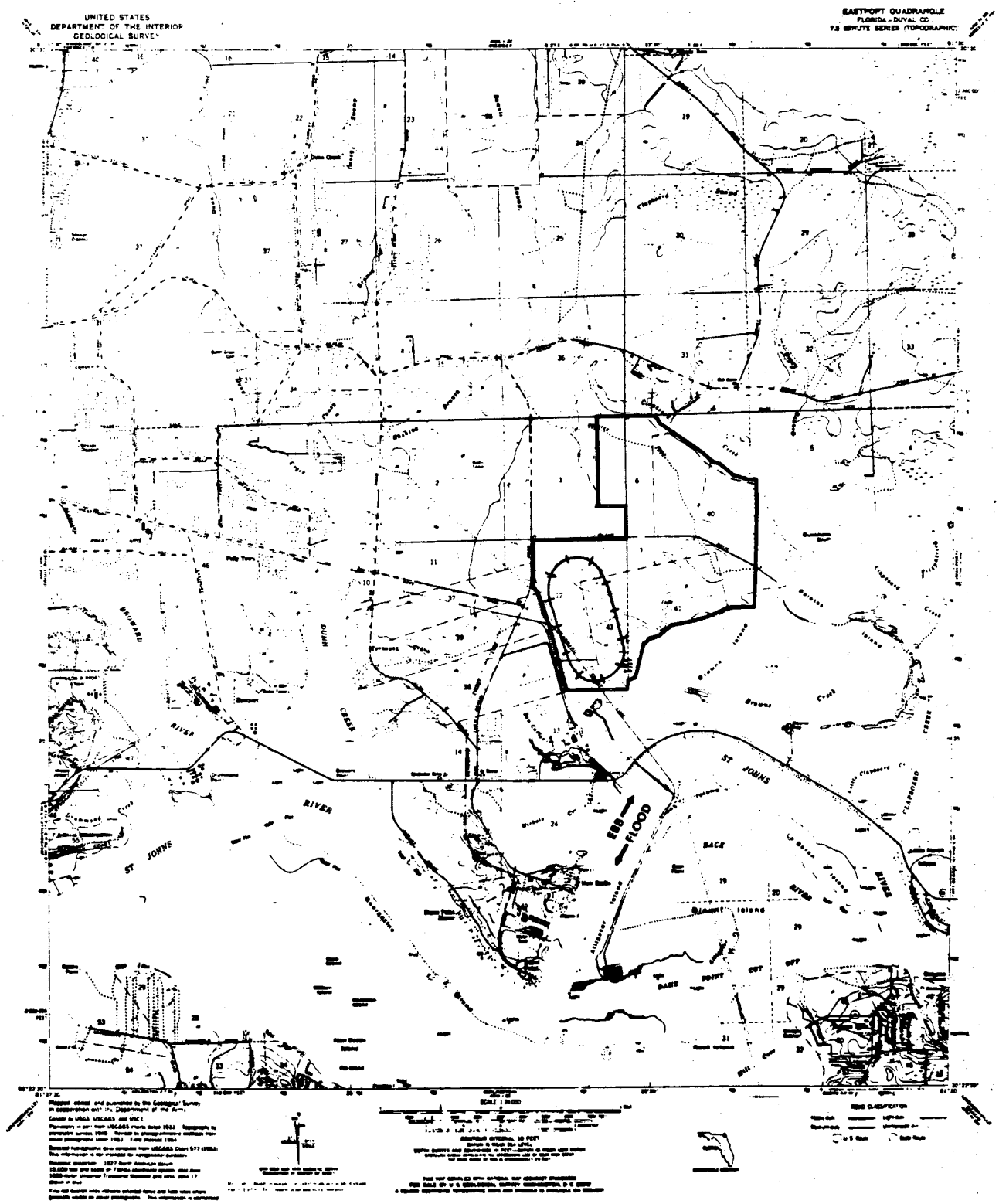
XIII. CERTIFICATION (see instructions)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those persons immediately responsible for obtaining the information contained in the application, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME & OFFICIAL TITLE (type or print)	B. SIGNATURE	C. DATE SIGNED
Royce Lyles Managing Director	Royce Lyles	2-17-81

COMMENTS FOR OFFICIAL USE ONLY

C



SITE LOCATION MAP

Please print or type in the unshaded areas only
(fill—in areas are spaced for elite type, i.e., 12 characters/inch).

