United States
Environmental Protection
Agency

Region 4
345 Courtland Street, NE
Atlanta GA 30308

EPA 904/9-78-026b
November 1978

EPA

Environmental Impact Statement

Final

Central Florida Phosphate Industry

Volume II

Background and Alternatives Assessment

EPA 904/9-78-026(B)

FINAL AREAWIDE ENVIRONMENTAL IMPACT STATEMENT

CENTRAL FLORIDA PHOSPHATE INDUSTRY

VOLUME II

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV
ATLANTA, GEORGIA 30308

APPROVED:

John C. White
REGIONAL ADMINISTRATOR

NOVEMBER, 1978
DATE

FINAL AREAWIDE ENVIRONMENTAL IMPACT STATEMENT

CENTRAL FLORIDA PHOSPHATE INDUSTRY

VOLUME II

BACKGROUND AND ALTERNATIVES ASSESSMENT

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SUMMARY SHEET FOR ENVIRONMENTAL IMPACT

STATEMENT ON THE

CENTRAL FLORIDA PHOSPHATE INDUSTRY

( ) Draft
(X) Final

U.S. Environmental Protection Agency, Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30308

1. Name of Action (X) Administrative ( ) Legislative

2. Description of Action: This Environmental Impact Statement (EIS) was prepared by the Region IV office of the Environmental Protection Agency (EPA) as the lead Federal Agency. The purpose of this Statement is to fulfill the requirements of the National Environmental Policy Act (NEPA) and the EPA January 11, 1977 regulations: Preparation of Environmental Impact Statements for New Source NPDES Permits (40 CFR 6.900). NEPA requires all Federal agencies to assess the impacts that would occur following a major Federal Action that has been determined to result in a significant impact on the human environment.

There are currently seventeen potential New Source mines in Polk, Hillsborough, Manatee, Hardee, and DeSoto Counties. Four NPOES Applicants have been determined to be New Sources. Five additional New Source determinations are likely during 1978. The other New Source Mines are projected to make application between 1980 and 1995. Issuance of New Source NPDES Permits to each of these mines will probably be determined a major Federal action which has a significant effect on the human environment, thus requiring an Environmental Impact Statement.

The purpose of this Areawide EIS is to assess the arewide and cumulative effects of the industry, and provide the bases for developing the site specific Environmental Impact Statements. It would not have been practicable to develop the areawide and cumulative effects on the entire Central Florida phosphate industry in each of the site specific studies.

3. Summary of Major Environmental Impacts

A. Land surface will be altered by surface mining and reclamation; soils and vegetation removed from the mining and associated areas; wildlife habitat and populations reduced; and there will be potential adverse impacts on air and water quality.

B. Livestock forage will be reduced during mining operations, and productivity of the mining area will be reduced even after reclamation.

C. Population and employment in the region will increase and the socioeconomic infrastructure stressed.

D. Recreational resources will be reduced, archeologic values may be destroyed, and esthetic aspects will change.

E. Redistribution of radionuclides, which result in an increase of human exposure, will occur.

F. The quantity of available groundwater will be reduced.

G. There will be an irrevocable commitment of resources, including phosphorus and fossil fuel.

4. Alternatives Considered

A. The development of the phosphate mining and processing industry associated with the issuance of National Pollution Discharge Elimination System (NPDES) (Section 402) and Section 404 of PL 92-500 permits to existing and new source phosphate facilities, all of which would meet effluent and receiving water standards applicable as of the date of the contractor's proposal to EPA; Florida Department of Environmental Regulations (DER) and EPA permits to air sources meeting requirements of the Clean Air Act and regulations promulgated pursuant to the Act, including but not limited to nonsignificant deterioration requirements, standards of performance for new stationary sources; and other local state and federal permits applicable as of the date of the contractor's proposal to EPA. Current reclamation requirements are also to be included.

B. Process Modifications for New Sources

1) Elimination of slime ponds

2) Chemical processing of wet rock (eliminate drying process)

3) Dry conveyor for matrix from mine to beneficiation

4) Recovery of fluoride from recirculated process water, including scrubber water

5) Uranium recovery from all phosphoric acid

6) Impervious lining for recirculated process water ponds at chemical plants

C. Reduced Water Usages

1) Existing Facilities

a) <u>Chemical Processing</u> (including elemental phosphorus and animal feed ingredient plants). Complete recirculation of all cooling and process water. Design for containment of cooling and process water for up to 10-year, 24-hour maximum rainfall event to meet BPT effluent limitations.

b) <u>Mining and Beneficiation</u>

Complete recirculation of all water, except surface runoff from undisturbed areas. Design for containment of 10-year, 24-hour rainfall event.

2) New Facilities

a) Chemical Processing (including elemental phosphorus and animal feed ingredient plants). Complete recirculation of all cooling and process water. Design for containment of cooling and process water for up to 25-year, 24-hour maximum rainfall event. Discharges as a result of rainfall exceeding the equivalent of a 25-year, 24-hour rainfall event to meet Standards of Performance for New Sources.

b) <u>Mining and Beneficiation</u>

Complete recirculation of all water, except surface runoff from undisturbed areas. Design for containment of 25-year, 24-hour rainfall event.

D. 1) No Mining or development of facilities for processing (beneficiation or chemical processing) in either waters of the United States or wetlands as defined by EPA and the Corps of Engineers in regulations promulgated pursuant to the Federal Water Pollution Control Act, as amended, Section 404.

2) Any disturbed wetlands are to be restored to provide at least an equivalent habitat for any species on the important Species List for which habitat existed prior to mining. Restoration is to be accomplished so that no more than 10 percent of such habitat is destroyed at any one time.

E. No development of phosphate mining and processing beyond that associated with the issuances of section 402 and 404 permits for exising sources, all of which would meet effluent and receiving water standards applicable as of the date of the contractor's proposal to EPA; Florida DER and EPA permits to air sources meeting requirements of the Clean Air Act and regulations promulgated pursuant to the Act, including but not limited to nonsignificant deterioration requirements, standards of performance for new stationary sources; and other appropriate local, state, and federal permits applicable as of the date of the contractor's proposal to EPA. This scenario constitutes the "no-action" alternative as required by the NEPA.

5. The following Federal, State, and local agencies and interested groups submitted written comments on this impact statement:

Federal Agencies

Corps of Engineers, Jacksonville District
Department of Agriculture
Department of Health, Education and Welfare
Department of the Interior
Department of the Air Force

Members of Congress

Honorable Lawton Chiles
United States Senate

Honorable Richard Stone
United States Senate

State

Dept. of Environmental Regulation
Dept. of Natural Resources
Dept. of Administration
Geological Survey

Game and Freshwater Fish Commission
Dept. of Commerce
Dept. of Health and Rehabilitative Services

Interest Groups

The Fertilizer Institute
Florida Phosphate Council
Florida Audubon Society
Manasota 88
Citizens Against River Pollution

Save Our Bays Association, Inc.
Izaac Walton League of America Florida Division
Florida Chapter of the Wildlife Society

Local and Regional

Sarasota County Commission
Manatee Co. Health Dept.
Sarasota Co. Environmental Control Dept.

Tampa Bay Regional Planning Council
Southwest Florida Regional Planning Council
Manatee Co. Planning & Dev. Dept.

6. Copies of the Final EIS, along with supporting documents (Working Papers) have also been sent to the following repositories, where they are available for review:

Lakeland Public Library
100 Lake Morton Drive
Lakeland, FL 33801

Bartow Public Library
315 E. Parket Street
Bartow, FL 33830

Wauchula - Ausley Memorial Library
131 N. 8th Avenue
Box 657
Wauchula, FL 33873

Arcadia - DeSoto County Public Library
519 W. Hickory Street
Arcadia, FL 33821

Ft. Myers - Lee County Free Library
3355 Fowler Street
Ft. Myers, FL 33901

Sarasota Public Library
701 Plaza de Santo Domingo
Sarasota, FL 33577

Bradenton - Manatee County Library System
417 12th Street W
Bradenton, FL 33505

Tampa - Tampa-Hillsborough County Public Library System
900 N. Ashley
Tampa, Florida 33602

EPA Region IV Library
345 Courtland Street
Atlanta, Georgia 30308

7. This Final EIS was made available to the EPA Office of Federal activities and to the public in December, 1978.

SECTION 1

BACKGROUND OF PROPOSED ACTION

A. DESCRIPTION OF CENTRAL FLORIDA PHOSPHATE INDUSTRY

1. Historical Background

The Central Florida Phosphate District encompasses phosphate deposits underlying an area of approximately 5180 square kilometers (2000 square miles) in Polk, Hillsborough, Manatee, Hardee, and DeSoto counties (Cathcart 1971).

The first discovery of Florida deposits was in 1879 near Hawthorn north of the Central District, followed closely by the discovery of river pebbles and large quantities of phosphatized vertebrate fossils in 1881 along the Peace River.

Levels of early phosphate production, which involved the use of hand labor, were very low. By 1888, however, production had shifted from river deposits to the more accessible land pebble deposits because of increasing demand and the relative ease with which they could be mined.

Continuing technological developments have marked the history of the phosphate industry in Florida, allowing increased production and more complete recovery of the phosphatic material from the mined ore. Among the most significant early improvements affecting mining and beneficiation operations were dredges and draglines. Finally, the introduction of the flotation process improved the recovery of fine-grained phosphate formerly discarded with sand and clay waste material.

Polk County is the site of most of the current phosphate industry activity, but several chemical plants and one mine are in operation in Hillsborough and Manatee counties. A large percentage of the mining facilities that are planned will be built in Hillsborough, Manatee, Hardee, and DeSoto counties as the richer phosphate deposits in Polk County are depleted.

The phosphate industry currently owns either the land or mineral rights on enough phosphate deposits to continue the present rate of production beyond the year 2000. The extent of the phosphate industry is depicted on Plate 1 in the map pocket. This map shows areas that have been subject to mining activity, those that are permitted at this time, and those with pending permits and areas projected to be actively considered by the year 2000; and locates existing chemical plants and sites of the richest phosphate deposits in the study area. The chemical plants are expected to remain in their current locations; future expansion will affect primarily the mining and beneficiation activities.

2. Production Data

In 1892, the production of phosphate rock in the Central Florida District was approximately 280,000 metric (308,000 short) tons (Cathcart 1971). Production had increased to 3,350,000 metric (3,700,000 short) tons by 1930, and it continued to increase with some market-induced fluctuations to the current level of 34,500,000 metric (38,000,000 short) tons in 1976. In 1976, total U.S. production was 44,136,000 metric (48,662,000 short) tons and the total worldwide was 105,666,000 metric (116,500,000 short) tons (Stowasser 1977b). The importance of the Central Florida Phosphate District to the U.S. and the rest of the world is obvious; it accounted for approximately 80 percent of U.S. production and 33 percent of world production in 1976. The remainder of the U.S. production comes from northern Florida (outside the study area), North Carolina, Tennessee, and some western states — principally Montana, Idaho, Utah, and Wyoming. U.S. production projections, along with projected domestic demands, are shown in Figure 1.1 (Stowasser 1977a). It can be seen that the U.S. could be a net exporter of phosphate rock through the year 2000, but that the demand would likely exceed the domestic supply before the year 2010, requiring that phosphate rock be imported to satisfy all requirements. A more detailed look at the remaining phosphate deposits in central Florida was taken by the U.S. Bureau of Mines in 1977 and appears in Table 1.1. In the short term, Polk County will continue to supply a large portion of the phosphate rock necessary to meet U.S. demand. Eventually, as economic conditions change and the more readily available rock is depleted, Manatee and Hardee county deposits (some of which are currently classified as subeconomic resources) may become the source of phosphate rock for future mining operations.

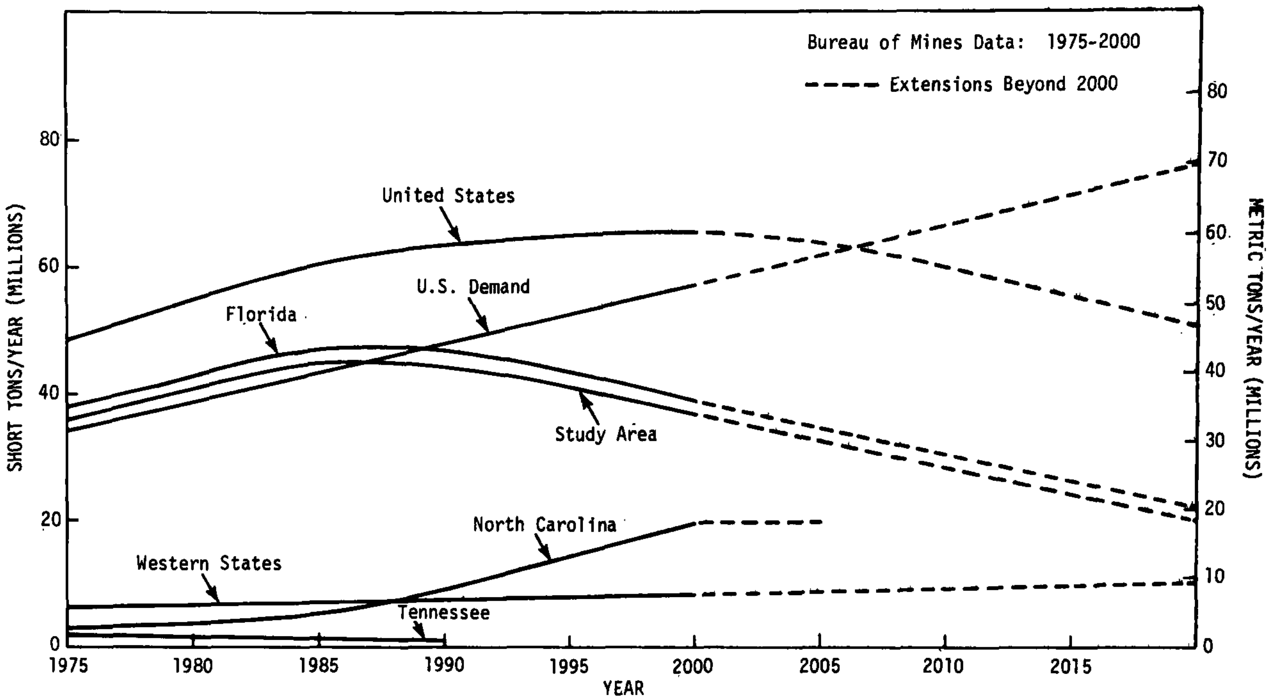


Figure 1.1. Phosphate Rock Supply-Demand Projections (Stowasser 1977a)

Table 1.1. Estimated Phosphate Rock Reserves and Resources in 7-County Study Area*

County	Recoverable Phosphate Rock: Measured Reserves [metric (short)		Measured Sub-economic Resources tons in millions]	
Polk	402.7	(444)	95.2	(105)
Hillsborough	181.4	(200)	13.6	(15)
Manatee	164.2	(181)	149.7	(165)
Hardee	176.0	(194)	299.3	(330)
DeSoto	16.3	(18)	63.5	(70)
Sarasota				
Charlotte				
Total	940.6	(1,037)	621.3	(685)

*Stowasser 1977b.

3. Socioeconomic Impact

Mining in the 7-county region employed 4,453 workers in 1960 and 5,047 in 1970, an increase of 13.3 percent. Data supplied by the Florida Phosphate Council (Table 1.2) include 1967-76 employment and salary data for all aspects of the industry's activity, not just mining. Employment showed only moderate growth, while payroll grew substantially. The divergence was due to increased earnings of employees. Mining has experienced moderate growth in the recent past. Growth from 1960 to 1976 tended to average 1 percent per year. However, there were significant variations in the trend. During this period, real income of employees increased, while actual payrolls increased at a substantial rate. Mining has not appeared to have played a significant role in the growth of the region since 1960. This fact, added to the slow growth of tourism and agriculture, indicates that growth has been driven by other industries — primarily services. It should be noted that this is the trend for the nation as a whole.

Table 1.2. Central Florida Phosphate Industry Payroll, 1967-76*

Year	Employment	Payroll (000)	Avg. Earnings	Price Index	Avg. real Earnings
1967	8,048	56,008	6,959	100.0	6,959
1968	7,309	55,588	7,605	104.2	7,298
1969	6,615	51,013	7,712	109.8	7,024
1970	7,065	55,781	7,895	116.3	6,788
1971	6,643	57,140	8,602	121.3	7,092
1972	6,673	62,358	9,345	125.3	7,458
1973	7,262	71,377	9,328	133.1	7,385
1974	8,067	87,576	10,856	147.7	7,350
1975	8,816	109,985	12,475	161.2	7,739
1976	8,837	119,250	13,494	170.5	7,914
Mean			9,477		7,301

*Florida Phosphate Council personal communication (1977).

The phosphate industry is a major constituent of the regional economy and will play a significant role in any economic assessment of the area. The U.S. Bureau of Mines estimated in 1974 that:

- Each new job in the phosphate industry generates 6.155 other new jobs.
- Each dollar of income earned in the phosphate industry generated $3.363 of other income.
- Each dollar of increased phosphate industry activity will generate $3.814 of other economic activity.

The phosphate industry also contributes considerably to the tax base of the counties in which it is located. Recent taxes paid by the industry are summarized in Tables 1.3 and 1.4.

Table 1.3. Phosphate Industry Ad Valorem Taxes Paid, 1972-76*

Year	County Ad Valorem Revenues	Production Tons (000,000)**	Revenues/ 1,000,000 Tons	Price Index	Real Revenue/ 1,000,000 Tons (1967 = 100)
1972	$5,174,586	32	$0.1617	125.3	$0.1291
1973	5,008,291	34	0.1473	133.1	0.1108
1974	4,040,700	35	0.1443	147.7	0.0977
1975	6,184,375	39	0.1586	161.2	0.0984
1976	8,466,411	NA			

*Florida Phosphate Council personal communication (1977).

**Metric

Table 1.4. Phosphate Industry School Taxes Paid, 1972-75*

Year	Ad Valorem Tax Revenues	Production Tons (000,000)**	Revenue/ 1,000,000 Tons	Price Index	Real Revenue/ 1,000,000 Tons (1967 = 100)
1972	$2,720,960	32	$0.085	125.3	$0.0679
1973	2,579,880	34	0.0759	133.1	0.057
1974	2,590,113	35	0.074	147.1	0.0501
1975	3,161,730	39	0.0811	161.2	0.0503
Mean					0.0563

*Florida Phosphate Council personal communication (1977).

**Metric

On a national level, the industry contributes to the improvement of the balance of trade: about one-fourth of the rock mined in the study area is exported.

4. Phosphate Uses

Table 1.5. Phosphate Rock End Uses, 1975*

Product	Metric Tons [Thousands (Short Tons)]
Fertilizer	24,484 (26,995)
Detergents	2,913 (3.212)
Animal feeds	1,396 (1,539)
Food products	248 (273)
Other	1,985 (2,188)
Total	30,989 (34,167)

*Stowasser 1977a

Phosphate rock has many uses, but by far the most important in the U.S. is in the production of chemical fertilizers. In 1975, fertilizer production consumed about 80 percent of the rock used domestically. Uses other than agricultural involve leavening agents, water-softening products, cleansing products, plasticizers, insecticides, beverages, ceramics, catalysts for oil refining processes, and dental cements (Ruhlman 1956). End uses in 1975 are summarized in Table 1.5.

The major portion of phosphate rock production in the U.S. is expected to continue to be for fertilizer production.

Study-area chemical plants process approximately 75 percent of the rock mined in the study area at least into elemental phosphorus or phosphoric acid if not into finished products. The remaining 25 percent is exported, usually as dry rock, to processing plants in other states or to foreign countries (Sweeney and Hasslacher 1970).

5. Industry Activities

The existence of the industry is totally dependent on the mining of the phosphate rock. In its processed form, the phosphate rock not only accounts for a significant portion of the final sales of the industry but is the basic material from which all other phosphate products are made.

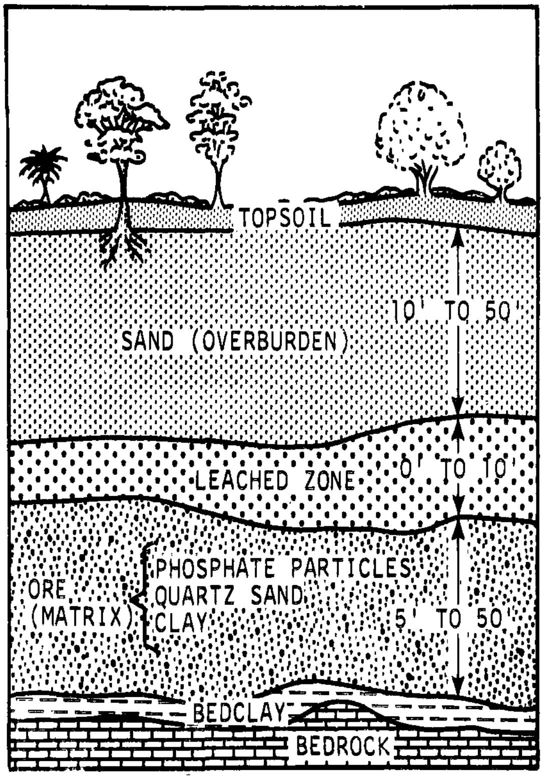


Figure 1.2. Typical Profile in Study Area (Fountain and Zellars 1972)

Florida land-pebble phosphate deposits are characterized by pebbles and fine phosphatic sand dispersed in a nonphosphatic, sandy clay. This matrix, varying in thickness from 1 to 50 feet but averaging about 16 feet, is covered by an overburden of quartz sand and clay that averages 20 feet in thickness. Figure 1.2 is a typical profile of the phosphate ore and overburden.

The standard mining practice in the Florida land-pebble phosphate fields is to strip the overburden and mine the phosphate matrix with draglines. Electric-powered walking draglines with 35- to 49-cubic-yard buckets work in cuts varying from 150 to 250 feet in width, from a few hundred yards to a mile or more in length, and from 50 to 70 feet in depth. A dragline stacks the overburden on unmined ground adjacent to the initial cut. As successive cuts are made by the dragline, overburden is cast into adjacent mined-out cuts. As each cut is stripped of overburden and then mined, the ore is stacked in a suction well or sluice pit that has been prepared on unmined ground. Water under high pressure is used to produce from the matrix a slurry that is about 40 percent solids. The slurry is then pumped via pipe to the washer plant. In this manner, a typical operation annually mines about 400 acres of land, removes 13,000,000 cubic yards of overburden, and mines 9,000,000 yards of matrix. As this mining progresses, mined-out areas are used for the disposal of tailings and slimes as well as for overburden. One ton of phosphatic clay and one ton of sand tailings must be disposed of for each ton of marketable phosphate rock produced. Some of the sand tailings and overburden is used to construct retaining dams in mined-out areas, behind which phosphatic clay slimes settle and dewater.

Water is used in the beneficiation process and as a transportation medium. The phosphate industry uses fresh water from deep wells as well as reclaimed water from slime-settling ponds. To produce 1 ton of marketable phosphate rock requires approximately 10,000 gallons of water; of that, about 85 percent is recycled.

Beneficiation methods differ slightly, depending on screen-size analysis of the feed; the ratio of washer rock to flotation feed; the proportions of phosphate, sand, and clay in the matrix; and equipment preference. Through a series of screens in closed circuit with hammermills and logwashers, the matrix is broken down to permit separation of the sand and clay from the phosphate-bearing pebbles. Three concentrates of marketable phosphate rock are produced: a very coarse pebble, a coarse fraction, and a fine fraction. The washed, oversized pebble fraction is a final product. The coarse fraction is called the coarse feed from which a coarse concentrate is obtained by gravity and flotation processes. The tailings or waste from this fraction is used in dam construction or land reclamation. The fine fraction is processed through a flotation section to recover a fine concentrate. The waste, a clay slime, is impounded in areas that have been mined. Up to two-thirds of the mined area can be committed to these clay-slime holding areas. The marketable phosphate rock derived from this process is either sold as a final product or used as a raw material in the production of a variety of industrial products such as wet-process phosphoric acid, normal superphosphate, triple superphosphate, ammonium phosphates, elemental phosphorus, defluorinated phosphate rock, and dicalcium phosphate.

Table 1.6 summarizes companies active in the study area in 1976 and their phosphate-related activities. The current rate of mining involves 2000 hectares (4940 acres) per year.

Current mining practice involves reclamation of the strip-mined areas. In most cases, the actual mine pits can be reclaimed to some uses within 2 to 3 years; the reclamation of areas dedicated to slime-holding ponds, however, generally takes longer because of the slow settling rate of the clays found in some of the mined areas. Settling may take as long as 10 years. Even then, the uses to which the land may be put are restricted to light-load applications such as pasture or other agricultural activities.

Table 1.6. Phosphate Industry Activities (Major Companies Only) in Study Area*

Company	Location	Activity
Brewster	Lonesome	Mining, beneficiation, drying
	Haynesworth	Mining, beneficiation, drying
Swift	Silver City	Mining, beneficiation, drying, grinding, normal superphosphate, sulfuric acid
	Watson	Mining, beneficiation
USS Agri-Chem	Bartow	Drying, grinding, sulfuric acid, phosphoric acid, nitrogen-phosphate grades
	Ft. Meade	Drying, grinding, sulfuric acid, phosphoric acid, triple superphosphate, fluorine products
	Rockland	Mining, beneficiation, drying
Gardinier	East Tampa	Normal superphosphate, sulfuric acid, phosphoric acid, triple superphosphate, nitrogen-phosphate grades, fluorine products, furnace slag
	Ft. Meade	Mining, beneficiation, drying
Borden	Palmetto	Sulfuric acid, phosphoric acid, triple superphosphate, nitrogen-phosphate grades
	Tenoroc	Mining, beneficiation, drying
	Plant City	Animal feed grades
T/A Minerals	Mulberry	Mining, beneficiation, drying
Electro-phos	Bartow	Drying, elemental phosphorus
IMC	Clear Springs	Mining, beneficiation
	Kingsford	Mining, beneficiation, drying, grinding
	Noralyn	Mining, beneficiation, drying, grinding
	New Wales	Sulfuric acid, phosphoric acid, superphosphoric acid, triple superphosphate, nitrogen-phosphate grades, animal feed grades
Farmland Ind	Bartow	Sulfuric acid, phosphoric acid, triple superphosphate, nitrogen-phosphate grades, ammonium sulfate
Mobil	Nichols	Calcining, drying, grinding, elemental phosphorus
	Nichols	Mining, beneficiation, drying
	Ft. Meade	Mining, beneficiation
Agrico	Pierce	Beneficiation, drying grinding
	South Pierce	Sulfuric acid, phosphoric acid, triple superphosphate, fluorine products
	Payne Creek	Mining, beneficiation
	Saddle Creek	Mining, beneficiation
	Fort Green	Mining, beneficiation
W. R. Grace	Bartow	Drying, sulfuric acid, phosphoric acid, triple superphosphate, nitrogen-phosphate grades
	Hooker's Prairie	Mining, beneficiation
	Bonny Lake	Mining, beneficiation, drying
Royster	Bartow	Grinding, sulfuric acid, phosphoric acid, triple superphosphate, nitrogen-phosphate grades
Conserv	Nichols	Drying, Sulfuric acid, phosphoric acid, triple superphosphate, nitrogen-phosphate grades
CF	Plant City	Sulfuric acid, phosphoric acid, triple superphosphate, nitrogen-phosphate grades, fluorine grades
	Bartow	Sulfuric acid, phosphoric acid, nitrogen-phosphate grades, fluorine grades

*McNeill 1977a; Florida Department of Environmental Regulation 1977.

Waste products generated by the phosphate industry include the clay slime and sand resulting from the ore beneficiation; phosphate, sulfate, fluoride, and suspended solids in wastewater effluents; and air emissions (primarily from the chemical plants) of SO_2, acid mist, fluoride, and dust. The industry's activities redistribute radioactive material (primarily uranium-238 and its decay products) found with the phosphate ore, causing some changes in existing background levels of radiation. The industry's air and water emissions are controlled by collection devices or other treatment to meet state and federal effluent standards. Scrubbers usually control particulates, fluorides, and SO_2 in air emissions. Chemical Plant wastewater is treated with two stage liming and settling to meet effluent standards. Recently, reclamation procedures have been modified to provide radioactively clean top dressing on land intended for human occupation.

A more detailed description of reclamation practices can be found in Volume VIII (Volume I - NTIS; see Volume III of this EIS for explanation of relationship of working papers to NTIS papers) of the working papers (TI 1977h).

B. NATURAL ENVIRONMENT

1. Atmosphere

a. Climate/Weather

The climate of the study area is subtropical. Annual temperature averages 22.5°C (72-73°F), and monthly averages range from 16°C (61°F) in January to 28°C (82°F) in July and August. Seasonal and diurnal variations are more pronounced in the inland areas, which are not under the moderating influence of the Gulf of Mexico. The area's annual rainfall averages 135 centimeters (53 inches), ranging from the winter monthly low of 4 to 5 centimeters (1.5 to 2.0 inches) to the summer monthly high of 20 to 21 centimeters (8.0 to 8.3 inches). Over one-half of the annual rainfall occurs during the summer "rainy" season, which includes the months of June through September. The record 24-hour rainfall events are usually associated with tropical storms or hurricanes. Thunderstorms are common, mainly during the summer. Winds in the area are usually moderate but are somewhat higher in the coastal areas because of the reliable land-sea breezes. The monthly average for winds ranges from Tampa's 3.3 to 4.5 meters per second (7.4 to 10.0 miles per hour) to Lakeland's 2.5 to 3.5 meters per second (5.5 to 7.8 miles per hour). Because of the area's flat terrain and steady winds, incidents of extreme air pollution in westcentral Florida are not common and occur primarily only in heavily populated or industrialized areas such as Tampa.

b. Air Quality

The most important air pollutants emitted by the phosphate industry are dust, SO_2, and fluoride. Air quality standards exist for dust and SO_2, and emission standards exist for all three.

Ambient dust levels reported to the state from 1972 through 1976 are presented in Table 1.7. The only trends that appear meaningful are the recent decreases in Polk and Manatee counties. Data collected by CF Industries in Hardee County from mid-1975 to mid-1976 showed levels between 20 and 40 micrograms per cubic meter.

Table 1.7. Countywide Averages for Annual Geometric Mean of 24-Hour TSP Data*

County	Micrograms per Cubic Meter				
	1972	1973	1974	1975	1976†
Charlotte	--	21	30	27	26
DeSoto	--	43	44	52	53
Hillsborough	50	51	53	50	51
Manatee	51	46	45	40	36
Polk	40	64	71	64	49
Sarasota	--	37	45	44	42

*Chadbourne (1977).
†Up to mid-1976.

Table 1.8 presents SO_2 data on file with the state for 1972-76. The EPA uncovered problems concerning the sampling method used to collect these data that indicated that the reported levels were low in most cases; actual levels could have been 2 to 3 times higher than those reported. SO_2 data collected by CF Industries in Hardee County during 1975-76 showed that the 24-hour levels in that area averaged less than 13 micrograms per cubic meter.

Table 1.8. Countywide Averages for Annual Arithmetic Average of 24-Hour SO_2 Data*

County	Micrograms per Cubic Meter				
	1972	1973	1974	1975	1976**
Charlotte	--	0	--	--	0
DeSoto	--	0	0	5	1
Hillsborough	17	29	24	15	12
Manatee	11	10	5	3	2
Polk	--	21	42	10	7
Sarasota	--	3	1	1	1

-- No data.
* Chadbourne (1977).
** Data reported to mid-1976.

Polk County ambient fluoride data (Figure 1.3) showed a steady decrease from 1965 through 1970 as the phosphate industry applied controls to its fluoride emissions. However, annual fluoride averages in the air have remained below 1 microgram per cubic meter throughout Polk County since 1970, and the 1976 data reported through mid-year showed that average levels throughout the study area were at or below 1 microgram per cubic meter.

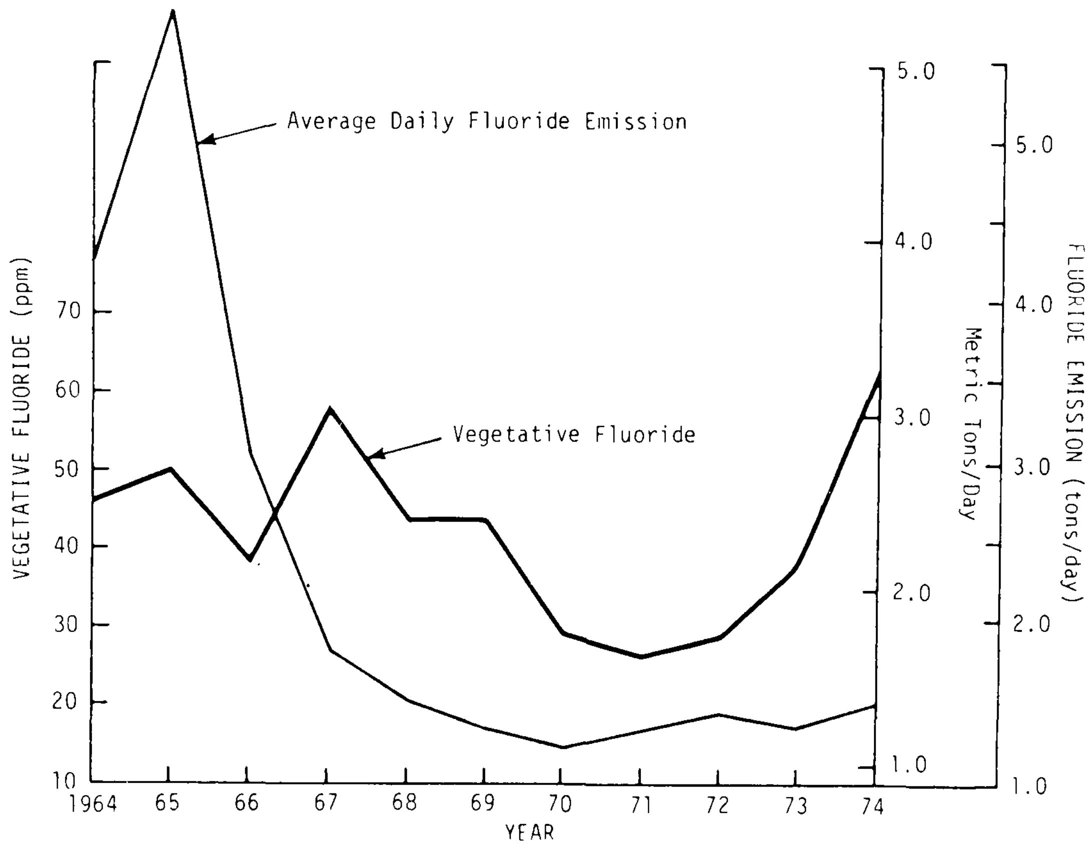


Figure 1.3. Vegetative and Fluorides Emissions in Polk County (Tessitore 1976)

Figure 1.3 also shows vegetative fluoride levels from 1964 through 1974, resulting from industry emissions in Polk County. Vegetative levels are not directly related to ambient levels; they are also dependent on rainfall frequency (1974 was a dry year).

Table 1.9 summarizes the point and area source emissions of dust and SO_2 for 1974 and 1976. It can be seen that the population-oriented area sources have increased. They are expected to continue this trend. Point sources except utilities had almost completely complied with emission standards by the end of 1976; so future increase in point source emissions is expected to come from utilities because of high sulfur fuels and anticipated increases in capacity.

Table 1.9. Summary of Point and Area Source Emissions in Study Area

County	Metric Tons per Year			
	1974		1976	
	Particulates	SO_2	Particulates	SO_2
Charlotte				
Area sources	1,835	141	1,862	147
Point sources	32	40	32	40
DeSoto				
Area sources	1,644	65	1,656	67
Point sources	29	85	29	85
Hardee				
Area sources	2,556	72	2,572	73
Point sources	37	114	37	114
Hillsborough				
Area sources	12,382	2,559	12,865	2,695
Point sources	29,358	267,620	7,909	238,649
Manatee				
Area sources	3,091	326	3,121	348
Point sources	399	746	614	5,593
Polk				
Area sources	10,983	841	11,199	901
Point sources	31,125	119,010	8,127	45,080
Sarasota				
Area sources	2,806	328	2,901	349
Point sources	115	175	115	175
Total				
Area sources	35,297	4,332	36,176	4,580
Point sources	61,095	387,790	16,863	289,736
All sources	96,392	392,122	53,039	294,316

Overall, the ambient levels of dust and SO_2 are expected to increase in the 7-county study area between 1976 and 2000. The 1976 fluoride emissions by the phosphate industry were reported to be 315 metric (346 short) tons. This level is not expected to change much before 2000.

2. Land

a. Physical Environment

1) Geology

The great projection of the North American continent dividing the Atlantic Ocean and the Gulf of Mexico is known as the Floridian plateau (Cooke 1945). This plateau trends N 15° W and supports peninsular Florida, a gently emergent peninsula with broad continental shelves to the west and east (Altschuler et al 1964). This peninsula, little more than 99 meters (325 feet) above sea level, lies predominantly east of the axis of the Floridian plateau. The peninsula and plateau terminate at the Florida Keys and Straits of Florida, respectively.

The surface geology of Florida has been extensively mapped by Cooke (1945). Figure 1.4 sketches the surface geology of the study area, Table 1.10 defines the surface formations, and Figure 1.5 shows the general structure and stratigraphy of section A-A' of Figure 1.4.

The immediate surface (Recent) at most places in Florida is underlain by Pleistocene deposits, of which two principal kinds are defined. The most widely distributed, which is included in the study area, is a series of seven sandy formations corresponding to seven different stages of sea level and generally regarded as terraces. They appear to record the oscillations of sea level corresponding to interglacial and glacial stages and are defined primarily by their topographic relations, the higher terraces being older than the lower ones. The other type of deposit, which underlies the East Coast and the southern part of the state, is divided into three contemporaneous marine formations, all containing marine shells.

The oldest rocks exposed at the surface in the study area are those of the Suwannee limestone formation of Oligocene age (Figure 1.4 and Table 1.10) in extreme northern Polk and Hillsborough counties. The next oldest formation in the area is the very pure Ocala limestone of Eocene age (the defining formation for the Ocala uplift), which lies unconformably below the Suwannee limestone. Rocks of the Paleocene epoch, next oldest epoch, appear to be absent. Underlying the rocks of the Tertiary period are those of the Cretaceous period of the Mesozoic era, and beneath those are rocks of the Paleozoic era. The core of the Floridian plateau is probably Precambrian and is doubtlessly composed of ancient metamorphic rocks like those of the Piedmont region of Georgia (Cooke 1945).

The land surface of the study area rises monotonously inland from the Gulf of Mexico across the Coastal Lowlands marine plain to essentially north-south elongated ridges and bars of low relief which characterize the Central Highlands. These ridges, named after nearby cities (viz., Lake Wales, Winter Haven, and Lakeland), are considered by Vernon (1970) to be barrier islands,

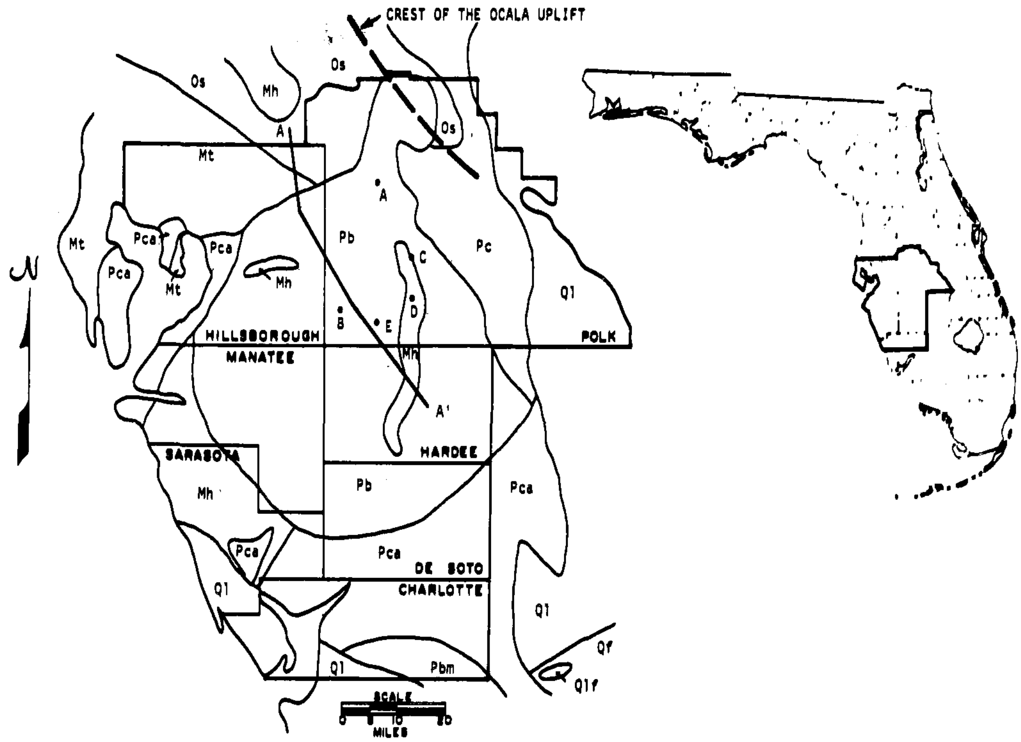


Figure 1.4. Surface Formations of Study Area (Cooke 1945)
(See Table 1.10 for formation descriptions)

Table 1.10. Surface Formations of Study Area*

Series	Formation	Description
Pleistocene (5,000-2,000,000 years BP)***	Lake Flirt marl (Qlf)**	Freshwater marl and limestone of late Wisconsin and Recent ages; widely distributed as thin sheets throughout Everglades
	Late Pleistocene deposits (Ql)	Marine and estuarine terrace deposits less than 30 meters (100 feet) above sea level; includes Anastasia, Wicomico, Penholoway, Talbot, and Pamlico formations
	Fort Thompson formation (Qf)	Three thin beds of marine shell marl separated disconformably by freshwater limestone; includes Coffee Mill hammock marl member at top
Pliocene (2,000,000-12,000,000 years BP)	Bone Valley formation (Pb)	Marine and estuarine phosphatic sand, clay, gravel
	Citronelle formation (Pc)	Chiefly sand and white or iron-stained clay; some deposits so mapped are early Pleistocene
	Caloosahatchee marl (Pca)	Marine sand and shell marl
Miocene (12,000,000-25,000,000 years BP)	Hawthorn formation (Mh)	Sandy phosphatic limestone weathering into vesicular sandstone or sand; in Gadsden County, includes large deposits of fuller's earth.
	Tampa limestone (Mt)	Marine, very fine sandy limestone of early Miocene age; commonly chalky
Oligocene (25,000,000-38,000,000 years BP)	Suwannee limestone (Os)	Hard white or cream-colored limestone commonly containing pockets of green residual clay

*Cooke 1945

**See Figure 1.4.

***BP before present

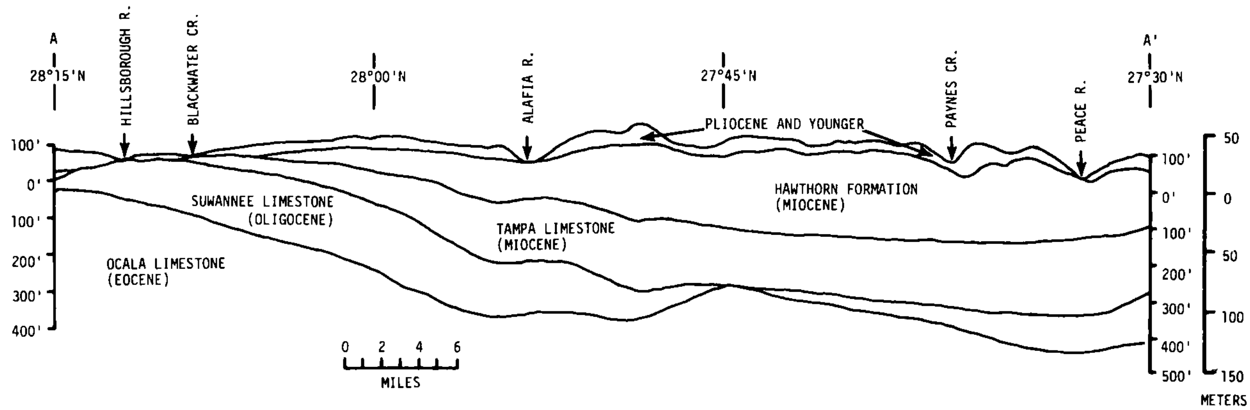


Figure 1.5. Cross Section of General Structure and Stratigraphy through Portion of Study Area (Altschuler et al 1964) (Location of this section shown in Figure 1.4)

beach ridges, or spits formed along ancient shorelines; together with the poorly drained and virtually undissected plains along the coast and the slightly rolling alluvial plains and shallow valleys of the Peace, Alafia, and Hillsborough rivers, they constitute the three principal types of terrain found in the study area (Figure 1.6).

Karsts, or sinkholes, characteristic of areas predominantly underlain by limestone as is the study area develop primarily because limestone is highly susceptible to solution weathering along lines of deposition (horizontal) and lines of fracturing (usually vertical). As rainwater falls through the atmosphere and seeps through the highly organic topsoil, it becomes weakly acidic and acts as a natural solvent to the limestone; the water then enters the rocks, following paths (channels) of least resistance. As the channels continue to grow, horizontal, generally interconnected caverns develop. Sinkholes develop when the caverns enlarge until the overlying sediments can no longer be supported. Most probable sinkhole regions in the study area are mapped as shown in Figure 1.7.