Form Approved OMB No. 158-S80004

FORM 3 RCRA | **EPA**

U.S. ENVIRONMENTAL PROTECTION AGENCY

HAZARDOUS WASTE PERMIT APPLICATION

Consolidated Permits Program

(This information is required under Section 3005 of RCRA.)

I. EPA I.D. NUMBER

F

FOR OFFICIAL USE ONLY

APPLICATION APPROVED	DATE RECEIVED (yr., mo., & day)	COMMENTS

II. FIRST OR REVISED APPLICATION

Place an "X" in the appropriate box in A or B below *(mark one box only)* to indicate whether this is the first application you are submitting for your facility or a revised application. If this is your first application and you already know your facility's EPA I.D. Number, or if this is a revised application, enter your facility's EPA I.D. Number in Item I above.

A. FIRST APPLICATION *(place an "X" below and provide the appropriate date)*

☐ 1. EXISTING FACILITY *(See instructions for definition of "existing" facility. Complete item below.)*

FOR EXISTING FACILITIES, PROVIDE THE DATE (yr., mo., & day) OPERATION BEGAN OR THE DATE CONSTRUCTION COMMENCED *(use the boxes to the left)*

C 8 | YR. | MO. | DAY

☒ 2. NEW FACILITY *(Complete item below.)*

FOR NEW FACILITIES, PROVIDE THE DATE (yr., mo., & day) OPERATION BEGAN OR IS EXPECTED TO BEGIN

YR.	MO.	DAY
85	12	05

B. REVISED APPLICATION *(place an "X" below and complete Item I above)*

☐ 1. FACILITY HAS INTERIM STATUS

☐ 2. FACILITY HAS A RCRA PERMIT

III. PROCESSES — CODES AND DESIGN CAPACITIES

A. PROCESS CODE — Enter the code from the list of process codes below that best describes each process to be used at the facility. Ten lines are provided for entering codes. If more lines are needed, enter the code(s) in the space provided. If a process will be used that is not included in the list of codes below, then describe the process *(including its design capacity)* in the space provided on the form *(Item III-C)*.

B. PROCESS DESIGN CAPACITY — For each code entered in column A enter the capacity of the process.

1. AMOUNT — Enter the amount.
2. UNIT OF MEASURE — For each amount entered in column B(1), enter the code from the list of unit measure codes below that describes the unit of measure used. Only the units of measure that are listed below should be used.

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Storage:		
CONTAINER *(barrel, drum, etc.)*	S01	GALLONS OR LITERS
TANK	S02	GALLONS OR LITERS
WASTE PILE	S03	CUBIC YARDS OR CUBIC METERS
SURFACE IMPOUNDMENT	S04	GALLONS OR LITERS
Disposal:		
INJECTION WELL	D79	GALLONS OR LITERS
LANDFILL	D80	ACRE-FEET *(the volume that would cover one acre to a depth of one foot)* OR HECTARE-METER
LAND APPLICATION	D81	ACRES OR HECTARES
OCEAN DISPOSAL	D82	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	D83	GALLONS OR LITERS

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Treatment:		
TANK	T01	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	T02	GALLONS PER DAY OR LITERS PER DAY
INCINERATOR	T03	TONS PER HOUR OR METRIC TONS PER HOUR; GALLONS PER HOUR OR LITERS PER HOUR
OTHER *(Use for physical, chemical, thermal or biological treatment processes not occurring in tanks, surface impoundments or incinerators. Describe the processes in the space provided; Item III-C.)*	T04	GALLONS PER DAY OR LITERS PER DAY