2) Soils

Most soils of the study area are young and underdeveloped, nearly level or gently sloping, acidic, very sandy with high permeability, and generally low in clay, organic matter, and plant nutrients (Beckenback 1973). Many were derived from sandy formations that have been little altered since

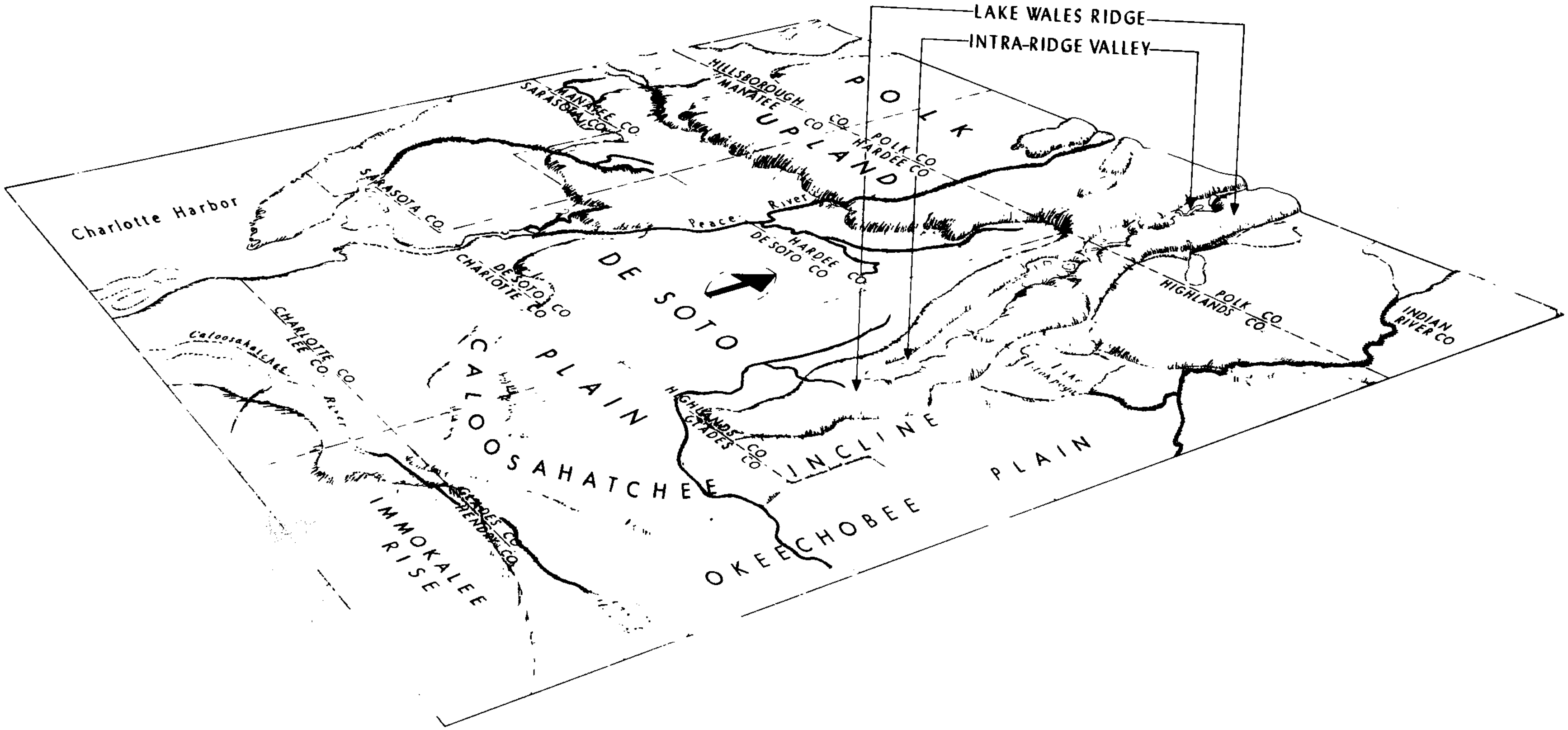
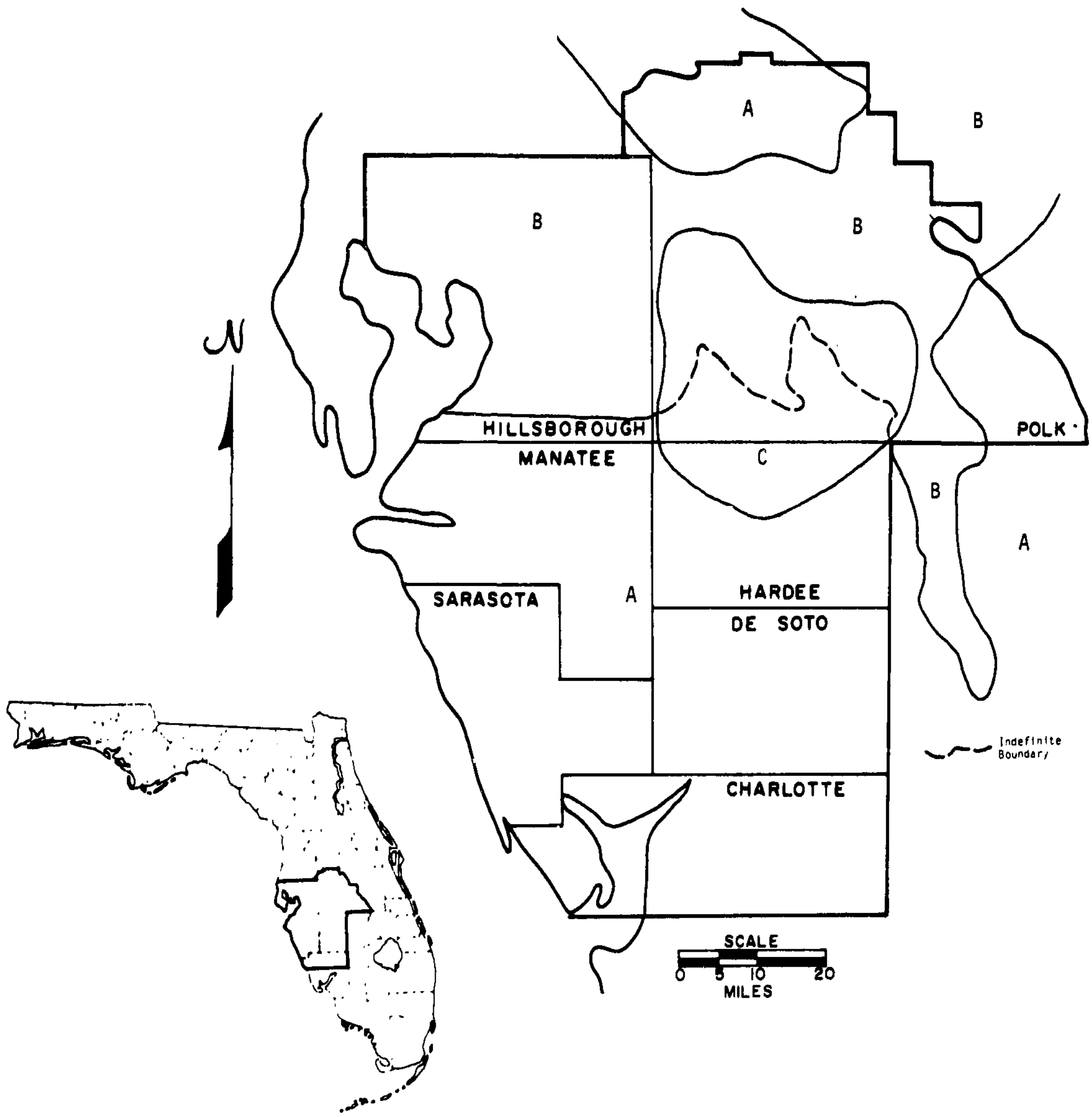


Figure 1.6. Topographic Features of Study Area (White 1970)



A Areas where peizometric surface is at or above land surface and/or thickness of clastic overburden exceeds 30 meters (100 feet). Appears to be least probable area for sinkhole development.

B - Area characterized by stable, prehistoric sinkholes, usually flat-bottomed, steep-sided, dry, or containing water. Modifications in geology and hydrology may activate process again.

C Moderate to thick overburden overlying cavernous limestones. Sinkhole collapse dependent on local overburden thickness and level of water table.

Figure 1.7. Most Probable Sinkhole Regions in Study Area (Wright 1974)

their deposition; thus, soils of the study area are generally sandy except in areas of low relief and poor drainage where peaty mucks are deposited. A complete description of the soils of the area at the soil association level is presented in Volume VI, Section 2 (TI 1977f), along with a map showing areal distribution of the associations.

3) Phosphate Deposits

The phosphate deposits of the study area's land-pebble district are of complex derivation: they are thought to have originated by marine deposition of phosphates, followed by extensive reworking and alteration. Initially, deep phosphate-rich ocean waters upwelled along steeply inclined continental slopes into relatively shallow areas of the continental shelf made up of carbonate deposits; the upwelling of such deep water to shallow, more agitated, warmer zones caused loss of dissolved CO_2, an increase in pH, and supersaturation of phosphate and furthered the precipitation of apatite. The apatite tended to replace calcite ($CaCO_3$) in the weathering debris of the underlying formation; thus, a variety of nodules, pellets, and replacement casts were formed. Much later, after the Coastal Plain sediments had emerged, acidic waters mobilized the phosphate and carried it downward to sites where aluminum (Al^{3+}) and iron (Fe^{2+}) were concentrated (Adams 1972). Nearly all investigators believe that the sea was the original source of the study area's phosphates, but there is evidence that the Florida deposits contain some reworked phosphorus of secondary terrestrial origin, especially in the southern portion. It is suspected that ancient rivers created large deltas and that phosphorite was apparently deposited in shallow, restricted bays by deltaic redistribution.

Figure 1.2 showed a typical section through the matrix or ore zone in the study area. The principal zones, in descending order are:

- Top soil or surface
- Overburden (excluding the aluminum phosphate zone which is considered overburden to phosphate mining)
- Leach or aluminum phosphate
- Matrix or calcium phosphate
- Bedclay
- Bedrock

b. Terrestrial Environment

1) Habitat Types

The distinctive Florida environment - sandy soils, low relief and elevation, poor drainage, and a mild climate with relatively even temperature, frequent lightning and rainfall characterized by great seasonal differences - is a major influence in shaping a spectrum of terrestrial biota that is unique within the United States. Among the particular biota of central Florida are many temperate-zone species at their southern limits, some hardy tropical species at their northern limits, and numerous species that are endemic to the state. Landscape units or habitat types with which terrestrial species are associated broadly include agricultural land, rangeland, forests, and wetlands.

The 7-county study area is predominantly agricultural land and rangeland (more than 450,000 hectares, or 1,000,000 acres of each); wetlands comprise approximately 178,000 hectares (440,000 acres), and forest comprise about 70,000 hectares (175,000 acres).

Approximately 75 percent of the study area's agricultural land is cropland and improved pasture; the remainder consists predominantly of orchards and groves (primarily citrus) and smaller extents of parklands and pine plantation. All of these habitat types generally are intensely managed, consist of comparatively few plant species, and have less wildlife value than either moderately managed or natural upland types. Important crops are tomato, watermelon, cucumber, green pepper, and strawberry. Pastures contain panolagrass, bahaigrass, carpetgrass, paspalum, and paragrass among others, along with several legumes. Slash pine is the important planted pine, and parklands are often predominantly ornamental horticultural species, although expanses of natural vegetation are not uncommon in larger parks (e.g., Hillsborough River State Park and Myakka River State Park).

Most of the rangeland of the study area comprises modified pine flatwoods. Modifications include removal of pines and periodic burning of remaining vegetation to maintain grazing conditions. Saw palmetto and wiregrasses are important plants in these habitats, which, when intensely managed as agricultural habitats are, are of comparatively little wildlife value. Of somewhat greater wildlife value and of considerable biogeographical significance is the comparatively small amount of rangeland that is natural dry prairie, or palmetto prairie; this unique habitat type, which consists primarily of wiregrasses and other herbaceous vegetation and occasional saw palmetto, is found only in Florida. Much of it has been converted to improved pasture. Remaining significant extents in the study area are in Polk County east of the present mining area and in DeSoto and Charlotte counties east and south of potential mining areas; smaller areas are in Sarasota and Manatee counties, and some of that in Manatee County is near projected mining areas.

By far the greatest amount of remaining forest in the study area is typical pine flatwoods. Longleaf pines dominate the overstory on drier sites, while slash pines dominate on wetter sites. Important understory species include saw palemtto, scrub oak, inkberry, shiny blueberry, and wiregrass. The small amount of deciduous forest in the study area includes three types of hammock: cabbage palm, a hydric association of cabbage palm-water oak-sweet gum; live oak, a xeric association dominated by live oak; and mesic, an association of trees found in the other hammocks, as well as southern magnolia and American holly. Hammocks generally are elevated islands scattered within pinewoods. Because of landcover fragmentation associated with development, remaining mixed forests in the seven counties also occupy small scattered areas. These forests, which support the greatest number of endemic species, comprise two communities: sandhills, a longleaf pine-turkey oak association; and sand pine scrub, a sand pine dominated association with several scrub oaks and a dense shrub layer characterized by sclerophyllous species. Except for a small amount in southeast Alabama, the sand pine scrub community is found only in Florida. The Florida Department of Natural Resources has classified as highly endangered the mixed forest communities, hammocks, and dry prairies. Each is important to wildlife.

The study area's wetlands include bayheads (dominated by broad-leaved evergreen species), hardwood swamps (dominated by broad-leaved deciduous species), cypress swamps, mangroves, wet prairies (emergent herbaceous species), freshwater marshes (emergent and floating herbaceous species), and saltwater marshes. These wetlands are the study area's most important ecosystems in terms of life support, or productivity, unless they have already been substantially degraded. Hardwood swamps are the most valuable wildlife habitats in the area, and cypress heads (seasonally flooded cypress areas) are second in value. Reflecting a growing consensus, the Florida Department of Natural

Resources has indicated that wetlands probably are the most valuable natural system from the standpoint of benefit to society. In addition to their more obvious benefits (e.g., recreation and aesthetic value), various wetlands trap sediments; reduce stream sediment load; remove nutrients; decrease eutrophication rates; process pollutants; tie up heavy metals, particulates, and radioactive wastes; treat domestic wastes; process sewage and wastewater; and retain water, releasing some as groundwater recharge. These wetlands types - hardwood swamps, wet prairies, and freshwater marshes - are classified as highly endangered lands in Florida. On a broader scope, all of central and south Florida's wetlands are important since they comprise, along with those of southeastern Louisiana, the remaining wetlands of significant extent and value in the United States. The most quantitative value of these wetlands is production of fish and shellfish; without adequate wetlands for nursery grounds, production of important commercial species declines.

2) Fauna and Flora

More than 500 species and subspecies of vertebrates (excluding fishes) are represented or have been represented in the recent past in the 7-county area; they include some 28 amphibians, 68 reptiles, 384 birds, and 55 mammals. Although the majority are distributed areawide, some are restricted to coastal habitats and others to the higher elevations of the ridges traversing Polk County. Nearly half of the species are of special interest or concern by virtue of population status or economic, recreational, or ecological importance. Table 1.11 lists these species and their designations. Of most concern are species considered threatened and endangered by either the United States Department of Interior or the Florida Game and Fresh Water Fish Commission. Other species have been determined by various scientific authorities in Florida (the Florida Committee on Rare and Endangered Plants and Animals) to be rare, of special concern (not currently endangered but habitats diminishing), or possibly threatened or endangered (status undetermined). Certain birds are "blue-listed" by the Audubon Society, i.e., they are experiencing either locally or widespread noncyclical population declines or range contractions. The many species of

Table 1.11. Important Amphibians, Reptiles, Birds, and Mammals of Study Area (Page 1 of 3)

AMPHIBIANS

Common Name	Scientific Name	Special Status
Peninsula Newt	Notophthalmus viridescens	Ecologically significant
Dwarf Siren	Pseudobranchus striatus	Ecologically significant
Southern Dusky Salamander	Desmognathus auriculatus	Ecologically significant
Dwarf Salamander	Eurycea quadridigitata	Ecologically significant
Slimy Salamander	Plethodon glutinosus	Ecologically significant
Eastern Spadefoot Toad	Scaphiopus holbrooki	Ecologically significant
Giant Toad	Bufo marinus	Ecologically significant
Florida Gopher Frog	Rana areolata	Threatened (FGFWFC, FCREPA)*
Bronze Frog	Rana clamitans	Ecologically significant
Bullfrog	Rana catesbeiana	Ecologically significant
Pig Frog	Rana grylio	Ecologically significant
Cuban Treefrog	Hyla septentrionalis	Ecologically significant
Ornate Chorus Frog	Pseudacris ornata	Ecologically significant

REPTILES

Common Name	Scientific Name	Special Status
American Alligator	Alligator mississippiensis	Threatened (USDI**, FGFWFC); special concern (FCREPA)
Eastern Box Turtle	Terrapene carolina	Ecologically significant
Diamondback Terrapin	Malaclemys terrapin	Ecologically significant
Suwannee Cooter	Chrysemys concinna suwanniensis	Threatened (FGFWFC, FCREPA)
Gopher Tortoise	Gopherus polyphemus	Threatened (FGFWFC, FCREPA)
Florida Softshell Turtle	Trionyx ferox	Economically significant
Atlantic Leatherback Turtle	Dermochelys coriacea	Endangered (USDI); rare (FCREPA)
Atlantic Loggerhead Turtle	Caretta caretta caretta	Threatened (FGFWFC, FCREPA)
Atlantic Ridley Turtle	Lepidochelys kempi	Endangered (USDI, FGFWFC, FCREPA)
Atlantic Green Turtle	Chelonia mydas	Endangered (FGFWFC)
Worm Lizard	Rhineura floridana	Ecologically significant
Green Anole	Anolis carolinensis	Ecologically significant
Fence Lizard	Sceloporus undulatus	Ecologically significant
Florida Scrub Lizard	Sceloporus woodi	Rare (FCREPA)
Blue-tailed Mole Skink	Eumeces egregius lividus	Threatened (FGFWFC, FCREPA)
Broad-headed Skink	Eumeces laticeps	Ecologically significant
Sand Skink	Neoseps reynoldsi	Threatened (FGFWFC, FCREPA)
Eastern Indigo Snake	Drymarchon corais couperi	Threatened (FGFWFC); special concern (FCREPA)
Southern Hognose Snake	Heterodon simus	Ecologically significant
Striped Swamp Snake	Liodytes alleni	Ecologically significant
Florida Water Snake	Natrix fasciata pictiventris	Ecologically significant
Mangrove Water Snake	Natrix fasciata compressicauda	Ecologically significant
Pine Woods Snake	Rhadinaea flavilata	Ecologically significant
Florida Swamp Snake	Seminatrix pygaea	Ecologically significant
Short-tailed Snake	Stilosoma extenuatum	Endangered (FGFWFC, FCREPA)
Red-bellied Snake	Storeria occipitomaculata	Ecologically significant
Florida Crowned Snake	Tantilla relicta	Ecologically significant
Smooth Earth Snake	Virginia valeriae	Ecologically significant
Pigmy Rattlesnake	Sistrurus miliarius	Ecologically significant

BIRDS

Common Name	Scientific Name	Special Status
Red-necked Grebe	Podiceps grisegena	Blue-listed
Western Grebe	Aechmophorus occidentalis	Blue-listed
Pied-billed Grebe	Podilymbus podiceps	Ecologically significant
White Pelican	Pelecanus erythrorhynchos	Blue-listed
Brown Pelican	Pelecanus occidentalis	Threatened (USDI, FGFWFC, FCREPA)
Double-crested Cormorant	Phalacrocorax auritus	Blue-listed
Magnificent Frigatebird	Fregata magnificens rothschildi	Threatened (FGFWFC, FCREPA)
Great Blue Heron	Ardea herodias	Ecologically significant
(Great White Heron)		Threatened (FGFWFC); special concern (FCREPA)
Green Heron	Butorides striatus	Ecologically significant
Little Blue Heron	Florida caerulea	Special concern (FCREPA)
Cattle Egret	Bubulcus ibis	Ecologically significant
Reddish Egret	Dichromanassa rufescens	Blue-listed; rare (FCREPA)
Great Egret	Casmerodius albus	Special concern (FCREPA)
Snowy Egret	Egretta thula	Special concern (FCREPA)
Louisiana Heron	Hydranassa tricolor	Special concern (FCREPA)
Black-crowned Night Heron	Nycticorax nycticorax	Blue-listed; special concern (FCREPA)
Yellow-crowned Night Heron	Nyctanassa violacea	Special concern (FCREPA)
Least Bittern	Ixobrychus exilis	Special concern (FCREPA)
American Bittern	Botaurus lentiginosus	Blue-listed
Wood Stork	Mycteria americana	Endangered (FGFWFC, FCREPA)
Glossy Ibis	Plegadis falcinellus	Ecologically significant
White Ibis	Eudocimus albus	Special concern (FCREPA)
Scarlet Ibis	Eudocimus ruber	Blue-listed
Roseate Spoonbill	Ajaia ajaja	Threatened (FGFWFC); rare (FCREPA)
American Flamingo	Phoenicopterus ruber	Blue-listed

*FGFWFC - Florida Game and Fresh Water Fish Commission
FCREPA - Florida Committee on Rare and Endangered Plants and Animals

**United States Department of Interior

BIRDS (CONTD)

Common Name	Scientific Name	Special Status
Canada Goose	Branta canadensis	Game species
Brant	Branta bernicla	Game species
Snow Goose	Chen caerulescens	Game species
Fulvous Whistling-Duck	Dendrocygna bicolor	Blue-listed; game species
Ruddy Sheldrake	Tadorna ferruginea	Game species
Mallard	Anas platyrhynchos	Game species
Black Duck	Anas rubripes	Game species
Mottled Duck	Anas fulvigula	Game species
Gadwall	Anas strepera	Game species
Pintail	Anas acuta	Game species
Cinnamon Teal	Anas cyanoptera	Game species
Green-winged Teal	Anas crecca	Game species
Blue-winged Teal	Anas discors	Game species
European Wigeon	Anas penelope	Game species
American Wigeon	Anas americana	Game species
Northern Shoveler	Anas clypeata	Game species
Wood Duck	Aix sponsa	Game species
Redhead	Aythya americana	Game species
Ring-necked Duck	Aythya collaris	Game species
Canvasback	Aythya valisineria	Blue-listed; game species
Greater Scaup	Aythya marila	Game species
Lesser Scaup	Aythya affinis	Game species
Common Goldeneye	Bucephala clangula	Game species
Bufflehead	Bucephala albeola	Game species
Oldsquaw	Clangula hyemalis	Game species
Common Eider	Somateria mollissima	Game species
White-winged Scoter	Melanitta deglandi	Game species
Surf Scoter	Melanitta perspicillata	Game species
Black Scoter	Melanitta nigra	Game species
Ruddy Duck	Oxyura jamaicensis	Game species
Masked Duck	Oxyura dominica	Game species
Hooded Merganser	Lophodytes cucullatus	Game species
Common Merganser	Mergus merganser	Game species
Red-breasted Merganser	Mergus serrator	Game species
Turkey Vulture	Cathartes aura	Ecologically significant
Black Vulture	Coragyps atratus	Ecologically significant
White-tailed Kite	Elanus leucurus majusculus	Rare (FCREPA)
Swallow-tailed Kite	Elanoides forficatus	Ecologically significant
Mississippi Kite	Ictinia mississippiensis	Ecologically significant
(Florida) Everglade Kite	Rostrhamus sociabilis plumbeus	Endangered (USDI, FGFWFC, FCREPA)
Sharp-shinned Hawk	Accipiter striatus	Blue-listed; ecologically significant
Cooper's Hawk	Accipiter cooperii	Blue listed; special concern (FCREPA)
Red-tailed Hawk	Buteo jamaicensis	Ecologically significant
Red-shouldered Hawk	Buteo lineatus	Blue-listed; ecologically significant
Broad-winged Hawk	Buteo platypterus	Ecologically significant
Swainson's Hawk	Buteo swainsoni	Blue-listed; ecologically significant
Short-tailed Hawk	Buteo brachyurus	Threatened (FGFWFC); rare (FCREPA)
Rough-legged Hawk	Buteo lagopus	Ecologically significant
Golden Eagle	Aquila chrysaetos	Ecologically significant
Bald Eagle	Haliaeetus leucocephalus	Endangered (USDI); threatened (FGFWFC, FCREPA)
Marsh Hawk	Circus cyaneus	Blue-listed; ecologically significant
Osprey	Pandion haliaetus	Blue-listed; threatened (FGFWFC, FCREPA)
Caracara	Caracara cheriway	Blue-listed; threatened (FGFWFC, FCREPA)
Peregrine Falcon	Falco peregrinus	Endangered (USDI, FGFWFC, FCREPA)
Merlin	Falco columbarius	Blue-listed; undetermined (FCREPA)
American Kestrel	Falco sparverius	Blue-listed; ecologically significant
Southeastern American Kestrel	Falco sparverius paulus	Threatened (FGFWFC, FCREPA)
Bobwhite	Colinus virginianus	Game species
Turkey	Meleagris gallopavo	Game species
Florida Sandhill Crane	Grus canadensis pratensis	Threatened (FGFWFC, FCREPA)
Limpkin	Aramus guarauna	Ecologically significant
King Rail	Rallus elegans	Blue-listed; game species
Clapper Rail	Rallus longirostris	Game species
Florida Clapper Rail	Rallus longirostris scottii	Undetermined (FCREPA)
Virginia Rail	Rallus limicola	Game species
Sora	Porzana carolina	Game species
Yellow Rail	Coturnicops noveboracensis	Ecologically significant
Black Rail	Laterallus jamaicensis	Undetermined (FCREPA)
Purple Gallinule	Porphyrula martinica	Ecologically significant
Common Gallinule	Gallinula chloropus	Game species
American Coot	Fulica americana	Game species
American Oystercatcher	Haematopus palliatus	Blue-listed; threatened (FGFWFC, FCREPA)
Piping Plover	Charadrius melodus	Blue-listed; special concern (FCREPA)
Cuban Snowy Plover	Charadrius alexandrinus tenuirostris	Blue-listed; endangered (FGFWFC, FCREPA)
American Woodcock	Philohela minor	Game species
Common Snipe	Capella gallinago	Game species
Upland Sandpiper	Bartramia longicauda	Blue-listed
American Avocet	Recurvirostra americana	Special concern (FCREPA)
Gull-billed Tern	Gelochelidon nilotica	Blue-listed
Roseate Tern	Sterna dougallii	Threatened (FGFWFC, FCREPA)

Table 1.11. (Page 3 of 3)

BIRDS (CONTD)

Common Name	Scientific Name	Special Status
Least Tern	Sterna albifrons	Blue-listed; threatened (FGFWFC, FCREPA)
Royal Tern	Sterna maxima	Special concern (FCREPA)
Sandwich Tern	Sterna sandvicensis	Special concern (FCREPA)
Caspian Tern	Sterna caspia	Special concern (FCREPA)
Black Skimmer	Rynchops niger	Special concern (FCREPA)
White-winged Dove	Zenaida asiatica	Game species
Mourning Dove	Zenaida macroura	Game species
Mangrove Cuckoo	Coccyzus minor	Threatened (FGFWFC); rare (FCREPA)
Yellow-billed Cuckoo	Coccyzus americanus	Blue-listed
Barn Owl	Tyto alba	Blue-listed; ecologically significant
Screech Owl	Otus asio	Ecologically significant
Great Horned Owl	Bubo virginianus	Ecologically significant
(Florida) Burrowing Owl	Athene cunicularia floridana	Blue-listed; special concern (FCREPA)
Barred Owl	Strix varia	Ecologically significant
Short-eared Owl	Asio flammeus	Blue-listed; ecologically significant
Common Nighthawk	Chordeiles minor	Blue-listed
Belted Kingfisher	Megaceryle alcyon	Ecologically significant
Pileated Woodpecker	Dryocopus pileatus	Ecologically significant
Red-headed Woodpecker	Melanerpes erythrocephalus	Blue-listed; ecologically significant
Hairy Woodpecker	Picoides villosus audubonii	Blue-listed; special concern (FCREPA)
Red-cockaded Woodpecker	Picoides borealis	Endangered (USDI, FGFWFC, FCREPA)
Ivory-billed Woodpecker	Campephilus principalis	Endangered (USDI, FGFWFC, FCREPA)
Cliff Swallow	Petrochelidon pyrrhonota	Blue-listed
Purple Martin	Progne subis	Blue-listed
Florida Scrub Jay	Aphelocoma coerulescens coerulescens	Threatened (FGFWFC, FCREPA)
White-breasted Nuthatch	Sitta carolinensis carolinensis	Special concern (FCREPA)
Brown-headed Nuthatch	Sitta pusilla	Ecologically significant
Bewick's Wren	Thryomanes bewickii	Blue-listed
Marian's Marsh Wren	Cistothorus palustris marianae	Special concern (FCREPA)
Eastern Bluebird	Sialia sialis	Blue-listed; ecologically significant
Loggerhead Shrike	Lanius ludovicianus	Blue-listed; ecologically significant
Starling	Sturnus vulgaris	Ecologically significant
Bell's Vireo	Vireo bellii	Blue-listed
Black-whiskered Vireo	Vireo altiloquus	Rare (FCREPA)
Worm-eating Warbler	Helmitheros vermivorus	Special concern (FCREPA)
Bachman's Warbler	Vermivora bachmanii	Endangered (USDI, FGFWFC, FCREPA)
Yellow Warbler	Dendroica petechia	Blue-listed
Kirtland's Warbler	Dentroica kirtlandii	Endangered (USDI, FGFWFC, FCREPA)
Florida Prairie Warbler	Dendroica discolor paludicola	Special concern (FCREPA)
Louisiana Waterthrush	Seiurus motacilla	Rare (FCREPA)
Yellow-breasted Chat	Icteria virens	Blue-listed
American Redstart	Setophaga ruticilla ruticilla	Rare breeder (FCREPA)
House Sparrow	Passer domesticus	Ecologically significant
(Florida) Grasshopper Sparrow	Ammodramus savannarum floridanus	Endangered (FGFWFC, FCREPA)
Henslow's Sparrow	Ammodramus henslowii	Blue-listed
(Scott's) Seaside Sparrow	Ammospiza maritima peninsulae	Special concern (FCREPA)
Vesper Sparrow	Pooecetes gramineus	Blue-listed
Bachman's Sparrow	Aimophila aestivalis	Blue-listed; ecologically significant

MAMMALS

Common Name	Scientific Name	Special Status
Opossum	Didelphis virginiana	
Southeastern Shrew	Sorex longirostris longirostris	Rare (FCREPA)
Short-tailed Shrew	Blarina brevicauda	Ecologically significant
Big Brown Bat	Eptesicus fuscus	Rare (FCREPA)
Hoary Bat	Lasiurus cinereus cinereus	Rare (FCREPA)
Northern Yellow Bat	Lasiurus intermedius	Ecologically significant
Eastern Big-eared Bat	Plecotus rafinesquii	Rare (FCREPA)
Nine-banded Armadillo	Dasypus novemcinctus	Ecologically significant
Marsh Rabbit	Sylvilagus palustris	Game species
Eastern Cottontail Rabbit	Sylvilagus floridanus	Game species
Black-tailed Jack Rabbit	Lepus californicus	Ecologically significant
Eastern Gray Squirrel	Sciurus carolinensis	Game species
Sherman's Fox Squirrel	Sciurus niger shermani	Threatened (FGFWFC, FCREPA)
Southeastern Pocket Gopher	Geomys pinetis	Ecologically significant
Eastern Harvest Mouse	Reithrodontomys humulis	Ecologically significant
Florida Mouse	Peromyscus floridanus	Threatened (FGFWFC, FCREPA)
Golden Mouse	Ochrotomys nuttali	Ecologically significant
Eastern Woodrat	Neotoma floridana	Ecologically significant
Round-tailed Muskrat	Neofiber alleni	Protected fur bearer (FGFWFC); special concern (FCREPA)
Black Rat	Rattus rattus	Pest species
Norway Rat	Rattus norvegicus	Pest species
House Mouse	Mus musculus	Pest species
Nutria	Myocastor coypus	Economically significant
Bottle-nosed Dolphin	Tursiops truncatus	Ecologically significant
Coyote	Canis latrans	Ecologically significant
Red Fox	Vulpes fulva	Fur bearer
Gray Fox	Urocyon cinereoargenteus	Fur bearer
Florida Black Bear	Ursus americanus floridanus	Game species; threatened (FGFWFC, FCREPA)
Raccoon	Procyon lotor	Fur bearer
Florida Long-tailed Weasel	Mustela frenata peninsulae	Rare (FCREPA)
Florida Mink	Mustela vison lutensis	Fur bearer; rare (FCREPA)
Eastern Spotted Skunk	Spilogale putorius	Fur bearer
Striped Skunk	Mephitis mephitis	Fur bearer
River Otter	Lutra canadensis	Fur bearer; ecologically significant
Florida Panther	Felis concolor coryi	Endangered (USDI, FGFWFC, FCREPA)
Bobcat	Felis rufus	Fur bearer; ecologically significant
Jaguarundi	Felis yagouaroundi	Ecologically significant
Manatee	Trichechus manatus latirostris	Endangered (USDI); threatened (FGFWFC, FCREPA)
White-tailed Deer	Odocoileus virginianus	Game species
Wild Hog	Sus scrofa	Game species

ecological significance are those with narrow habitat restrictions, biosystematic and zoogeographic significance, or particular status in the community (e.g., important predators, indicators of environmental change).

The study area's flora includes several species that have been proposed for federal listing as threatened and endangered or are considered so by the Florida Committee on Rare and Endangered Plants and Animals (Table 1.12). Also represented are species protected by Florida's rare plant law (most bromeliads, all native orchids, most native ferns, and all native palms except cabbage palm).

Table 1.12. Threatened and Endangered Plants Known To Occur in 7-County Study Area

Scientific Name	Common Name
Asplenium auritum	Auricled spleenwort
Centrosoma arenicola	Butterfly pea
Chionanthus pygmaeus	Pygmy fringe-tree
Hartwrightia floridana	-
Hypericum cumulicola	Highlands scrub hypericum
Liatris ohlingerae	Blazing star
Nolina brittoniana	Bear grass
Ophioglossum palmatum	Hand fern
Paronychia chartacea	Whitlow-wort
Polygala lewtonii	Lewton's polygala
Polygonella myriophylla	Jointweed
Prunus geniculata	Scrub plum
Rhapidophyllum hystrix	-
Triphora latifolia	Nodding cap
Verbena maritima	Vervain
Warea cartei	-
Zamia integrifolia	Coontie palm

Further development of the Florida phosphate industry will significantly affect the seven counties' existing uplands and wetlands biota, including many important floral and faunal species. Beyond the effects of devegetation or disturbance, as much as 30 percent of the terrestrial habitat in mined areas becomes aquatic habitat (lakes and ponds), permanently displacing the associated flora and fauna. Irreversible alterations in local topography and soil structure of remaining land preclude the reestablishment of certain existing plant communities, including associations within typical pine flatwoods, dry prairies, hammocks, sandhills, sand pine scrub, and forested and nonforested wetlands. Rather than promote some degree of development of natural habitat as has occurred in long-abandoned mining areas, current reclamation regulations and practices produce a landscape of managed systems — primarily improved pasture. As the landscape diversity in the area declines, so does the floral and faunal diversity. Although diversity declines primarily because hardwood swamps and mixed forest can be neither reclaimed nor naturally restored on mined land, establishment of habitat similar to existing types is possible and necessary if much of the area's important biota is to be maintained.

3. Water

a. Quality

1) Surface Water

The surface water quality in the study area is greatly influenced by the discharge patterns of the streams and rivers. Mineral content is generally higher (evidenced by higher total dissolved solids and higher specific ion concentrations) during the dry period (considered to be October-May) than during the wet season (June-September). The flow of most of the study area's rivers is highly variable and may vary greatly within a short time. This variability is particularly evident along the Peace River where overland runoff is a predominant contributor to increased flow. The Southwest Florida Regional Planning Council (1977) has provided evidence that the flow of the Peace River at Arcadia in the past has increased 500 percent in a single day. For all of the other major streams within the study area except the Peace River, low or no flow incidents have been recorded.

Within the study area, an inverse relationship has been found between river discharge and salinity and dissolved oxygen (Dragovich et al 1968). The large input of fresh water during the rainy season from both overland runoff and the water table dilutes the rivers, causing decreased salinity values. Dragovich et al (1968) found that plant production heavily influenced dissolved-oxygen (D.O.) concentrations. During increased river discharge (wet season, June-September), D.O. concentrations in many of the rivers in the study area decrease because of the dislodging of submerged aquatic flora as well as the influx of increased quantities of organic material (humus from forest beds, swamp flushings, livestock areas runoff) via surface runoff, which has a high biochemical oxygen demand.

The water quality of streams is affected also by contributions from groundwater flow and municipal and industrial discharges. These become most evident during the dry season when they can contribute the major portion of the base flow to some streams. The Peace and Alafia are the two rivers most affected by phosphate mining and processing; high levels of phosphate and fluoride in their waters at various points from their headwaters to the coast are attributed to this activity.

The surface water quality of the study area is characterized by the following parameter ranges (U.S. Army Corps of Engineers 1977):

Total dissolved solids (TDS)	61-409 mg/l
Hardness	34-264 mg/l
Sulfate	6-198 mg/l
Chloride	3-23 mg/l
pH	5-8 pH units
Color	0-280 Pt-Co units
Phosphate	0.4-3.9 mg/l
Turbidity	0-350 JTUs

It was established in the 1960s that discharges of phosphorus and nitrogen degrade water quality in the Peace and Tampa Bay basins. Primary effects of eutrophication (overenrichment with plant nutrient material) were noted in Hillsborough Bay, the Peace River, and Charlotte Harbor. As a result of these findings, the phosphate industry and other dischargers to these basins were issued notice and orders to reduce the quantity of phosphorus discharges by 95 percent and nitrogen discharges by 90 percent. This requirement was subsequently amended by the Wilson-Grizzle Act of 1971, which required municipal discharges in these basins to meet Advanced Water Treatment (AWT) standards and industrial dischargers to meet the equivalent of AWT as defined by the Florida Department of Pollution Control.

Most natural surface waters in central Florida exceed recommended criteria for phosphorus concentrations. Because other nutrient materials including carbon are also above limiting levels, any discharges of phosphorus or nitrogen add to primary productivity (growth of algae and other types of aquatic plants). Water quality studies on the receiving waters (including estuarine systems) have documented the degradation.

The spatial distribution of the dominant surface-water contaminants is shown in Figure 1.8.

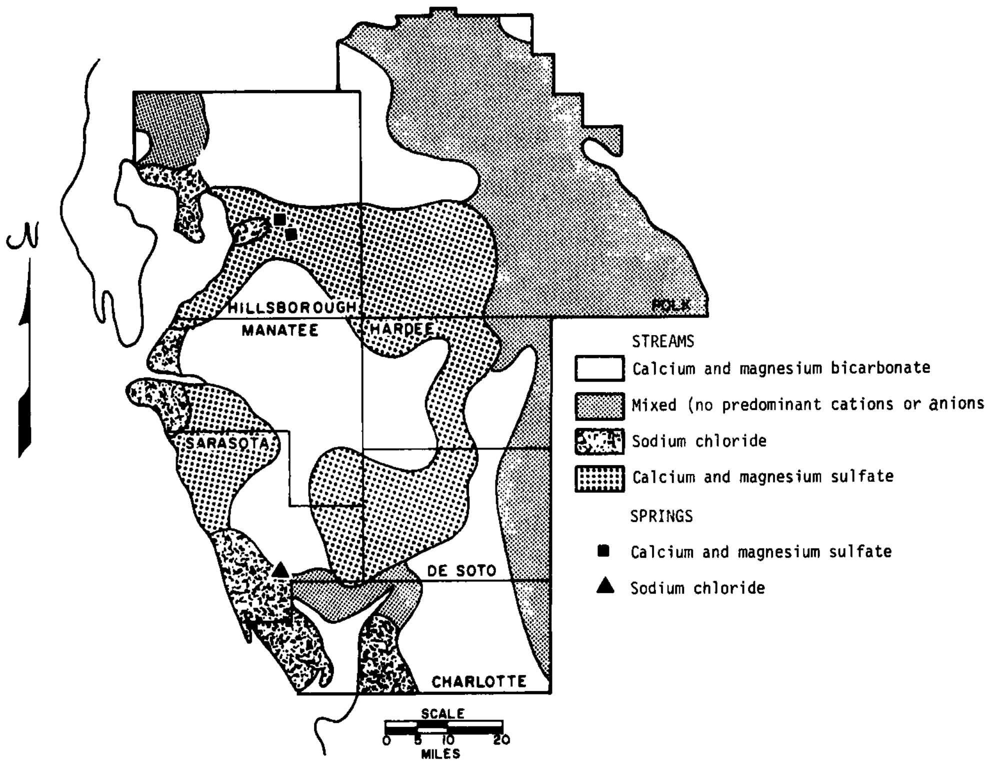


Figure 1.8. Chemical Types of Water
(U.S. Army Corps of Engineers 1977)

2) Ground Water

a) Water-Table Aquifer

The water in the water-table aquifer is generally soft and has a low dissolved-solids content (less than 100 milligrams per liter) except in the shoreline area; there, the chloride content exceeds 250 milligrams per liter because of natural hydrologic events or natural saltwater encroachment resulting from withdrawals of fresh water from wells. The construction of drainage canals and channels in some coastal areas has lowered the water-table aquifer and apparently has caused some inward migration of salty water (discussed in more detail later in this subsection). Contaminating the water-table aquifer locally are nutrients from fertilized agricultural land, sewer leakages, and seepage from industrial lagoons, septic systems, and landfills. Contamination is generally evidenced by increased concentrations of dissolved constituents such as chloride, nitrate, fluoride, phosphate, sulfate, and in some areas bacteria and viruses (U.S. Army Corps of Engineers 1977).

b) Floridan Aquifer

The Floridan aquifer underlies the entire study area. The fresh water in the aquifer in the study area is primarily a calcium bicarbonate type that is slightly to moderately mineralized. The water's dissolved-solids content is normally 150 to 350 milligrams per liter, and its hardness is classified as moderately hard to hard.

In general, man's activities have not contaminated the Floridan aquifer in the study area to problem proportions. There has been some encroachment of salty water locally in Gulf and bay shoreline areas because of heavy pumping of wells or dredging of channels and canals.

Although chloride occurs to some extent in all natural waters, it is obvious from Shampine's (1965) investigations of chloride concentrations in the upper zone of the Floridan aquifer that the most serious concern is in the southern portions of Sarasota County and in the western and eastern portions of Charlotte County. The chloride content of the aquifer water in these areas is about 1000 milligrams per liter. This water is used to irrigate salt-tolerant crops and as a result percolates downward into the water-table aquifer, contaminating it.

Sulfate also is found in almost all natural water. In rainwater, it is dissolved from impurities and gases in the atmosphere, and it may also be dissolved from materials on the surface of the ground (e.g., decaying organic matter such as leaves and trees). Sulfate is discharged also in various industrial wastes and may increase upon entering the ground because of leaching from gypsum and other sulfate minerals, connate water contamination, salt water from the ocean, or pollutants. In the upper part of the Floridan aquifer in the coastal area, sulfate concentrations (Figure 1.9) are particularly high because of the influence of salt water from the ocean; this extends inland to occupy almost all of Sarasota County. Water from deeper zones usually contains greater concentrations of sulfate.

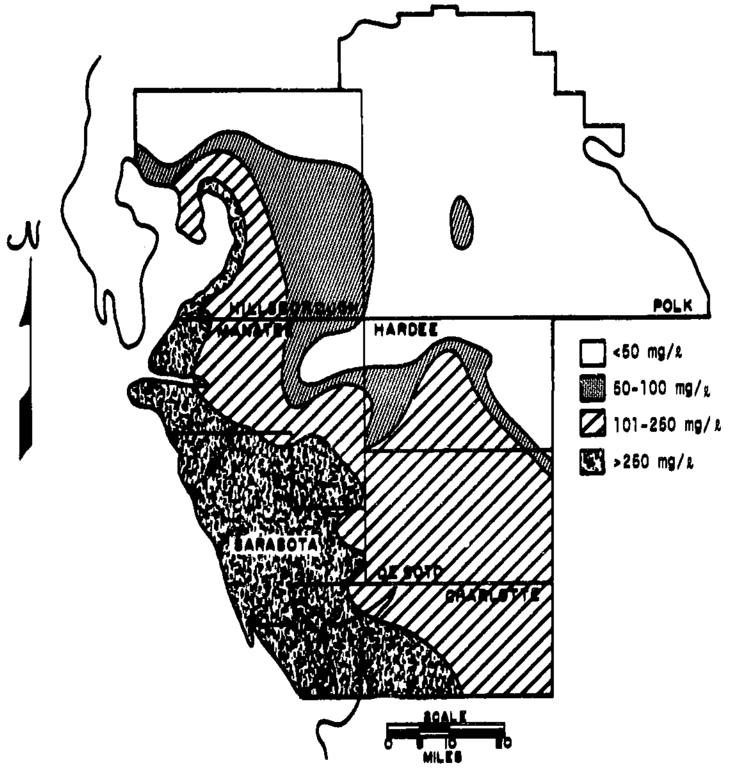


Figure 1.9. Concentrations of Sulfate in Water from Upper Floridan Aquifer (Shampine 1965)

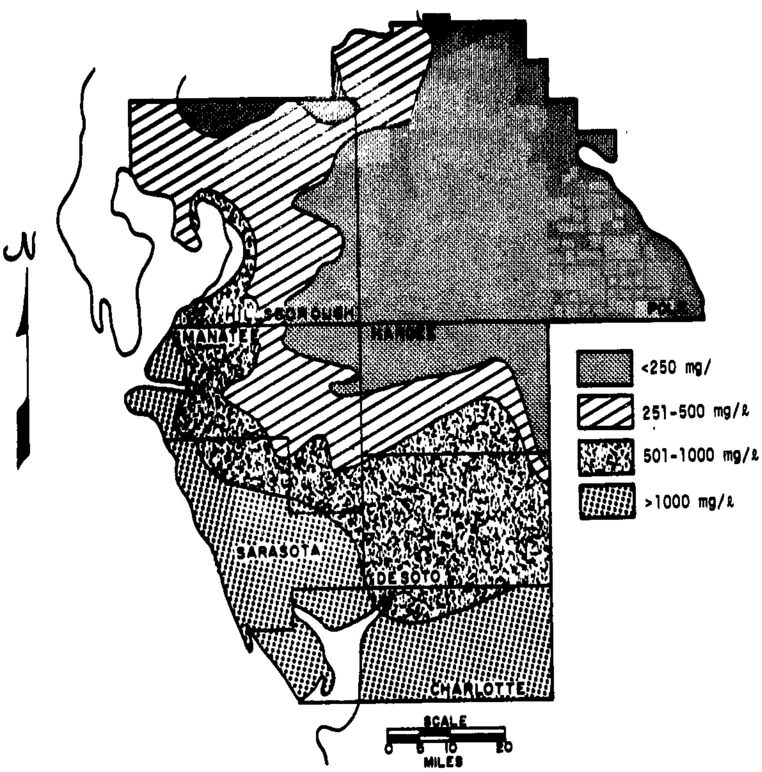


Figure 1.10. Dissolved Solids in Water from Upper Part of Floridan Aquifer (Shampine 1975)

All natural waters contain dissolved solids, primarily carbonates, bicarbonates, chlorides, sulfates, phosphates, fluorides, and nitrates of calcium, magnesium, and sodium and only small amounts of potassium, iron, manganese, strontium, and sulfide. The distribution of dissolved solids in the study area is shown in Figure 1.10.