UNIT OF MEASURE	UNIT OF MEASURE CODE
GALLONS	G
LITERS	L
CUBIC YARDS	Y
CUBIC METERS	C
GALLONS PER DAY	U
LITERS PER DAY	V
TONS PER HOUR	D
METRIC TONS PER HOUR	W
GALLONS PER HOUR	E
LITERS PER HOUR	H
ACRE-FEET	A
HECTARE-METER	F
ACRES	B
HECTARES	Q

EXAMPLE FOR COMPLETING ITEM III *(shown in line numbers X-1 and X-2 below)*: A facility has two storage tanks, one tank can hold 200 gallons and the other can hold 400 gallons. The facility also has an incinerator that can burn up to 20 gallons per hour.

C DUP T/A C 1

LINE NUMBER	A. PROCESS CODE (from list above)	B. PROCESS DESIGN CAPACITY 1. AMOUNT (specify)	B. PROCESS DESIGN CAPACITY 2. UNIT OF MEASURE (enter code)	FOR OFFICIAL USE ONLY	LINE NUMBER	A. PROCESS CODE (from list above)	B. PROCESS DESIGN CAPACITY 1. AMOUNT	B. PROCESS DESIGN CAPACITY 2. UNIT OF MEASURE (enter code)	FOR OFFICIAL USE ONLY
X-1	S02	600	G		5				
X-2	T03	20	E		6				
1	T02	2×10^6	U		7				
2	T01	360,000	U		8				
3	S01	330	G		9				
4					10				

Continued from the front.

III. PROCESSES *(continued)*

C. SPACE FOR ADDITIONAL PROCESS CODES OR FOR DESCRIBING OTHER PROCESSES *(code "T04")*. FOR EACH PROCESS ENTERED HERE INCLUDE DESIGN CAPACITY.

Item II, A (2) - The new facility consists of two generating units; the first to be certified operational on Dec. 5, 1985 and the second on May 29, 1987.

Item III, Line 3 - The design capacity indicated represents the maximum container volume anticipated for storage of spent degreasing solvent prior to its disposal off-site.

IV. DESCRIPTION OF HAZARDOUS WASTES

A. EPA HAZARDOUS WASTE NUMBER – Enter the four–digit number from 40 CFR, Subpart D for each listed hazardous waste you will handle. If you handle hazardous wastes which are not listed in 40 CFR, Subpart D, enter the four–digit number*(s)* from 40 CFR, Subpart C that describes the characteristics and/or the toxic contaminants of those hazardous wastes.

B. ESTIMATED ANNUAL QUANTITY – For each **listed waste** entered in column A estimate the quantity of that waste that will be handled on an annual basis. For each **characteristic** or **toxic contaminant** entered in column A estimate the total annual quantity of all the non–listed waste*(s)* that will be handled which possess that characteristic or contaminant.

C. UNIT OF MEASURE – For each quantity entered in column B enter the unit of measure code. Units of measure which must be used and the appropriate codes are:

ENGLISH UNIT OF MEASURE	CODE	METRIC UNIT OF MEASURE	CODE
POUNDS	P	KILOGRAMS	K
TONS	T	METRIC TONS	M

If facility records use any other unit of measure for quantity, the units of measure must be converted into one of the required units of measure taking into account the appropriate density or specific gravity of the waste.

D. PROCESSES

1. PROCESS CODES:
   For listed hazardous waste: For each **listed** hazardous waste entered in column A select the code*(s)* from the list of process codes contained in Item III to indicate how the waste will be stored, treated, and/or disposed of at the facility.
   For non–listed hazardous wastes: For each characteristic or toxic contaminant entered in column A, select the code*(s)* from the list of process codes contained in Item III to indicate **all** the processes that will be used to store, treat, and/or dispose of all the non–listed hazardous wastes that possess that characteristic or toxic contaminant.
   Note: Four spaces are provided for entering process codes. If more are needed: (1) Enter the first three as described above; (2) Enter "000" in the extreme right box of Item IV-D(1); and (3) Enter in the space provided on page 4, the line number and the additional code*(s)*.
2. PROCESS DESCRIPTION: If a code is not listed for a process that will be used, describe the process in the space provided on the form.