There is concern about the radiation environment in Florida, particularly in relation to groundwater contamination. An EPA investigation in 1977 assessed radiation levels due to radium in nonmineralized areas (those not containing marketable phosphate matrix reserves), mineralized but unmined areas (those having marketable phosphate matrix not yet mined), and mineralized, mined areas (those having marketable phosphate matrix being mined) in the 7-county study area. The study considered two subareas: (1) Polk, Hardee, Hillsborough, DeSoto, and Manatee counties; and (2) Sarasota County. Study-area 1 displayed the following:

- Water-Table Aquifer

  The dissolved radium assessment indicated no significant difference between mined and unmined mineralized areas, and none of the radium-226 concentrations in mined areas exceeded the EPA regulation for total radium in drinking water.

- Upper Floridan Aquifer

  The dissolved radium assessment indicated significant differences between the areas, with the highest values in nonmineralized areas. Concentrations were higher than the water-table aquifer.

- Lower Floridan

  No significant differences were found between the different areas.

Study-area 2 displayed the following:

- Ra-226 concentrations were 100 times higher in the water-table aquifer and almost 10 times higher in the upper and lower Floridan aquifers than in study-area 1.

- Ra-226 concentrations in the water-table aquifer in the coastal area were significantly greater than in the inland area.

- Higher-than-average (relative to Florida and U.S.) Ra-226 concentrations in both the water-table and Floridan aquifers are attributed to natural enrichment (probably related to radium-enriched, mineralized ground water that is deep beneath the central Florida peninsula and shallow in the coastal areas) and to dissolution of Ra-226 from the Hawthorn formation (which is very near the land surface in western Sarasota County).

As far as the entire 7-county study area is concerned:

- A detrimental effect by phosphate mining on Ra-226 in the upper Floridan aquifer is not documented. Existing radium data do not substantiate previously alleged widespread radium contamination of ground water by the phosphate industry. Natural variability in the radium content of ground water complicates determination of background versus contaminated conditions.

- Ra-226 data collected from the water-table, upper Floridan, and lower Floridan aquifers in 1966 by the Federal Water Pollution Control Administration and in 1974-76 by the United States Geological Survey revealed no statistically significant difference for the decade interval (1966-76).

- Hydrogeologic conditions favor entrance of contaminants to at least the water-table and upper Floridan aquifers. However, contamination is generally poorly documented due at least in part to monitoring deficiencies.

b. Water Quantity

The central Florida phosphate industry is a major user of the water resources in the seven counties being studied for this areawide impact assessment program. Thus, the industry's impact on these water resources had to be judged in the same manner used for the other natural resources. This required an understanding of the existing hydrologic regimes and the dynamics of the hydrologic cycle operational in central Florida, as well as existing and projected demands on the system.

1) Hydrologic Regime

a) Physiographic Overview

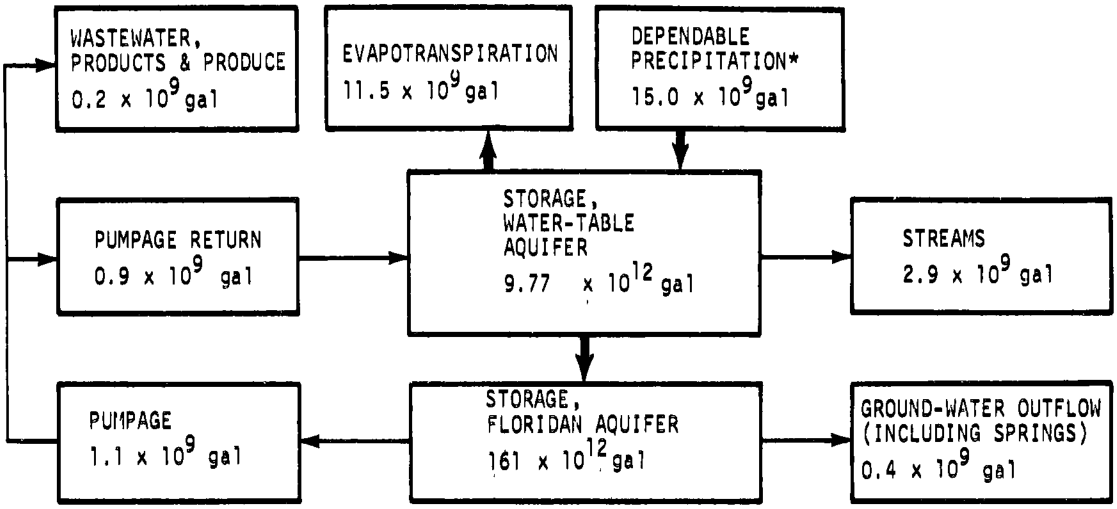
The study area encompasses approximately 6242 square miles in west-central Florida and covers Polk, Charlotte, Hillsborough, Manatee, Hardee, DeSoto, and Sarasota counties. The area is bordered on the north by Lake, Pasco, and Sumter counties and on the west by the Gulf of Mexico; the boundary generally coincides with the boundaries of the Southwest Florida Water Management District (SWFWMD) on the east and south. The area's principal streams are the Hillsborough, Alafia, Little Manatee, Manatee, Myakka, and Peace rivers, Horse and Shell creeks, and Big Slough Canal. The area is contained within two natural topographic regions:

- The Coastal Lowlands, comprising low, nearly level plains (commonly called flatwoods); gently undulating to rolling areas with numerous intermittent ponds, swamps, and marshes; and sinkholes with many lakes and perennial streams.
- The Central Highlands, a ridge and sinkhole region that divides Polk County nearly in half and cuts across the county in a northwest-to-southeast direction.

Elevations range from sea level along the coast to nearly 300 feet above mean sea level (msl) in the Central Highlands of Polk County.

b) Hydrologic System - General Water Budget

Figure 1.11 is a schematic of the hydrologic system in westcentral Florida. Precipitation provides the primary input to the system, and evapotranspiration is the primary loss. Water is stored in both the surface, or



*Available 70 percent of the time or more.

Figure 1.11. Generalized Water Budget for Central Florida Phosphate District (prepared by Geraghty & Miller Inc.)

water-table aquifer, and the deep Floridan aquifer. Secondary losses occur by surface runoff through streams as well as groundwater outflow through streams, springs, and directly into the ocean. Some losses occur when water is pumped from the groundwater system and not returned to the system. The latter may be added to streamflow as wastewater or exported from the area with other products (produce, wet phosphate rock, etc.).

c) Surface-Water Resources

The surface-water resources of the study area encompass parts of all seven counties and include springs, wetlands, lakes, streams, and runoff within given watersheds (see Plate 1 in map pocket). The streamflow characteristics for the various watershed areas are summarized in Table 1.13; the data are based on information obtained from USGS gaging stations nearest the stream discharge points that are still unaffected by the tide.

- Springs

  A spring represents natural overflow from an aquifer. In the study area, there are nine major springs: seven in Hillsborough and two in Sarasota County. They generally discharge into surface-water bodies (the Hillsborough and Alafia rivers). Spring discharge varies naturally as a result of pumping and seasonal fluctuations of water levels (U.S. Army Corps of Engineers 1977).

Table 1.13. Summary of Streamflow Characteristics (Period of Record)

Watershed	Gaging Station	Location	Years of Record	Drainage Area at Gage (mi^2)	Total Basin or Sub-basin Area (mi^2)	Flow of Record: Mean (cfs)	Mean (mgd)	Max. (cfs)	Max. (mgd)	Min. (cfs)	Min. (mgd)	Avg at Mouth (cfs)	Avg at Mouth (mgd)	Remarks
Hillsborough River Basin					690									
Hillsborough River	02304500	City of Tampa dam	37 (10/39-9/76)	650		615	398	14,600 (3/21/60)	9,436	0 (11/30 & 12/2/45)	–	653	422	Water supply, City of Tampa
Six Mile Creek	–	S.R. 574	4	28	40	49	32	135	87	20	13	70	45	
Peace River Basin					2,403									
Peace River	02296750	Arcadia	44 (4/31-9/76)	1,367		1,195	772	36,200 (9/9/33)	23,396	37 (5/28/49)	24	2,100	1,357	
Horse Creek	02297310	10 mi from mouth	25 (4/50-9/76)	218		209	135	11,700 (8/11/60)	7,562	0				
Shell Creek	02298202	City of Punta Gorda dam	10 (1/65-11/76)	373		356	230	6,110 (6/28/74)	3,949	0				Water supply, City of Punta Gorda
Prairie Creek	0298123	4 mi downstream from Myrtle slough	14 (10/64-9/68; 10/69-current)	233		166	107	2,950 (7/74)	1,907	0 (6/3 & 7/65)				
Myakka River Basin					540									
Myakka River	02298830	36 mi from mouth	39 (8/36-1/77)	229		256	165	8,670 (8/1/60)	5,603	0		615	397	
Big Slough Canal	02299470	Murdock upstream from dam	9 (2/36-9/72	87.5	99	86.6	56	2,560 (7/31/65)	1,655	0		98	63	Water supply, North Port
Manatee River Basin					350									
Manatee River	02299950	Myakka head 36 mi from mouth	11 (5/66-9/76)	65.3		65	42	2,410 (8/31/72)	1,558	0.12 (5/24/75)	0.08	348	225	Water supply, Manatee County
Little Manatee River Basin					225									
Little Manatee River	02300500	Wimauma 15 mi from mouth	36 (3/39-9/76)	149		175	113	14,000 (6/11/60)	9,048	1.2 (6/6 & 4/75)	0.78	264	171	
Alafia River Basin					420									
Alafia River River	02301500	Lithia 16 mi from mouth	43 (10/33-1/77)	335		373	241	45,900 (9/9/33)	29,665	6.6 (6/5 & 7/45)	4	468	302	
Total						3,546	2,292	145,235	93,866	65	42	4,616	2,982	

- Wetlands

  Wetlands are defined in USGS land-use/land-cover mapping programs as areas in which the water table is at, near, or above the land surface for a significant part of most years. The hydrologic regime is such that aquatic or hydrophytic vegetation is usually established (although alluvial and tidal flats may be nonvegetated). Wetlands frequently are associated with topotraphic lows and include marshes, mudflats, and swamps situated on the shallow margins of bays, lakes, ponds, streams, and man-made impoundments; wet meadows; and seasonally wet or flooded basins, playas, or potholes with no surface-water outflow. Wetlands comprise 12.34 percent of the land cover in the study area.

- Lakes

  Most of the numerous lakes of various sizes within the study areas are in Polk County. Water-level fluctuations generally correspond with those of the local water table; however, in some locations in which a lake is directly connected with the aquifer through a sinkhole, a lake's water level will change with fluctuations of the potentiometric surface of the Floridan aquifer (U.S. Army Corps of Engineers 1977). Of lakes in the study area that are 100 acres or more in surface area, there are 71 in Polk County, 1 in Hardee, 1 in Charlotte, 2 in Sarasota, and 3 in Hillsborough. Such lakes represent approximately 2.0 percent of the study area's total surface area.

d) Groundwater Resources

The groundwater system in the 7-county area is essentially a tripartite arrangement. The uppermost unit is a shallow, unconfined, sandy, marly water-table aquifer. Next is a clayey unit that is thin in the north, thickens to the south, and is composed largely of the Hawthorn formation, Tampa limestone (clay), the Bone Valley formation (clay and phosphate ores), Caloosahatchee marl (clay and marl), and the Tamiami formation (clay). The extensive and thick hydrologic unit, the Floridan aquifer (Parker 1951, Parker et al 1955), consists of two subunits, both primarily limestone and dolomite (Wilson 1977a). In some areas, there are one or more aquifer zones well separated from the underlying Floridan aquifer. In Charlotte County, five aquifer zones have been identified below the water-table aquifer (Sutcliffe 1975). Wilson (open file report, 77-822) concludes that the base of the Florida aquifer corresponds to the top of the Lake City Limestone, and represents the lower confining bed.

The Floridan aquifer system is basically bipartite, i.e., composed of two principal but intimately related and functioning hydrologic units: the Floridan aquiclude, which acts as a lid or confining cap to the underlying aquifer and by its presence allows the development of artesian conditions in the aquifer (Parker 1951, Parker et al 1955); and the Floridan aquifer, which stores and transmits water, generally under artesian (confined) conditions. The hydrogeologic sections depicted in Figure 1.12 show a north-south section through the study area.

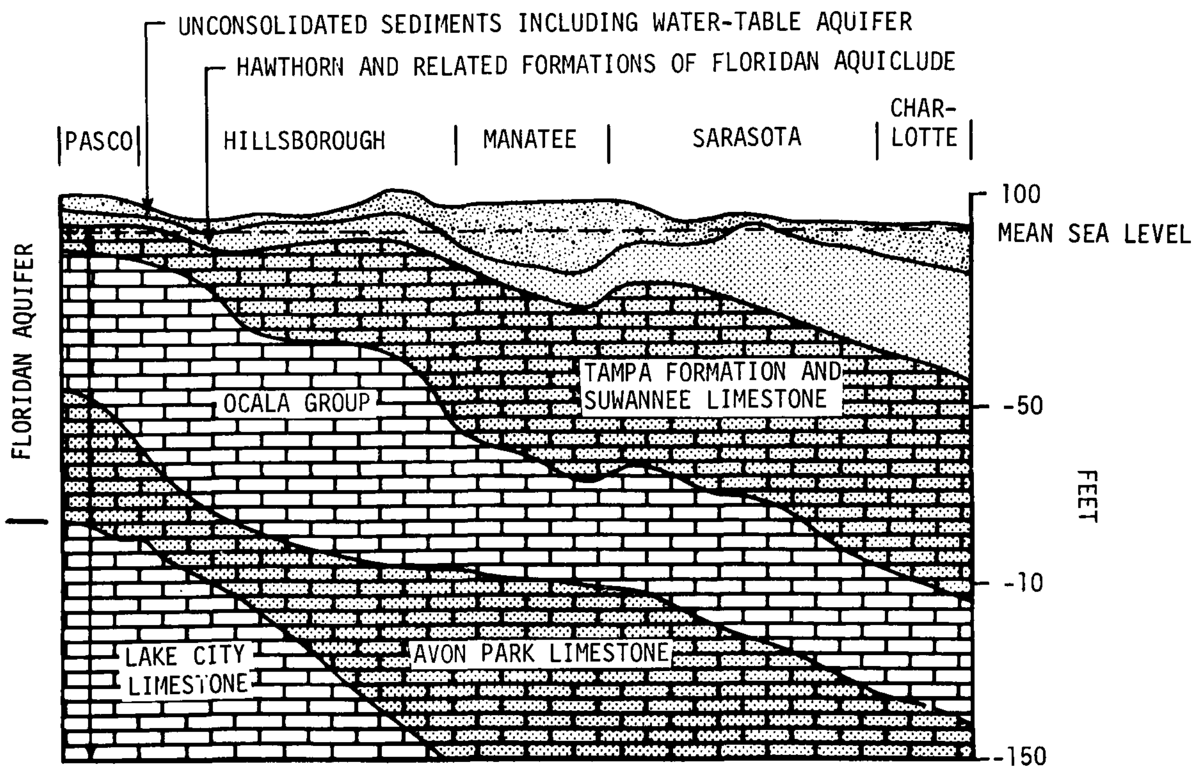


Figure 1.12. Generalized Hydrogeologic North-South Section (modified from Wright 1974)

The potentiometric surface is continually fluctuating (Figure 1.13) in response to a variety of forces (earthquakes, winds, tides, trains, and atmospheric pressure changes as well as recharge to and discharge from the aquifer [Parker and Stringfield 1950]) exerted on the artesian system. Figure 1.13 shows seasonal, short-term, and long-term fluctuations as measured in a well in Hardee County 4 miles east of Wauchula and 0.7 mile south of the Old Sebring Road; this is a fairly typical well in the study area and indicates large drawdowns when each irrigation season begins and the almost equally large and rapid recovery that occurs when each irrigation season ends. The record of this particular well shows seasonal fluctuations due to irrigation

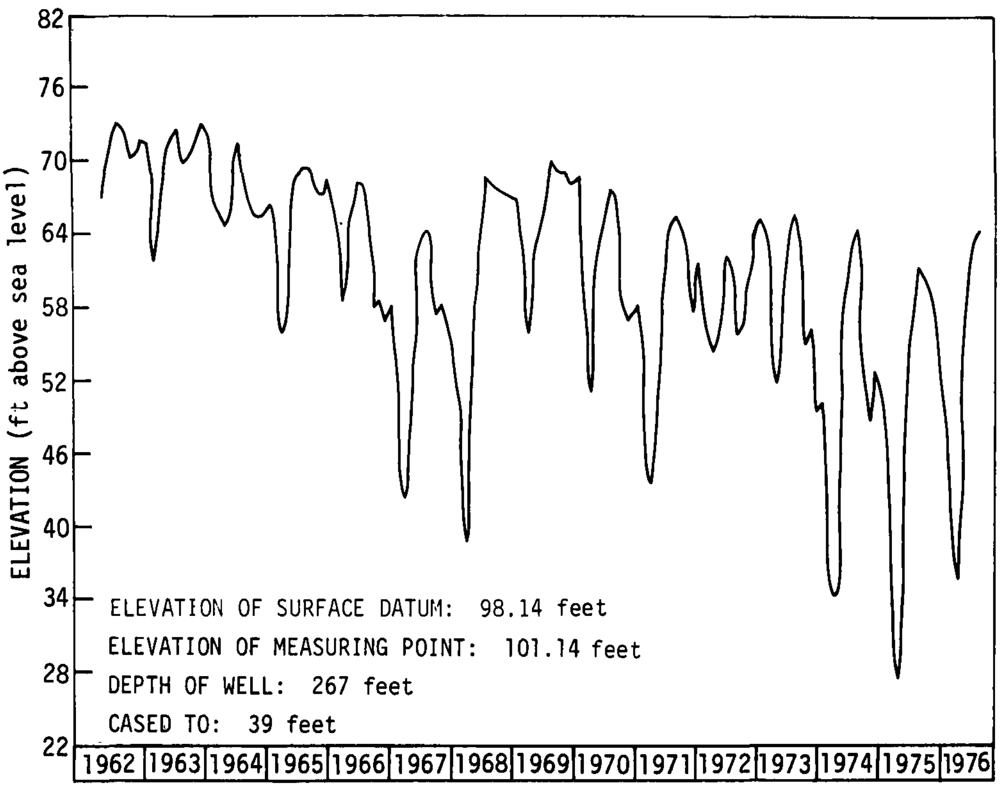


Figure 1.13. Seasonal Fluctuations of Potentiometric Surface in Observation Well Tapping Floridan Aquifer in North-central Hardee County, Florida (prepared from USGS data)

that are as great as 42 feet (September 1974 to May 1975). Also, when comparing the early part of the record (1962-73) with the later part (1973-76), there is evidence of an increase in amplitude of drawdown and recovery. This indicates increasing total irrigation pumpage during the period because irrigation pumpage is of a seasonal nature, which is contrary to pumpage for industrial uses.

It is important to note the overall downward and long-term trends of water levels, even though recovery following some irrigation seasons is equal to or greater than the previous drawdown. The decline is about 9 feet in 14 years (1962-76), indicating that more artesian water is being taken from storage than is naturally being replenished by recharge. It is also important to note the abrupt change of the potentiometric surface when the pumping rate is changed. This characteristic of artesian systems indicates pressure changes, not the dewatering of the artesian aquifer that would occur in the water-table aquifer if the water table dropped.

On a long-term areawide basis, the potentiometric surface has tended to decline over a good portion of the study area. The decline at the end of the rainy season (September) between 1949 and 1975 centered in southwest Polk County; to a large extent, it can be attributed to groundwater pumpage by the phosphate industry. However, when the potentiometric maps for May 1969 are compared with those for May 1975, which corresponds to the end of the dry season and the period of most extensive irrigation, an extensive area of drawdown is found outside of Polk County in Manatee and Hardee counties, which can be attributed mainly to agricultural water usage. This is illustrated in figure 1.14.

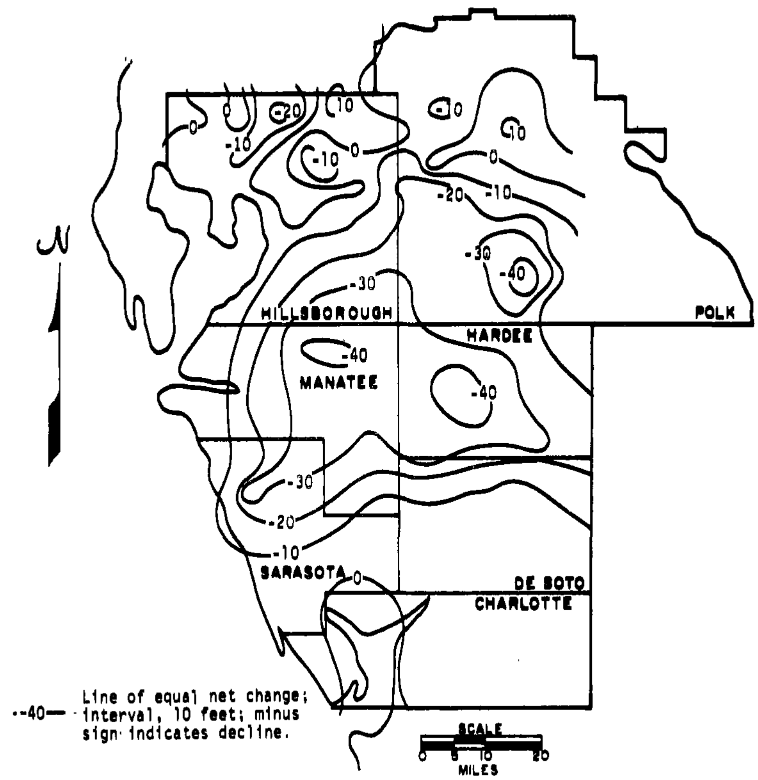


Figure 1.14. Change in Potentiometric Surface of Floridan Aquifer, May 1969 to May 1975 (adapted from USGS data)

Along the coast of the Central Florida Phosphate District, the outflow of fresh ground water from the Floridan aquifer has long been in equilibrium with the denser saline water of the Gulf, thereby preventing inland saltwater encroachment. However, if the coastal freshwater head were reduced sufficiently, the outflow of ground water would be reduced and the saltwater/freshwater interface would gradually move inland, causing seawater to replace the fresh. Thus, the decline in the potentiometric surface of the Floridan aquifer has caused great concern. There have been localized cases in which wells have shown increases in their chloride content, and several studies are in progress (although specific data are not yet available).