NOTE: HAZARDOUS WASTES DESCRIBED BY MORE THAN ONE EPA HAZARDOUS WASTE NUMBER – Hazardous wastes that can be described by more than one EPA Hazardous Waste Number shall be described on the form as follows:

1. Select one of the EPA Hazardous Waste Numbers and enter it in column A. On the same line complete columns B,C, and D by estimating the total annual quantity of the waste and describing all the processes to be used to treat, store, and/or dispose of the waste.
2. In column A of the next line enter the other EPA Hazardous Waste Number that can be used to describe the waste. In column D(2) on that line enter "included with above" and make no other entries on that line.
3. Repeat step 2 for each other EPA Hazardous Waste Number that can be used to describe the hazardous waste.

EXAMPLE FOR COMPLETING ITEM IV *(shown in line numbers X-1, X-2, X-3, and X-4 below)* – A facility will treat and dispose of an estimated 900 pounds per year of chrome shavings from leather tanning and finishing operation. In addition, the facility will treat and dispose of three non–listed wastes. Two wastes are corrosive only and there will be an estimated 200 pounds per year of each waste. The other waste is corrosive and ignitable and there will be an estimated 100 pounds per year of that waste. Treatment will be in an incinerator and disposal will be in a landfill.

LINE NO.	A. EPA HAZARD. WASTE NO (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (if a code is not entered in D(1))
X-1	K 0 5 4	900	P	T 0 3 D 8 0	
X-2	D 0 0 2	400	P	T 0 3 D 8 0	
X-3	D 0 0 1	100	P	T 0 3 D 8 0	
X-4	D 0 0 2				included with above

Continued from page 2.

NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

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EPA I.D. NUMBER (enter from page 1)			FOR OFFICIAL USE ONLY		
W		1	W DUP	2	DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

LINE NO.	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (if a code is not entered in D(1))
1	D002	6300	T	T02 T01	
2	F001	11010	P	S01	
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
26					

Continued from the front.

IV. DESCRIPTION OF HAZARDOUS WASTES *(continued)*

E. USE THIS SPACE TO LIST ADDITIONAL PROCESS CODES FROM ITEM D(1) ON PAGE 3.

Item IV, line no. 1 - The quantity of waste listed is the estimated quantity of boiler cleaning wastes anticipated to be collected at the facility per cleaning event. The frequency of cleaning should be once every three to five years per unit.

EPA I.D. NO. *(enter from page 1)*

													T/A	C
F														6

V. FACILITY DRAWING

All **existing** facilities must include in the space provided on page 5 a scale drawing of the facility *(see instructions for more detail).* NA

VI. PHOTOGRAPHS

All existing facilities must include photographs *(aerial or ground—level)* that clearly delineate all existing structures; existing storage, treatment and disposal areas; and sites of future storage, treatment or disposal areas *(see instructions for more detail).* NA

VII. FACILITY GEOGRAPHIC LOCATION

LATITUDE *(degrees, minutes, & seconds)*	LONGITUDE *(degrees, minutes, & seconds)*
30 26 00.0	081 32 00.0

VIII. FACILITY OWNER

[X] A. If the facility owner is also the facility operator as listed in Section VIII on Form 1, "General Information", place an "X" in the box to the left and skip to Section IX below.

B. If the facility owner is not the facility operator as listed in Section VIII on Form 1, complete the following items:

1. NAME OF FACILITY'S LEGAL OWNER	2. PHONE NO. *(area code & no.)*
E	

3. STREET OR P.O. BOX	4. CITY OR TOWN	5. ST.	6. ZIP CODE
F	G		

IX. OWNER CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME *(print or type)*	B. SIGNATURE	C. DATE SIGNED
Royce Lyles	Royce Lyles	2-17-89

X. OPERATOR CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME *(print or type)*	B. SIGNATURE	C. DATE SIGNED
Royce Lyles	Royce Lyles	2-17-89

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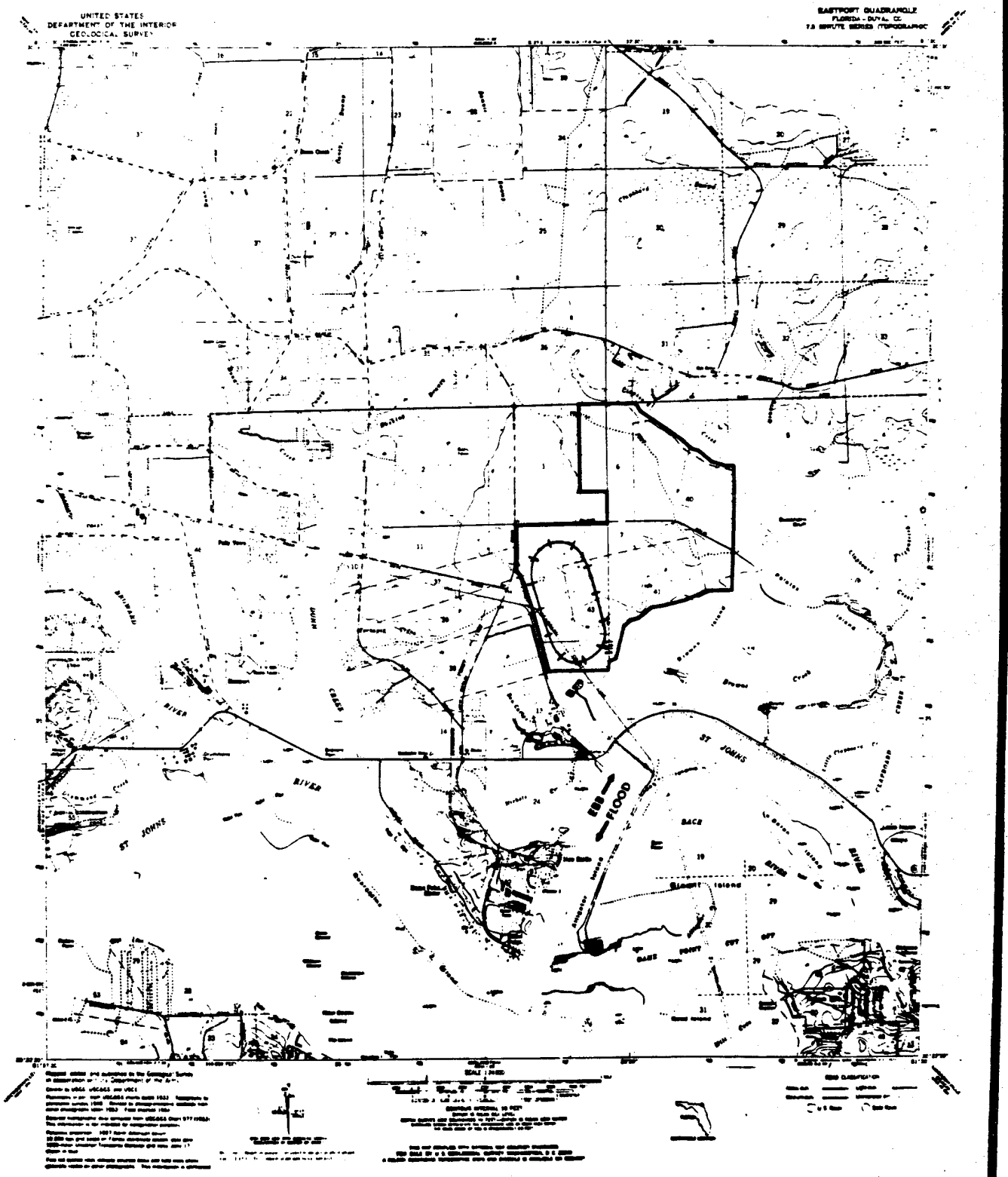
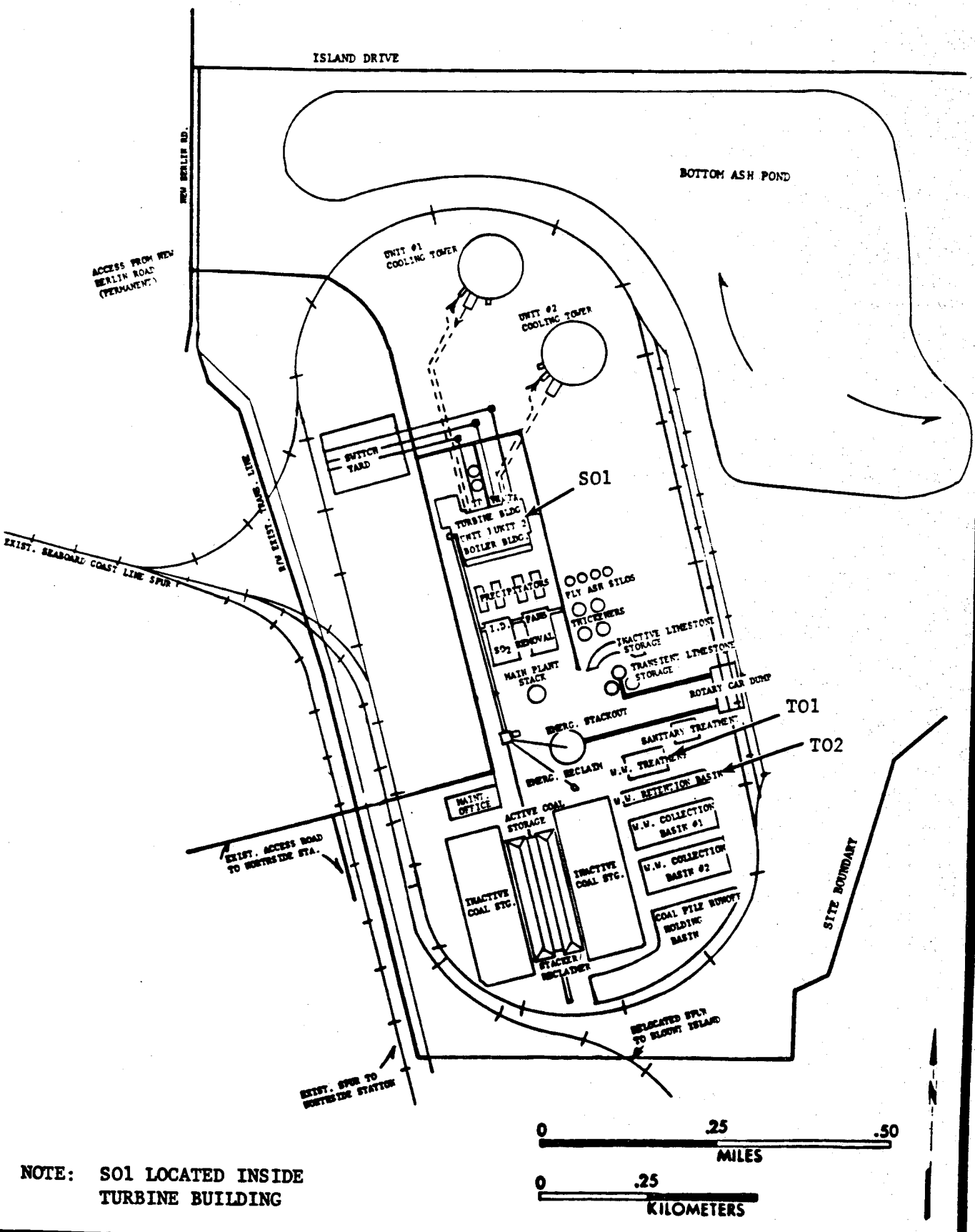
V. FACILITY DRAWING *(see page 4)*

Not applicable for new facility.



SITE LOCATION MAP



NOTE: SO1 LOCATED INSIDE TURBINE BUILDING

LOCATION OF HAZARDOUS WASTE TREATMENT AND STORAGE AREAS