The whole issue of saltwater encroachment is very complex (Parker et al 1955, Reichenbaugh 1972). In certain parts of Manatee County, for example, the potentiometric surface has declined below mean sea level generally in the spring and then has risen above msl again during the rainy season; while some bay people suspect that substantial saltwater encroachment should have occurred, current data do not support this suspicion. However, there is a great lag in the response of seawater to inland movement as a result of lowered freshwater levels inland. Perhaps not enough time has elapsed since the drawdowns occurred on a scale large enough to induce saltwater encroachment very far inland, and the lowering during the irrigation season may very well be offset by the rise during off-irrigation. Although highly speculative, it is also possible that geologic structure plays a role in retarding or preventing saltwater encroachment.

A much greater threat to the quality of the freshwater resources in the coastal zones of the Floridan aquifer is the contamination of the freshwater zones by highly mineralized water (predominantly water with a high sulfate content) leaking upward from deeper, more mineralized zones through uncased or leaky well casings. This problem has been recognized by SWFWMD which, since 1975, has been plugging as many of these free-flowing artesian wells as funding permits. This program has two goals: by plugging the wells, water loss is prevented, thereby increasing aquifer pressures and in turn helping to prevent saltwater encroachment; and the contamination by upward leakage is prevented.

2) Water Demands

Water demands for the study area in 1976 and those projected for 1985 and 2000 are summarized in Table 1.14. The changes primarily reflect changes in municipal demands, power-plant and agricultural usage, and phosphate mining activity.

Historically, water demands in the study area have been met by surface-water impoundment (Hillsborough and Manatee), shallow wells (coastal area and individual domestic or small agricultural wells), well fields remote from the immediate area of use, or local well fields. In the inland area, water

Table 1.14. Total Present and Projected Water Demands by County

County	1976	Projected 1985	Change 1976-85	Projected 2000	Change 1976-2000
			Demand (mgd)		
Charlotte	26	31	5	43	17
DeSoto	109	316*	207	366	257*
Hardee	190	232	42**	352	162
Hillsborough	180	248	68†	268	88
Manatee	113	166	53†	217	104
Polk	740	739	-1	646	-94‡
Sarasota	56	70	14	103	47

*Reflects assumed power-plant operational status.

**Reflects large increase in projected irrigation pastures.

†Increase mining activity.

‡Decrease in mining activity.

has been and will continue to be abundantly available from the Floridan aquifer. In coastal areas, however, water quantity and quality have been more of a problem because of the limited supply of potable ground water near the coast. Groundwater supplies will continue to meet increased demands in inland areas. Near the coast, there are several options that must be balanced against each other in each use area to determine the most economical:

(1) Groundwater well-field development with export to areas of usage

(2) Surface-water storage similar to existing reservoirs at Tampa and Lake Manatee

(3) Transport of excess surface flow to heavy-demand areas such as Tampa and Sarasota

(4) Injection of excess surface water into the Floridan aquifer for subsequent removal and use

c. Aquatic Biota

1) General

The biota of the study area's fresh, brackish, and marine waters comprises unusually rich and diverse assemblages of aquatic organisms that represent a valuable resource to westcentral Florida. The high diversity can be attributed largely to the study area's geographic position at the intergrade of temperate and subtropical climates. Water temperatures seldom drop low enough in water to kill tropical organisms and are moderate enough in summer to be tolerated by most of the temperate species. Although the local climate is mild enough to support essentially a year-round growing season, seasonal influences in biotic cycles are evident but more muted than in temperate climates. A major influence is the "wet" and "dry" season periodicity, which regularly alters streamflow regime, freshwater discharge into the estuaries, and the amount of standing water in the study area.

2) Aquatic Communities

Three basic aquatic community types exist within the study area: lentic communities (standing fresh water: lakes, ponds, pits), lotic communities (running fresh water: rivers, streams), and estuarine and bay communities. Wetlands (swamps, marshes, wet prairies), which have been treated along with terrestrial communities, are considered an adjunct to the three basic aquatic community types.

a) Lentic Communities

The standing freshwater communities comprise natural and man-made lakes and impoundments, ponds, pits, and seasonally wet depressions. Many smaller lentic waterbodies in the study area are intermittent, generally becoming dry during early spring; they support transitional communities only part of the year or, in a few areas, only during years of adequate rainfall. The majority of the larger waterbodies, however, have permanent water; they are naturally shallow, averaging less than 20 feet, having sloping sides with wide littoral (shore) zones, and maintain moderate to luxuriant algal and vascular plant communities that support comparatively large populations of zooplankters, macroinvertebrates, and fishes. Some of the waterbodies that maintain permanent water, particularly those in Hillsborough and Polk counties, are reclaimed or naturally revegetated and recolonized mining pits; these lakes generally have steeply graded sides and narrow littoral zones of comparatively low diversity.

b) Lotic Communities

The running-water communities are represented by the biotic assemblages of the rivers, streams, and tributaries of the 7-county study area. The communities generally are rich and diverse, and the major water courses as a whole are of considerable aesthetic and recreational importance to the study area, serving as sources of water supply and supporting substantial sport fisheries, and contributing to commercial fisheries.

Most streams in the study area, typical of others in the southeastern Coastal Plain, have water that exhibits a tea color due to dissolved organic acids that are washed from adjacent standing water during abundant rainfall. Current speed among (and within) the streams varies: many of the streams are comparatively slow and moderately to heavily covered with emergent aquatic vegetation. The slow streams have biota similar in both appearance and composition to that of lakes and ponds, with substantial development of planktonic communities and more mobile benthic macroinvertebrates. The swifter streams contain little emergent or floating vegetation, have few resident zooplankters, and support populations of narrowly ranging and sessile macroinvertebrates that filter-feed or graze.

c) Bay and Estuarine Communities

The study area's estuarine habitats include Tampa Bay, Charlotte Harbor, and the bays and inlets of the "Manasota" coast, which comprises the coastline of Manatee and Sarasota counties. The comparatively small estuarine areas of the Manasota coast have features of both Tampa Bay and Charlotte Harbor.

Both Tampa Bay and Charlotte Harbor are complex estuarine systems in which water quality characteristics are influenced to a large degree by basic morphometry, a highly variable quantity and quality of freshwater influx, mixed tides, wind, and, of course, man's activities. The respective biotas of the two estuarine systems reflect the nature of the physicochemical complexities. As estuaries, both systems represent the interface or zone of intergrade between the freshwater environments inshore and the marine environment offshore.

The biota of these embayments includes typical euryhaline (tolerant to a broad range of salinity) estuarine flora and fauna as well as adventitious stenohaline (tolerant to a narrow range of salinity) freshwater and marine forms.

The vascular aquatic flora of the estuarine portions of the study area comprises seagrass beds, mangrove swamps, and salt marshes that play important roles in the overall ecology of both Tampa Bay and Charlotte Harbor estuaries through substrate stabilization, primary productivity, provision of habitat, and structural basis for development of diverse and highly productive communities.

3) Threatened and Endangered Species

In the study area, 13 aquatic species considered endangered, threatened, rare, or of special concern have been reported (Table 1.15). Phosphate mining within the study area might potentially affect only three of the 13: the manatee, American alligator, and Suwannee cooter.

Table 1.15. Study Area Aquatic Species Designated Endangered, Threatened, Rare, or of Special Concern

Species	Status*
Atlantic Geoduck	Rare (FCREPA)
Opossum Pipefish	Rare (FCREPA)
Mangrove Crab	Threatened (FCREPA)
Atlantic Sturgeon	Threatened (FCREPA)
Rivulus	Threatened (FCREPA)
Suwannee Cooter	Threatened (FGFWFC, FCREPA)
Atlantic Loggerhead	Threatened (FGFWFC, FCREPA)
American Alligator	Threatened (USDI, FGFWFC); special concern (FCREPA)
Atlantic Leatherback Turtle	Endangered (USDI; rare (FCREPA)
Atlantic Ridley	Endangered (USDI, FGFWFC, FCREPA)
Atlantic Green Turtle	Endangered (USDI, FGFWFC, FCREPA)
Atlantic Hawksbill	Endangered (USDI, FGFWFC, FCREPA)
Manatee	Endangered (USDI); threatened (FGFWFC, FCREPA)

*FCREPA Inventory of rare and endangered biota of Florida compiled by the Florida Committee on Rare and Endangered Plants and Animals, 1976.

FGFWFC The wildlife code of the Florida Game and Freshwater Fish Commission, 1976.

USDI United States Department of Interior list of endangered and threatened wildlife, 1974.

The manatee, or sea cow, has been reported throughout the coastal areas of the 7-county study area as well as in the Peace, Myakka, Manatee, Little Manatee, Alafia, and Hillsborough rivers. In 1975, the USDI designated the northern portion of Charlotte Harbor and the lower reaches of the Peace, Myakka, Manatee, and Little Manatee rivers as "critical habitat" for the manatee.

The American alligator is distributed in wetlands and aquatic habitats throughout Florida and is common in the study area. Because of legal protection and, in part, population resiliency, the reptile's numbers have now increased to the point that the animal, although still threatened in other parts of the county, is not seriously threatened in Florida.

The Suwannee cooter is an aquatic turtle restricted to certain rivers and spring runs draining into the Gulf of Mexico. Its distribution within the study area is apparently limited to the Alafia River and particularly in the Lithia Springs area.

4) Species of Commercial and Recreational Importance

Categories and examples of species of commercial and/or recreational importance in the study area are listed in Table 1.16. There are no freshwater invertebrates of significant commercial or recreational value in the study area, but there is a considerable freshwater fishery resource. The study area has many lakes, streams, and coastal rivers that support commercial and sport fisheries. Although naturally established fish communities inhabit many of these waterbodies, fisheries management maintains a considerable number of them. Additionally, increasing numbers of phosphate pits have recreational potential if properly reclaimed, and many have been transformed into private and/or public fish management areas and parks.

While the fresh waters of the study area have substantial commercial and recreational opportunities, the extremely productive estuarine waters have outstanding commercial and recreational resources. Saltwater sport fishes are a tremendous economic asset to the west coast of Florida. Undoubtedly, the majority of the activity is concentrated near the tourist and population centers of the Tampa Bay and Charlotte Harbor areas and the "Manasota" coast. In

Table 1.16. Species of Commercial and/or Recreational Importance

Categories	Examples
Freshwater	
Game fishes	Largemouth bass, bream (bluegill, redear sunfish, etc.)
Commercial fishes	Channel catfish, blue tilapia
Bait/forage fishes	Minnow, shiner
Estuarine	
Game fishes	Snook, tarpon, spotted seatrout, red drum, etc.
Commercial fishes	Mullet, crevalle, pompano, red snapper, spotted seatrout, grouper, etc.
Bait/forage fishes	Bay anchovy, menhaden, silverside, etc.
Commercial invertebrates	Shrimp, blue crab, stone crab, etc.

the study area's estuarine waters, approximately 79 fish species and seven invertebrate (shellfish) species of some commercial value are found in at least one life stage. In 1975, 30 of the species had an annual dockside value exceeding $1000 in at least one of the shoreline counties in the study area. On a poundage basis, shrimp, mullet, grouper, red and black drum, pompano, spotted seatrout, spanish mackerel, red snapper, crevalle jack, sand perch (mojarra), sheepshead, blue crab, and stone crab represented the largest landings in the Tampa Bay-Charlotte Harbor area; on a dollar basis, shrimp was by far the most important species landed.

5) Nuisance or Pest Species

The same environmental factors that provide the outstanding biotic resources of the fresh and salt waters of the study area also promote growth of certain native and exotic species to nuisance population levels (Table 1.17).

Pest or nuisance organisms and conditions associated with fresh waters of the study area include algal blooms, exotic hydrophytes, mosquitos, midges, the Asiatic clam, and a variety of native and exotic fishes. Abundances and associated problems generally vary locally. Perhaps the most severe nuisance of the fresh waters is the prolific growth of exotic hydrophytes including

Table 1.17. Aquatic Nuisance and Pest Species in Study Area

Categories	Examples
Freshwater	
Macrophytes	Water hyacinth, Hydrilla, water milfoil
Algae	Filamentous and colonial green and blue-green algae
Midges/Mosquitos	Midges/mosquitos
Asiatic clam	Asiatic clam (Corbicula)
Native nuisance fishes	Gizzard shad, bowfin, gar
Exotic fishes	Tilapia, walking catfish
Estuarine	
Gymnodinium (red tide)	Gymnodinium
Gracilaria (red alga)	Gracilaria
Fouling organisms	Barnacles, bivalves, algal mats

water hyacinth, Hydrilla, and water milfoil; these hydrophytes, as well as others, proliferate readily in the nutrient-rich waters, clogging waterways, shading out more desirable aquatic flora, deoxygenating the water and producing sulfide odors as they deteriorate. Millions of dollars are spent annually in an attempt to control these pests.

The organism most devastating to the estuaries and marine waters of the study area is the single-celled alga Gymnodinium breve, a minute, narrow dinoflagellate. About every 3 to 5 years, the population of this organism "blooms" for largely unknown reasons, creating the condition known as "red tide" off the west coast of Florida. The economic consequences are staggering. Total estimated losses attributed to two major outbreaks — one during summer 1971 and the other during winter and early spring 1973-74 — was about $35,000,000.

Another nuisance condition in the saline waters of the study area results from the death and deterioration of prolific growths of the red alga Gracilaria. This nuisance condition is not as widespread as the red tide; heavy growths appear to be restricted to the Hillsborough Bay portion of Tampa Bay.

4. Radiation Environment

a. Introduction

The world's primary phosphate occurrences are of sedimentary origin and contain radioactive materials, predominantly uranium and its decay products. Uranium, along with a very small amount of thorium, is thought to have been deposited contemporaneously with the phosphate. The phosphate deposits of the study area contain uranium concentrations of between 0.01 and 0.02 percent; despite the fact that ore mined in the western United States solely for its uranium content contains 10 to 20 times this concentration, the phosphate industry currently mines slightly more total uranium than does the uranium industry (Guimond 1976a).

As indicated in Figure 1.15, radioactive material associated with phosphate is confined at a depth at which its impact on man and his immediate environment is mitigated. However, the mining, processing, and transporting of phosphate ore and its derived products containing small concentrations of radioactive material potentially expose the local population to radiation levels above those they would encounter if these activities were absent. Mills (1974) states four potential ways in which individuals and the population in general may be exposed to these materials by the acts of phosphate mining, processing, product manufacturing, and product use:

- Air-gases and particles

  Gaseous and particulate radioactive material is released to the air, posing the possibility of inhalation and decreasing overall air quality.

- Water-effluents, runoff, and leaching from wastes

  The radioactive material in the ore or products can enter ground waters, rivers, and other waterbodies through effluent discharges, land runoff, and leaching from waste piles.

- Direct contact

  Direct contact or close proximity to the radioactive materials directly exposes workers, individuals, and the population.

- Food chain

  Because of the application of phosphate fertilizers, the food chain can become contaminated and result in man's ingestion of radioactive material.

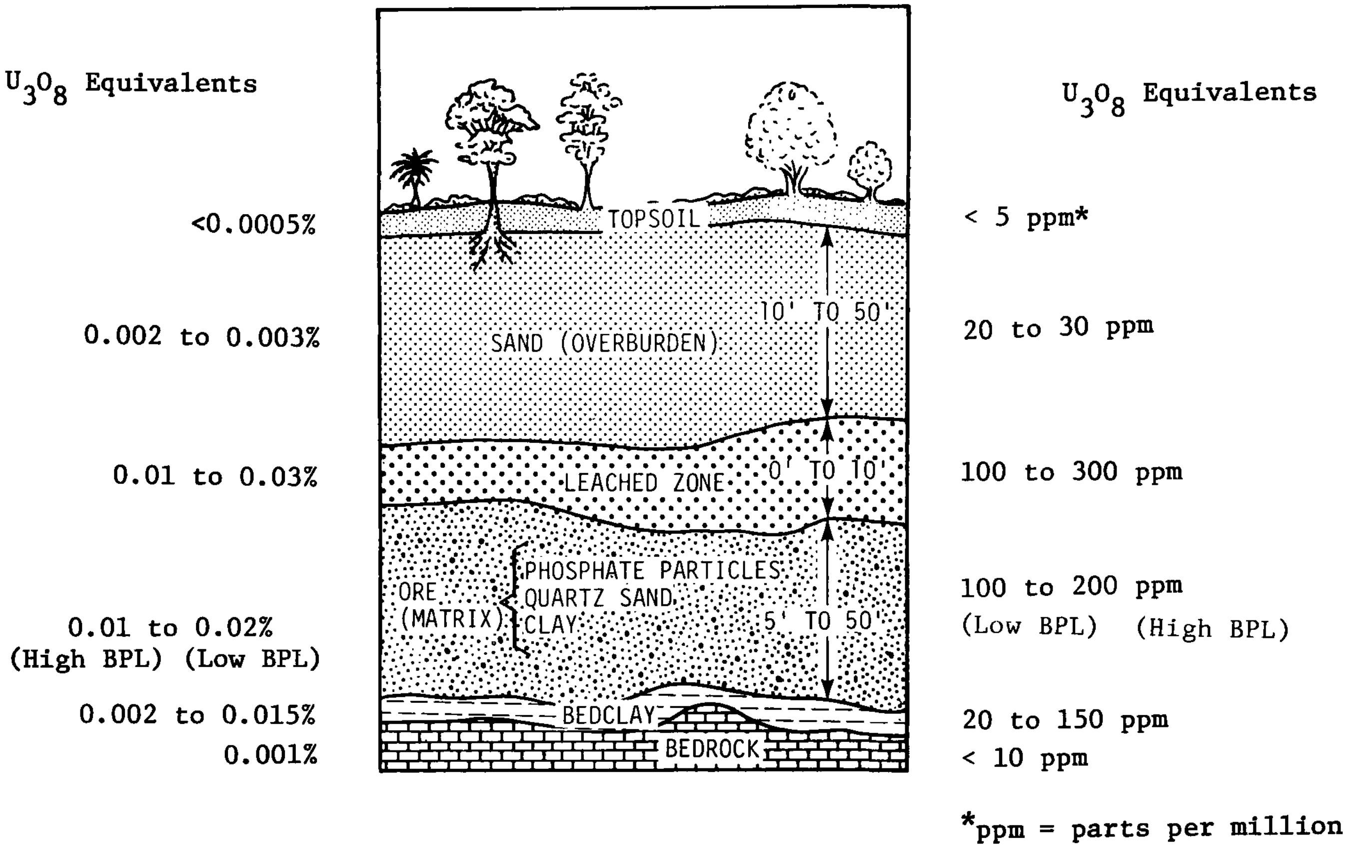


Figure 1.15. Average Uranium Concentrations as U_3O_8 (Altschuler et al 1956, Cathcart 1965, McKelvey 1956) in Typical Central Florida Phosphate District Profile (Fountain and Zellars 1972)

The radionuclides of greatest importance to this program are uranium-238, radium-226, and radon-222. Uranium-238 is important because of its abundance in the area and because it is the parent material that establishes the disintegration rate under conditions of secular equilibrium for the more hazardous daughter products. Of the several uranium-238 decay products, radium-226 and radon-222 (and its principal daughter products)* are the most hazardous to human health if present in sufficient quantities; radium-226 is of particular concern because of its toxic character and its affinity for replacing calcium in bone. (Radium replacement is displayed by the relatively high radium-226 concentrations found in gypsum [$CaSO_4 \cdot 2H_2O$] stacks at the fertilizer manufacturing plants.) Radium-226 may be ingested through drinking water in which the material has been dissolved, through food containing minute quantities of the material, or by breathing dust containing radium contamination. Radon-222,

*Polonium-218, lead-214, bismuth-214, and polonium-214.

an inert gas with a relatively short half-life (3.82 days), can be breathed, along with its decay products, as particulate matter associated with respirable particles of dust.

Man's exposure to radiation can be the result of both external and internal irradiation, i.e., by being near a radiation source or inhaling or ingesting radioactive material. Internal irradiation can be especially harmful to vital organs of the body because of their proximity to the radioactive emitter. Damage from nuclear radiation is thought to be more severe when the body is subjected to large doses in a relatively short time than when the same exposure occurs over a longer time. Long-term effects of low radiation doses are not fully known.

Although guidelines for radiation protection generally are given in terms of dose rate to specific body organs or the whole body above existing natural background levels, all radiation exposure is considered harmful, with adverse effects assumed to be proportional to dose. In other words, a linear theory rather than a threshold hypothesis is accepted.

b. Background Radiation

External gamma radiation levels in Florida approximate 7 to 10 microroentgens per hour, whereas the levels in the area of the Bone Valley phosphate deposits approximate 13 microroentgens per hour. Variances within the study area are common, depending largely on depth of deposits. Overall, external whole-body gamma radiation exposure levels for Floridians are essentially equal to those reported for the average U.S. citizen, i.e., approximately 100 millirems per year. Additional variations in external gamma radiation levels are associated with materials used for construction (primarily roadways) and varied histories of land use, primarily phosphate mining and reclamation, although nearly all are within the range of the background.

Exposures from air principally result from radon-222 gas (and its particulate daughter products) originating from the decay of radium-226 in soils. Average airborne radon-222 levels have been reported to be higher in Bartow than in Orlando or Jacksonville, Florida (Williams et al 1965). Lung dosage from radon-222 is 0.240 rads per year in the Bone Valley area compared with 0.130 in the remainder of the state. According to the Florida Department of Health and Rehabilitative Services (1977), the mean, annual, natural background, working-level (WL) concentration for the area is 0.004 compared with an inferred U.S. average of 0.001. Additional exposure is possible due to dust generated by the drying of phosphate rock and by chemical processing. Table 1.18 indicates the levels of radium emissions associated with chemical processing (USEPA 1977).

Table 1.18. Radium Levels Associated with Phosphate Chemical Processing*

	Air Flow (m^3/min)	Total Op Time (hr)	Total Vol (m^3)	Total Particulates (mg)	Ra-226** (pCi)
GTSP dryer	57	4560	15.6×10^6	5.9×10^8	12.5×10^6
Dry-product (GTSP) shipping	481	500	14.4×10^6	12.4×10^8	26.1×10^6
Phosphate rock grinding	294	3950	69.7×10^6	15.3×10^8	64.1×10^6
Phosphate acid process	54	6460	20.9×10^6	17.6×10^8	$74. \times 10^6$
(rock)	54	4000	13.0×10^6	2.0×10^8	8.4×10^6

*USEPA (1977).

**Radioactive data calculated from Facility Report and previous radioactivity measurements of phosphate rock and GTSP.

In water the principal contaminant is radium-226 (Kaufmann and Bliss 1977). Lower Floridan aquifer water samples from nonmineralized areas in Central Florida exhibit a mean value of 1.4 picocuries per liter, and those for the upper Floridan are 5.1 picocuries per liter. In mineralized but unmined areas, the respective values are 2.0 and 2.3, respectively, with the water-table waters containing 0.17 picocuries per liter. In mineralized and mined areas, the values are 1.96, 1.61, and 0.55, respectively. Radium-226 radioactivity concentrations in waters underlying Sarasota County have been shown to be higher than those of the remainder of the study area; the reasons are apparently related to the outcropping of the Hawthorn formation and the occurrence of monazite sand in the county.

Radioactivity concentrations in homes and other structures built on reclaimed land have been shown to be higher than in structures located on land outside the mineralized, phosphate area. According to the Florida Department of Health and Rehabilitative Services (1978), the average annual excess exposure to daughters of Radon-222 (i.e. average above natural background) for persons living on enhanced [reclaimed] land within the study area is calculated to be 540 millirems per year to the whole lung. They found that: 1) radiation levels on undisturbed non-mineralized land do not approach or exceed the National Council on Radiation Protection and Measurements (NCRP) Maximum Dose Recommendations; 2) radiation levels in structures on undisturbed-mineralized land approach and some exceed those guidelines; and 3) radiation levels in structures built on reclaimed lands approach and some exceed the guidelines.

Radiation exposures to phosphate employees working under normal procedures and conditions have been found to be well within the guidelines for occupational exposures and generally within the guidelines for the general population. Elevated levels of radiation were found only in the vicinity of acidulation tanks and phosphoric acid filters, piping, and filtrate tanks — and these areas are not routinely occupied by workers. Radon progeny levels have been found to be high in rock-loading tunnels, but this can be controlled by proper ventilation. Specific exposures to workers are highly variable (Table 1.19), depending on the absolute localized radioactivity concentrations, the number of hours that the workers spend at the various locales, and the distance to the various concentration levels. Gross alpha radioactivity in vegetables grown in the Bone Valley phosphate region is higher than in vegetables grown outside the region and gross beta radioactivity is slightly higher.

c. Summary

Radiation relative to the phosphate industry is of concern because of its possible adverse health effects. These would be expected to be manifested in cancer statistics, especially lung cancer, which might be induced by inhalation of radioactively contaminated dust emitted by rock and chemical processing and by inhalation of radon progeny, the concentration of which is also affected locally by phosphate industry activities. According to cancer mortality statistics for 1950-69 (U.S. Department of Health, Education, and Welfare 1974), Polk County did not experience an increase in mortality due to lung cancer even though the phosphate industry has been most active within this county. Nationally, the age-adjusted mortality for white males (per 100,000) averages 37.98 nationally and 44.93 for Florida. Polk is 31st of 67 counties when Florida counties are ranked and fourth of the seven in the study area (Table 1.20).

Table 1.19. Representative Radium-226 Concentrations in 7-County Study Area Environment

Item	Radium-226 Concentration	Reference
Background soil	1.5 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Silt	1.1 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Beach sand	0.9 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Reclaimed soil	10-30 pCi/g	Mills et al (1977)
Overburden (excluding leach zone)	10 pCi/g	Kaufmann and Bliss (1977)
Leach zone materials	40 pCi/g	Kaufmann (1977)
Matrix	40 pCi/g 60 pCi/g	Florida Department of Health and Rehabilitative Services (1975) Guimond and Windham (1975)
Wet phosphate rock	29-34 pCi/g 42 pCi/g	Florida Department of Health and Rehabilitative Services (1975) Guimond (1976a)
Sand tailings	7.5 pCi/g 6.2-8.8 pCi/g	Kaufmann and Bliss (1977) Florida Department of Health and Rehabilitative Services (1975)
Slime particles	45 pCi/g 33-52 pCi/g	Kaufmann (1977) Florida Department of Health and Rehabilitative Services (1975)
Slime decant water (dissolved fraction)	1-2 pCi/ℓ	Florida Department of Health and Rehabilitative Services (1975)
Slime decant water (undissolved fraction)	33.5-52 pCi/g	Florida Department of Health and Rehabilitative Services (1975)
Mine water	<1.5 pCi/ℓ	Kaufmann and Bliss (1977)
Ground water	<1.5 pCi/ℓ	Kaufmann and Bliss (1977)
Slime-pond water	<2 pCi/ℓ	Kaufmann and Bliss (1977)
Leachate from gypsum pond	60-100 pCi/ℓ	Kaufmann and Bliss (1977)
Gypsum	21-33 pci/ℓ	Kaufmann and Bliss (1977)
Phosphate products (undifferentiated)	42 pCi/g	Kaufmann and Bliss (1977)
Phosphoric acid plant effluent after double liming	1.8-4.5 pCi/ℓ	Guimond and Windham (1975)
Slag from calcination processes	56 pCi/g	Guimond and Windham (1975)
Water-table water (mineralized mined areas)	0.55 pCi/ℓ	Kaufmann and Bliss (1977)
Upper Floridan water (mineralized mined areas)	1.61 pCi/ℓ	Kaufmann and Bliss (1977)
Lower Floridan water (mineralized mined areas)	1.96 pCi/ℓ	Kaufmann and Bliss (1977)
Ammonium phosphates	5-6 pCi/g	Guimond (1976a)
Superphosphates	21 pCi/g	Guimond (1976a)
Phosphoric acid	<1 pCi/ℓ	Guimond (1977)
Animal feed supplements	5-6 pCi/g	Guimond and Windham (1975)

Table 1.20. Cancer Mortality Rates in Central Florida Phosphate Region, 1950-69*

County	Rate (per yr per 100,000)	Rank in State
Hillsborough	52.5	7
Charlotte	45.0	18
DeSoto	43.9	23
Polk	41.8	31
Sarasota	40.0	35
Hardee	36.3	43
Manatee	36.0	48

*USDHEW (1974).

C. MAN-MADE ENVIRONMENT

1. Demography and Economics

a. Current Population Profile

Florida's population grew by 25 percent between the 1970 population census and July 1975. Table 1.21 shows that growth in four of the seven counties was greater than the substantial increase in the state's population. Charlotte led the list of high-growth counties (a 53 percent increase between 1970 and 1975). DeSoto, Sarasota, and Manatee counties also had greater percentage increases than the state; however, Hardee, Hillsborough, and Polk counties grew less than 25 percent.

Table 1.21. Population by State and Seven Counties in Study Area, 1970 and 1975*

County	April 1, 1970 Census	July 1, 1975 Estimate	Percent Change
Charlotte	27,559	42,190	53
DeSoto	13,060	18,190	39
Hardee	14,889	18,511	24
Hillsborough	490,265	605,597	24
Manatee	97,115	123,506	27
Polk	227,222	275,973	21
Sarasota	120,413	163,172	36
Total	990,523	1,247,139	26
Florida	6,791,418	8,485,230	25

*University of Florida (1975), U.S. Bureau of Census (1970).

The population growth was caused largely by migration rather than by natural increases (Table 1.22).

Table 1.22. Percentage of Growth by Natural Increase and Migration, 1970-75*

County	% Natural Increase	% Net Migration
Charlotte	10.6	110.6
DeSoto	8.2	91.8
Hardee	25.2	74.9
Hillsborough	17.6	82.4
Manatee	-8.4	108.4
Polk	17.9	82.1
Sarasota	-10.7	110.7

*University of Florida (1976).

b. Age Distribution

Age is perhaps the population's most significant feature: a large influx of new residents of any one age group may affect the character of the area's economic base. The median in Charlotte County, for example, is 58.3; half of the residents are 58 or older. Many of the newer residents in the study area are older, a trend which has existed for several years (Table 1.23).

Table 1.23. Median Age of Population by County, 1960 and 1970*

County	1960	1970	1970 % over Age 65
Charlotte	44.8	58.3	35.1
DeSoto	36.5	34.5	15.6
Hardee	29.1	26.6	10.0
Hillsborough	30.4	28.5	10.4
Manatee	41.1	48.7	30.2
Polk	29.1	29.8	12.6
Sarasota	40.5	49.6	28.6

*U.S. Bureau of the Census (1960 and 1970).

New housing units in the study area increased by more than 90,000, or an average of about 3 percent annually, from 1960 to 1970. The number of persons per unit remained the same during 1960-70, but the average per unit dropped from 2.5 to 2.3 from 1970 to 1973. Substandard housing in 1970 exceeded 16,000 of the more than 278,000 units, with Negro-occupied units representing the largest percentage; more than 25 percent of the Negro-occupied units were considered substandard.

c. Income Distribution

Per-capita income and distribution of income are important indicators of an area's economic well-being. Sources of income indicate the ratio of farm to nonfarm and gains to losses.

In the study area, more than $1.4 billion of income results from persons commuting, so worker mobility is obviously important. Table 1.24 shows sources of income, net income, and per-capita income for the study area and for each of its counties, and Table 1.25 shows the 1975 effective buying income per capita and the 1970 median total income per family.

Table 1.24. Distribution of Income, 1973, by Study Area and County of Residence (in thousands of dollars except for per-capita)*

	Study Area	Charlotte	DeSoto	Hardee	Hillsborough	Manatee	Polk	Sarasota
Farm Income	199,101	1,850	11,527	23,520	25,526	23,678	107,121	5,879
Nonfarm Income	1,758,419	70,575	32,958	24,745	140,560	254,823	786,953	447,805
Dividends, Interest, Rent	837,685	42,758	5,452	5,937	248,272	107,127	138,526	289,613
Transfer Payments	748,352	42,307	9,250	7,560	281,219	103,464	147,289	157,263
Adjustment for Commuting	1,439,917	(+)5,836	(-)2,432	(+)5,095	(-)100,747	(+)8,175	(-)38,334	(-)10,018
Contributions to Social Insurance	207,495	3,845	1,562	1,058	117,399	14,201	44,188	25,245
NET INCOME	5,190,972	159,481	55,193	65,799	2,464,769	483,066	1,097,367	865,297
ADJUSTED 1973 PER-CAPITA INCOME	4,409	4,339	3,726	3,938	4,506	4,282	4,311	5,764
ADJUSTED 1970 PER-CAPITA INCOME		3,290	2,586	2,792	3,366	3,294	3,344	4,681

*Business and Economic Dimensions, July-August 1975.

Table 1.25. 1975 Effective Buying Income and 1970 Median Total Income per Family*

	State	Charlotte	DeSoto	Hardee	Hillsborough	Manatee	Polk	Sarasota
1975 Effective Buying Income per Capita	4365	4266	NA	3166	4081	4136	4208	NA
1970 Median Total Income per Household	7117	5362	5434	5254	7100	7740	6566	7739

*Sales Management Magazine

d. Employment/Unemployment

Table 1.26 gives the basic labor market statistics for the seven counties of the study area in terms of percentage changes from March 1973 to March 1974 and from March 1974 to March 1975. Large percentage increases in the number of unemployed and the unemployment rate, along with comparable changes in the ratio of persons employed, can be seen. (The three exceptions are indicated with minus signs.)

Table 1.26. Percentage Changes: Employment/Unemployment

	Percent Change in Unemployed Number		Percent Change in Employment Ratio	
	3/73-3/74	3/74-3/75	3/73-3/74	3/74-3/75
Charlotte	79	150	83	120
DeSoto	267	164	255	133
Hardee	350	-16	291	-7
Hillsborough	37	128	27	117
Manatee	58	209	42	184
Polk	7	47	-2	33
Sarasota	72	250	61	232

The major industries forming the region's economic base are agriculture, construction, manufacturing, mining, trade (both retail and wholesale), transportation, tourism, and government. Collectively, agriculture and construction (the latter is closely related to tourism/retirement) constitute the most significant portion of the economic base. Mining, however, is a significant industry, especially in Hardee and Polk counties, as is manufacturing. Mining, manufacturing, and agriculture derive their significance from the fact that they produce a physical product for export. The region's industrial mix did not change substantially between 1960 and 1970 (see Table 1.27). Except in construction, regional shifts were in accord with the national pattern: while the nation had a slight increase of 0.1 percent, the region declined 1.3 percent. Reflecting the stability, no new industrial categories were introduced, nor did any of the existing industries disappear. The region's industrial mix contrasted significantly with the nation's industrial mix ratio in the following aspects:

- Agriculture decreased only 8.8 percent, contrasting with a nationwide decrease of 44.8 percent.
- The decrease of mining was just about half that experienced by the nation.
- Construction increased 1.7 percent for the nation but decreased 13.4 percent for the region.
- Manufacturing held steady in the region, while decreasing 4.4 percent nationally.
- The transportation decline was about the same for both region and nation.
- The wholesale trade increase nationally was almost double that of the region.
- Retail trade in the region compared favorably with that of the nation.
- Finance, insurance, and real estate were about the same nationwide and regionwide.
- Other industries in the region were about 6.6 percent below the national average.

The 7-county study area has a substantial tourist industry. Exerting a strong influence is the state's largest single tourist attraction, Walt Disney World, which is immediately adjacent to the area. Tourism has been registering a slow but constant growth rate since 1970 (except in 1974, the year of the "gasoline crisis"). State tourism is expected to grow slowly to 1980, averaging 2 percent projected growth in number of tourists.

Table 1.27. Industrial Mix in 7-County Region and U.S., 1960 and 1970

	Percentages					
	1960		1970		Δ/1960	
Industry Category	Region	U.S.	Region	U.S.	Region	U.S.
Agriculture	6.8	6.7	6.2	3.7	-8.8	-44.8
Mining	1.7	1.0	1.5	0.8	-11.8	-20.0
Construction	9.7	5.9	8.4	6.0	-13.4	1.7
Manufacturing	15.6	27.1	15.6	25.9	-0-	-4.4
Transportation	4.0	4.2	3.5	3.7	-12.5	-11.9
Wholesale trade	5.2	3.4	5.8	4.1	11.5	20.6
Retail trade	17.7	14.8	18.9	16.0	6.8	8.1
Finance, insurance real estate	4.5	4.2	5.3	5.0	17.8	19.1
Others	34.8	32.7	34.8	34.8	-0-	6.4

Mining in the 7-county region employed 4453 workers in 1960 and 5047 in 1970, an increase of 13.3 percent. Data supplied by the Florida Phosphate Council showed approximately 2000 more jobs in 1970 than did the census, but the council was reporting all individuals employed by the mining companies, whereas the census was reporting only those individuals actively involved with mining. Mining employment has shown only moderate growth, but the payroll has grown substantially. The divergence is due to the increased earnings of employees. As discussed in subsection A of this section, mining does not appear to have played a significant role in the growth of the region since 1960. This fact, added to the slow growth of tourism and agriculture, indicates that growth has been dirven by other industries — primarily services. It should be noted that this is the trend for the nation as a whole.

e. Projections

Various population projections and the University of Florida estimates of population by county in 1975 are contained in Table 1.28. There were more than 1,250,000 persons in the seven counties in 1975. The low projection (OBERS*E) forecasted an increase to about 1,750,000 by 2000, while the other two

*Office of Business Economics of Department of Commerce and Economic Research Service of Department of Agriculture (since 1972, known as Bureau of Economic Analysis). OBERS E and OBERS EA assume different birth and immigration rates. UF 208 is University of Florida 208.

Table 1.28. Alternative Population Projections (thousands) by County, 1980, 1985, 1990, 2000

	1975	1980			1985			1990			2000		
	UF*	OBERS E**	OBERS EA†	UF 208*	OBERS E	OBERS EA	UF 208	OBERS E	OBERS EA	UF 208	OBERS E	OBERS EA‡	UF 208
Charlotte	42.2	39.8	56.0	56.5	42.1	70.4	70.9	44.6	88.6	85.8	47.0	140.3	119.1
Desoto	18.2	14.7	19.0	22.2	15.4	21.6	26.0	16.1	24.5	29.4	16.8	31.5	35.9
Hardee	18.5	16.5	21.0	21.9	16.9	23.2	25.3	17.2	25.6	28.6	17.7	31.2	35.5
Hillsborough††	605.6	624.2	642.3	691.6	677.0	703.2	757.4	734.4	759.8	810.6	836.9	887.0	907.9
Manatee	123.5	111.8	146.0	150.6	116.9	167.6	176.3	122.2	192.4	200.0	126.5	253.6	241.6
Polk	276.0	289.7	300.0	318.6	313.7	325.0	360.3	339.6	350.7	398.4	381.7	408.4	470.4
Sarasota	163.2	191.5	220.0	200.2	223.5	265.2	238.7	260.9	318.5	274.4	300.8	459.4	418.0
TOTAL	1247.1	1288.2	1404.3	1461.6	1405.5	1576.2	1654.9	1535.0	1760.1	1827.2	1727.4	2211.4	2152.2

*University of Florida (1976).

**U.S. Water Resources Council (1972).

†U.S. Department of Commerce (1975).

‡Derived assuming same percent growths, 1980-90

††OBERS projections derived from projections of Tampa SMSA using University of Florida shares

series forecasted a rise to about 2,200,000 inhabitants. Thus, the two high series predicted that the population of the seven counties would almost double in the last quarter of the 20th century.

Almost half the total population of the seven counties lived in Hillsborough in 1975, and OBERS E predicted that Hillsborough would maintain this share to the year 2000 (Table 1.29). Polk would also retain its share of over one-fifth but Sarasota would increase its share at the expense of the remaining four counties. Both the OBERS EA and UF 208 forecast a decline of about 40 percent in Hillsborough's share. The University of Florida projections foresaw a constant share for Polk, but OBERS EA predicted a substantial decline. OBERS EA and UF 208 expected Charlotte and Manatee to gain.

2. Land Use

a. Current Land Use

More than 75 percent of the land use in the study area (Table 1.30 is classified under four Level-I and Level-II categories:* rangeland, 31.28 percent; cropland and pasture, 22.18 percent; wetland, 12.34 percent; and orchards-groves, 9.44 percent. All Level-II categories under "Urban or Built

*USGS land use-land cover classifications.

Table 1.29. Alternative Projections by County Shares (Percentages) in Regional Total Population

COUNTY	1975 UF	1980 OBERS E	1980 OBERS EA	1980 UF 208	1985 OBERS E	1985 OBERS EA	1985 UF 208	1990 OBERS E	1990 OBERS EA	1990 UF 208	2000 OBERS E	2000 OBERS EA	2000 UF 208
Charlotte	3.4	3.1	4.0	3.9	3.0	4.5	4.3	2.9	5.0	4.7	2.7	6.3	5.5
Desoto	1.5	1.1	1.0	1.5	1.1	1.4	1.6	1.1	1.4	1.6	1.0	1.4	1.7
Hardee	1.5	1.3	1.2	1.5	1.2	1.5	1.5	1.1	1.5	1.6	1.0	1.4	1.7
Hillsborough	48.6	48.5	44.4	47.3	48.2	44.6	45.8	47.8	43.2	44.4	48.5	40.1	42.2
Manatee	9.9	8.7	8.0	10.3	8.3	10.6	10.7	8.0	10.9	11.0	7.3	11.5	11.2
Polk	22.1	22.5	20.6	21.8	22.3	20.6	21.8	22.1	19.9	21.8	22.1	18.5	21.9
Sarasota	13.1	14.9	13.6	13.7	15.9	16.8	14.4	17.0	18.1	15.0	17.4	20.8	15.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 1.30. Generalized Land Use, 7-County Study Area, 1975

Applicable LUDA Levels Level I/Level II	Area Hectares	(Acres)	Percent of Study Area
Urban or Built Up			
Residential	79,345.1	(196,059)	5.49
Commercial and services	8,738.8	(21,593)	0.61
Industrial	10,358.3	(25,595)	0.72
Transportation, communications, and utilities	7,459.1	(18,431)	0.52
Industrial and commercial complexes	558.1	(1.379)	0.04
Mixed Urban or built-up areas	5,787.1	(14,300)	0.40
Other urban or built-up areas	22,428.5	(55,420)	1.55
Agricultural Land			
Cropland and pasture	320,404.6	(791,709)	22.18
Orchards, groves, vineyards, nurseries, and ornamental horticultural areas	136,324.6	(336,854)	9.44
Other agricultural land	-	-	-
Rangeland	451,741.5	(1,116,238)	31.28
Forest Land	69,649.3	(172,101)	4.82
Water	67,411.0	(166,570)	4.67
Wetland	178,267.9	(440,494)	12.34
Barren Land			
Strip mines, quarries, and gravel pits	45,073.4	(111,375)	3.12
Other barren land	40,714.9	(100,605)	2.82
Study Area Total	1,444,262.2	(3,568,723)	100

Up" (Level I) total only 9.33 percent of the study area and are not distributed evenly; instead, they are located primarily along the Gulf Coast between Tampa and Sarasota along major transportation arteries. In the case of the concentration between Tampa and Sarasota, "Urban and Built-Up" areas follow the main transportation route, I-275 (U.S. 41). There is another concentration between Tampa and Lakeland along I-4 and U.S. 92. In the interior, this category is scattered.

The Level-I categories "Agricultural Land" and "Rangeland" dominate the interior of the study area. The majority of the former is in the Level-II category "Cropland and Pasture." The other Level-II category with a large representation in the study area is "Transitional Areas" (those areas that are in transition from one land use to another). The largest concentration of this category is a large, unoccupied subdivision north of Charlotte Harbor in Charlotte and Sarasota counties. Under the Level-I category "Barren Land," the Level-II category "Strip Mines, Quarries, and Gravel Pits" comprises only 3.12 percent (111,375 acres) of the entire study. Polk County has a noticeable concentration, however (102,742 acres); 12.5 percent of the county is in this land-use category. (This category does not take into account how long mined land has been mined - or mining has ceased - nor its condition in regard to revegetation.)

USGS maps do not reveal the presence of reclaimed land, but there is much in Polk County where phosphate mining has been the most extensive. Reclaimed land is typically converted to improved pasture ("Land and Lakes").

Present land-use patterns are affected by not only the physical environment but also the economic forces and regulatory factors. Landownership is closely related to the economic influences on land use. Landowners participate in land-use decisions that are frequently dictated by the desire to maximize profits. Phosphate companies own approximately 14 percent of the study area (225,466 hectares, or 557,120 acres), but their land-use decisions are within the constraints of local, regional, and state land-use regulations even though profit-oriented.

b. Future Land Use

Table 1.31 summarizes actual areas and projected changes in land use in the 7-county study area.

Table 1.31. 7-County Study Area Generalized Land Use, 1975 and 2000

Applicable LUDA Level I/Level II	1975 Hectares	1975 Acres	1975 % of Study Area	1985 % of Study Area	2000 Hectares	2000 Acres	2000 % of Study Area	% Change: 1975-2000	2035 % of Study Area
Urban or Built Up									
Residential	79,345	196,059	5.49	7.05	119,291	294,764	8.26	50.5	11.08
Commercial and services	8,739	21,593	0.61	0.70	10,965	27,094	0.76	24.6	0.87
Industrial	10,358	25,595	0.72	1.13	15,562	38,451	1.08	50.0	0.95
Transportation, communications, and utilities	7,459	18,431	0.52	1.15	16,470	40,697	1.14	119.2	1.16
Industrial and commercial complexes	558	1,379	0.04	0.07	583	1,441	0.04	0	0.04
Mixed Urban or built-up areas	5,787	14,300	0.40	0.40	5,826	14,396	0.41	2.5	0.41
Other Urban or built-up areas	22,429	55,420	1.55	1.65	25,152	62,147	1.74	12.3	1.95
Agricultural Land									
Cropland and pasture	320,405	791,709	22.18	20.46	299,396	739,800	20.73	-7.0	21.35
Orchards and groves	136,325	336,854	9.44	9.02	127,384	314,760	8.82	-6.8	8.35
Other agricultural land	-	-	-	-	-	-	-	-	-
Rangeland	451,742	1,116,238	31.28	29.38	422,286	1,043,455	29.24	-7.0	28.91
Forest Land	69,649	172,101	4.82	3.81	58,784	145,255	4.07	-18.4	4.67
Water *	67,411	166,570	4.67	4.72	68,038	168,120	4.71	0.9	4.71
Wetland	178,268	440,494	12.34	12.21	176,145	435,247	12.20	-1.1	12.15
Barren Land									
Strip mines, quarries, and gravel pits	45,073	111,375	3.12	4.98	51,070	126,193	3.54	13.5	0.17
Other barren land	40,715	100,605	2.82	3.27	47,070	116,308	3.26	15.6	3.23
County Total	1,444,262	3,568,723	100.00	100.00	1,444,262	3,568,723	100.00		100.00

*Surface water acres will be higher than this estimate, according to industry projections (see Tables 2.5 and 2.7).

1) Urban or Built Up

Between 1975 and 2000, this Level-I category will experience a 44 percent increase in land use; primary impetus will be from the Level-II categories "Residential," "Industrial," and "Transportation, Communications, and Utilities" (Table 1.31). The industrial growth will be related primarily to the phosphate industry, while additional power-plant construction will increase the area devoted to this land-use class. Residential expansion will occur primarily along the Gulf Coast, along existing and planned major transportation arteries (e.g., I-4, I-75, I-7, and U.S. 92 and 41), and in the scattered existing population modes along lesser transportation routes (e.g., U.S. 17).

2) Agricultural Land

This Level-I category will decrease approximately 7 percent over the 7-county study area, representing displacement of former agricultural land by both the "Urban and Built-Up" category and phosphate mining. Displacement by phosphate mining is temporary, however, and reclamation of mined lands will undoubtedly return some of the former agricultural land, especially improved pasture, to production. This reclamation will continue after the year 2000, as evidenced by an increase in agricultural land between 2000 and 2035 (Table 1.31).

3) Rangeland

Rangeland will decline 7 percent between 1975 and 2000, primarily because of expansion of the "Urban and Built-Up" category. Former rangeland in DeSoto County, however, will be occupied by a Florida Power & Light power-plant complex. Also, some former rangeland will be converted to strip mines.

4) Forest Land

This Level-I category will decline more in total area (18.4 percent) between 1975 and 2000 than any other Level-I category, and more will be displaced by phosphate mining than by urban expansion.

5) Water

Water, which includes all surface water, will increase over the 7-county study area between 1975 and 2000 by only 0.9 percent.

6) Wetlands

The reader is asked to refer to the discussion of terrestrial biota, which appeared in subsection B of this section.

7) Barren Land

The Level-I category "Barren Land" includes two entirely different and distinct Level-II categories, "Strip Mines" and "Other Barren Land." Almost all of the strip-mined area in the seven counties of the study area except a few sand and gravel pits will be for phosphate. The area occupied by phosphate mining is expected to increase 13.5 percent between 1975 and 2035. The "Other Barren Land" category, which includes land having "less than one-third of the area with vegetation or other cover" or lands "in an obvious state of transition" (Anderson et al 1976), is expected to increase 15.6 percent between 1975 and 2035.

A majority of the planners and phosphate industry representatives contacted considered that the area in this Level-I category has been overestimated for the year 2000 and that, although some formerly mined areas will not have been completely reclaimed, 3.26 percent of the study area (47,070 hectares, or 116,308 acres) will not be in transition.

c. Archeological, Historical, and Recreational Resources

The 7-county study area contains 791 historical and archeological sites listed on the State of Florida Master Site File (Florida Division of Archives, History, and Records Management 1976). Most sites (62 percent) are classed as "prehistoric," i.e., predating the 16th century. A number of federal, state, and local laws offer varying degrees of protection to archeological resources but do not exempt them from the possibility of disturbance. Most archeological sites are extremely fragile and would be permanently altered or destroyed if mined. Any site listed on the Florida Master Site file is considered for inclusion in the National Register.

The study area also has a variety of public and private recreational sites. Public recreational areas are administered at state and federal levels by such agencies as Florida Division of Recreation and Parks, Florida Game and Fresh Water Fish Commission, Florida Division of Resource Management, U.S. Fish and Wildlife Service, and National Park Service. All counties in the study area have county and municipally sponsored parks; the number and facilities vary widely. Also contributing to the recreational resource base of the study area are private recreational areas such as golf courses, marinas, and campgrounds. Table 1.32 indicates by county the total number of hectares (acres) in recreational areas.

Table 1.32. Extent of Recreational Areas in Seven Counties of Study Area

County	Total Hectares (Acres) in Recreational Areas	
Hillsborough	8,578.0	(21,196.0)
Manatee	4,753.6	(11,746.1)
Sarasota	8,761.8	(21,650.4)
Charlotte	25,443.9	(62,871.8)
DeSoto	90.5	(223.6)
Hardee	312.3	(771.7)
Polk	28,818.2	(71,209.7)
Total	76,758.3	(189,669.3)

SECTION 2

ALTERNATIVES ASSESSMENT

A. ASSESSMENT METHODOLOGY

The effects assessment methodology used on the Central Florida Phosphate Industry Areawide Impact Assessment Program consisted of a rational, methodical series of events within a system's (holistic) point of view performed by a highly interactive interdisciplinary team of experts. These events are outlined in Figure 2.1.

A 2-dimensional array (sometimes called a matrix) was prepared for the central Florida phosphate industry (Plate 2) to:

- Display causative factors from the alternatives, as well as beneficial and adverse significant effects
- Inventory environmental elements (i.e., entities, properties, or processes affecting man directly or through his relationship to his natural, societal, or economic environment) to give technical direction to the staff and assure thoroughness
- Reveal interactions among the elements within each group (i.e., alternative versus environmental elements)

The matrix was used also to formulate plans for avoiding, minimizing, or mitigating adverse effects and enhancing beneficial effects; the display includes interacting elements and the nature and effect of their interaction. When alternative plans were modified, effects were modified and each matrix for the appropriate alternatives summarized to the limit of quantification to reflect the overall stature of each alternative with respect to the environmental elements.

Elements for inclusion in an environmental effects (EE) matrix were determined based on a priori information, scenarios describing alternatives, laws and regulations, input from affected governmental and private groups, and guidance from the steering and the advisory committees. The steering committee consisted of representatives of the Federal Departments of the Interior (Fish and Wildlife Service, Geological Survey, and Bureau of Mines); Army (Corps of Engineers) and Agriculture; the Office of Federal Activities of the EPA; the

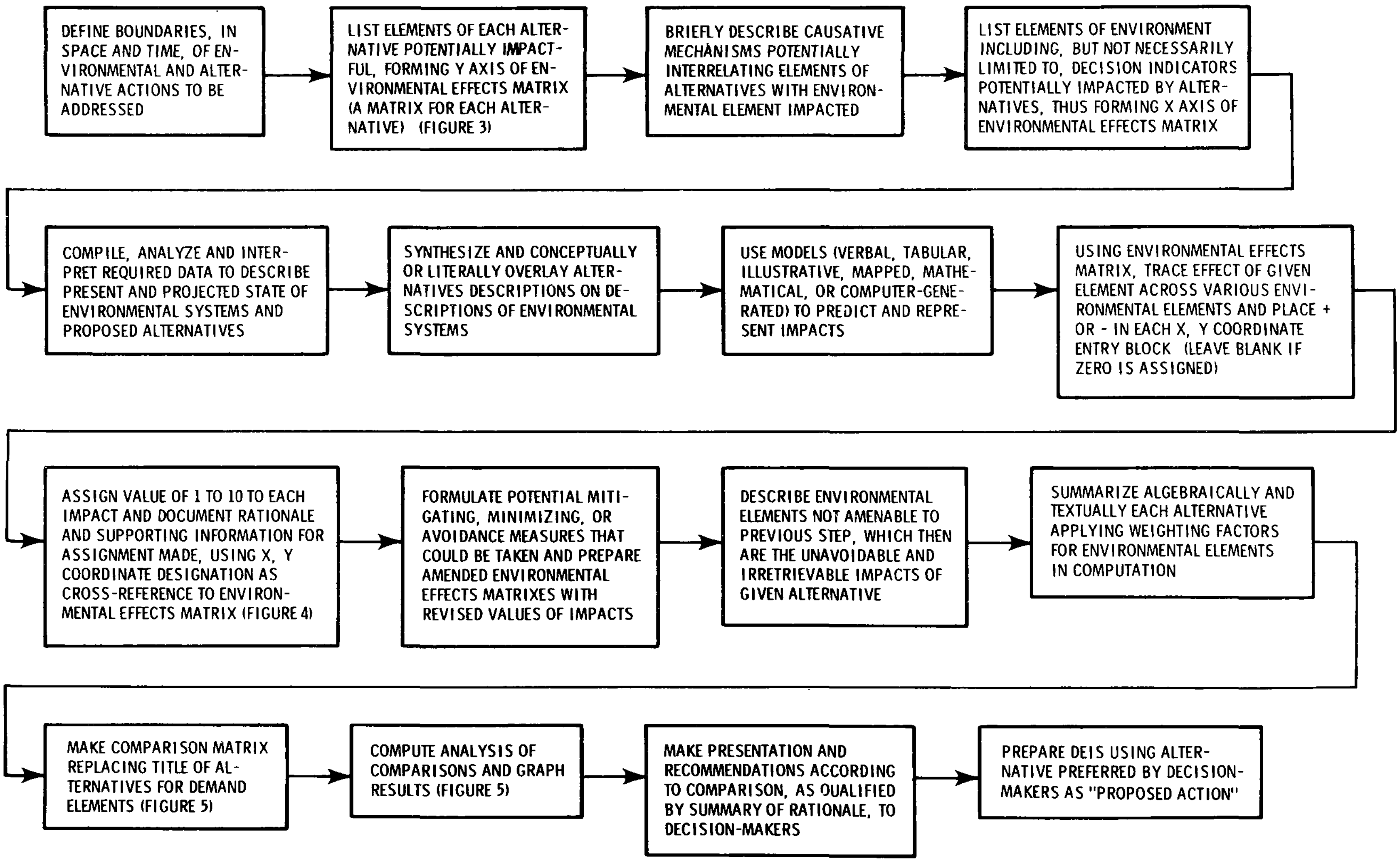


Figure 2.1. Flowchart of Methodology for Environmental Impact Assessment

President's Council on Environmental Quality; and the Florida Department of Environmental Regulation. The advisory committee consisted of representatives of each of the seven counties in the study area (Hillsborough, Manatee, Sarasota, Charlotte, DeSoto, Hardee, and Polk), the Florida Audubon Society, the Southwest Florida Water Management District, and the Florida Phosphate Council. Elements listed under "alternative demand elements" represent causative factors. The listed environmental elements were based on government guidelines, implementing instructions, a priori knowledge, and investigative results as appropriate to the planning area and represented the decision indicators established by the committees.

During an intensive workshop with each discipline (key team member), represented environmental effects of alternative scenario causative elements were assigned a (-), (0), or (+), depending on whether they are respectively adverse, neutral, or beneficial. Accompanying each alternative EE matrix is a set of narratives describing the rationale behind the assignment of each (-) or (+) effect.

Values reflecting change from the baseline (without action alternative) relative to "least regret" conditions were assigned on a scale of 1 (slight) to 10 (great), as determined by an expert in that field, and the effects were algebraically added under each environmental element. With the concurrence of the decision-makers, elements showing greatest effects received the greatest time and effort for detailed analysis, thus assuring adequate information on the elements needed for good decisions.

From the summary matrix, alternative scenarios were compared. Committee members assigned each environmental element a weighting coefficient reflecting its relative importance to the issues to be evaluated by the decision-makers. Thus, weighted and unweighted magnitudes of effect were obtained.

B. INVESTIGATION OF DECISION ALTERNATIVES

Various alternatives have been proposed as the basis for assessing the effects of the central Florida phosphate industry. To assess effects and determine impacts, the environmental setting (present and projected through the year 2000) was figuratively overlaid with projections of conditions that would occur according to each alternative for environmental regulation of the phosphate industry. The decision to be made was which alternative presents the least regrettable effect on the environment.

To ensure that relevant information was brought forth to aid in the decision-making, the description of the alternatives is an important consideration. The first description was in the form of a scenario that conveyed the intent of that alternative. (Scenario is a synopsis of a play; in terms of regulatory policy decisions, it conveys a theme and intent of administrative action.) Each scenario then was described in terms operational for the assessment of environmental effects. In this subsection, each scenario is described in terms that convey the issues of potential effects, thus giving direction to the assessment of effects.

The list of alternative scenarios investigated resulted from interagency review of the issues involved, as perceived by interested private parties, industry, and federal, state, and local governments. Additionally, EPA solicited comments by newsletter. The form of the following scenarios represents revisions subsequent to that effort:

2.11 Permit Existing and New Sources

The development of the phosphate mining and processing industry associated with the issuance of National Pollution Discharge Elimination System (NPDES) (Section 402) and Section 404 of PL 92-500 permits to existing and new source phosphate facilities, all of which would meet effluent and receiving water standards applicable as of the date of the contractor's proposal to EPA; Florida Department of Environmental Regulations (DER) and EPA permits to air sources meeting requirements of the Clean Air Act and regulations promulgated pursuant to the Act, including but not limited to nonsignificant deterioration requirements, standards of performance for new stationary sources; and other local state and federal permits applicable as of the date of the contractor's proposal to EPA. Current reclamation requirements are also to be included.

2.12 Require Process Modifications for New Sources

1) Elimination of slime ponds

2) Chemical processing of wet rock (eliminate drying process)

3) Dry conveyor for matrix from mine to beneficiation

4) Recovery of fluoride from recirculated process water, including scrubber water

5) Uranium recovery from all phosphoric acid

6) Impervious lining for recirculated process water ponds at chemical plants

2.13 Required Reduced Water Usages

A) Existing Facilities

1) Chemical Processing (including elemental phosphorus and animal feed ingredient plants). Complete recirculation of all cooling and process water. Design for containment of cooling and process water for up to 10-year, 24-hour maximum rainfall event to meet BPT effluent limitations.

2) Mining and Beneficiation
Complete recirculation of all water, except surface runoff from undisturbed areas. Design for containment of 10-year, 24-hour rainfall event.

B) New Facilities

1) Chemical Processing (including elemental phosphorus and animal feed ingredient plants). Complete recirculation of all cooling and process water. Design for containment of cooling and process water for up to 25-year, 24-hour maximum rainfall event. Discharges as a result of rainfall exceeding the equivalent of a 25-year, 24-hour rainfall event to meet Standards of Performance for New Sources.

2) Mining and Beneficiation
Complete recirculation of all water, except surface runoff from undisturbed areas. Design for containment of 25-year, 24-hour rainfall event.

2.14 Control Activities in Waters of U.S. and Wetlands

A) No mining or development of facilities for processing (beneficiation or chemical processing) in either waters of the United States or wetlands as defined by EPA and the Corps of Engineers in regulations promulgated pursuant to the Federal Water Pollution Control Act, as amended, Section 404.

B) Any disturbed wetlands are to be restored to provide at least an equivalent habitat for any species on the Important Species List for which habitat existed prior to mining. Restoration is to be accomplished so that no more than 10 percent of such habitat is destroyed at any one time.

2.15 Existing Source Permits Only

No development of phosphate mining and processing beyond that associated with the issuances of section 402 and 404 permits for existing sources, all of which would meet effluent and receiving water standards applicable as of the date of the contractor's proposal to EPA; Florida DER and EPA permits to air sources meeting requirements of the Clean Air Act and regulations promulgate pursuant to the Act, including but not limited to nonsignificant deterioration requirements, standards of performance for new stationary sources; and other appropriate local, state, and federal permits applicable as of the date of the contractor's proposal to EPA. This scenario constitutes the "no-action" alternative as required by the NEPA.

From the scenario language and information provided by the EPA, private industry, and various federal, state, and local agencies, a translation was made, resulting in descriptions operationally useful for assessment efforts.

The scenarios range from no further permitting of effluent or air discharges beyond those sources existing as of August 1, 1976, to permitting all applicants pending review as of August 1, 1976. Between these extremes and serving as considerations with them are scenarios related to water conservation, technological process modifications, and development in waters of the U.S. and wetlands.

Additionally, with the use of information supplied by individual phosphate companies in response to a land-use questionnaire, scenario 2.11' was constructed, which represents the sum of the individual plans of present and future operators in westcentral Florida (Plate 4).

1. Issuance of Existing Source Permits Only ("Without Action" Alternative)

This scenario imposes the condition that only mining operations and processing plants permitted as of August 1, 1976, will be allowed to operate. Applicable permits relate to the Federal Water Pollution Control Act (PL 92-500), Sections 402 and 404, for existing sources; Environmental Protection Agency and Florida Department of Environmental Regulation requirements of the Clean Air Act; and other local, state, and federal permits applicable as of August 1, 1976, including reclamation. The immediate impact of the limitations is to eliminate the opening of any additional mining sites and expansion or construction of new processing plants.

According to information at EPA's Region IV, 18 mines and 15 processing plants are operating under existing permits. One of the mining companies also will reprocess old mine tailings for additional phosphate rock not previously considered economical to recover. In addition, several companies are expected to conduct scavenger operations to recover high-grade phosphate rock from old tailings (Hoppe 1976).

From current information on present production and reserves in permitted mines, the probable annual mining rates in the study area under the limitations established by this scenario have been estimated by mine and are shown in Figure 2.2. In Figure 2.3, these rates are compared with production projections under other scenarios. Figure 2.4 presents supply-demand projections for Florida and the United States (U.S. Bureau of Mines 1975). Table 2.1 indicates world phosphate reserves and resources, and Table 2.2 presents reserves and resources for the 7-county study area.

Based on the tonnage in Figures 2.2 and 2.3, Table 2.3 displays a projection of water withdrawal for the phosphate mining industry based on the constraints imposed by this scenario. Ground water is the primary source of this supply, but one mine now obtains a portion of its supply from surface water and another plans to do so in the near future. With current emphasis on conservation of water resources, the mining companies probably will be able to reduce their makeup water requirements further.

For phosphate chemical processing plants, water consumption cannot be estimated on the basis of per-ton of rock mined because not all of the mined rock is processed locally; the processing plants can operate on imported phosphate rock supplies as the land supply diminishes. However, the 15 permitted plants in the study area use an estimated 93,040,000 gallons per day.

The primary source of energy for the phosphate mining and processing industry is electricity. The main supplier of electric power in the study area is Tampa Electric Company, with lesser amounts supplied by Florida Power Corporation and Florida Power and Light Corporation. During 1975, electrical energy requirements by the phosphate mining and processing industry in the study area totaled approximately 3.845 billion kilowatt-hours. Under the arrangement

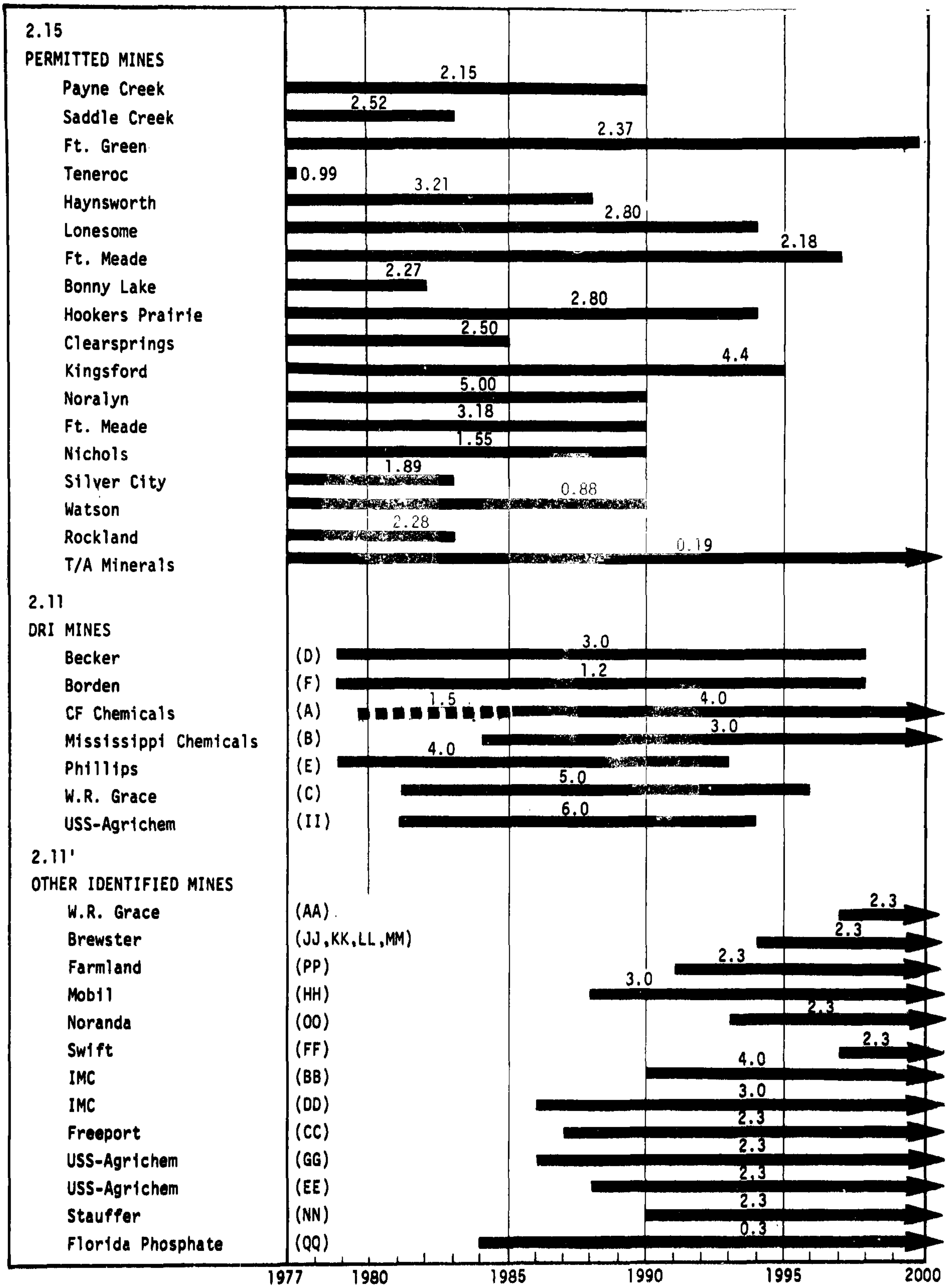


Figure 2.2. Projected Life and Production Rates ($X10^6$ tons/year) for Central Florida Phosphate Mines. (Capital letters in parentheses refer to Plate 1.)

between the phosphate companies and the power companies, a substantial portion of the electrical service is interruptible during periods of peak demands or emergencies. Thus, the service is provided at lower rates than would be possible without the interruptible feature. Florida Power Company reports that this eliminates the need for 200 megawatts of generating capacity for peaking purposes (FPC, FP&L, TEC personal communications 1977).

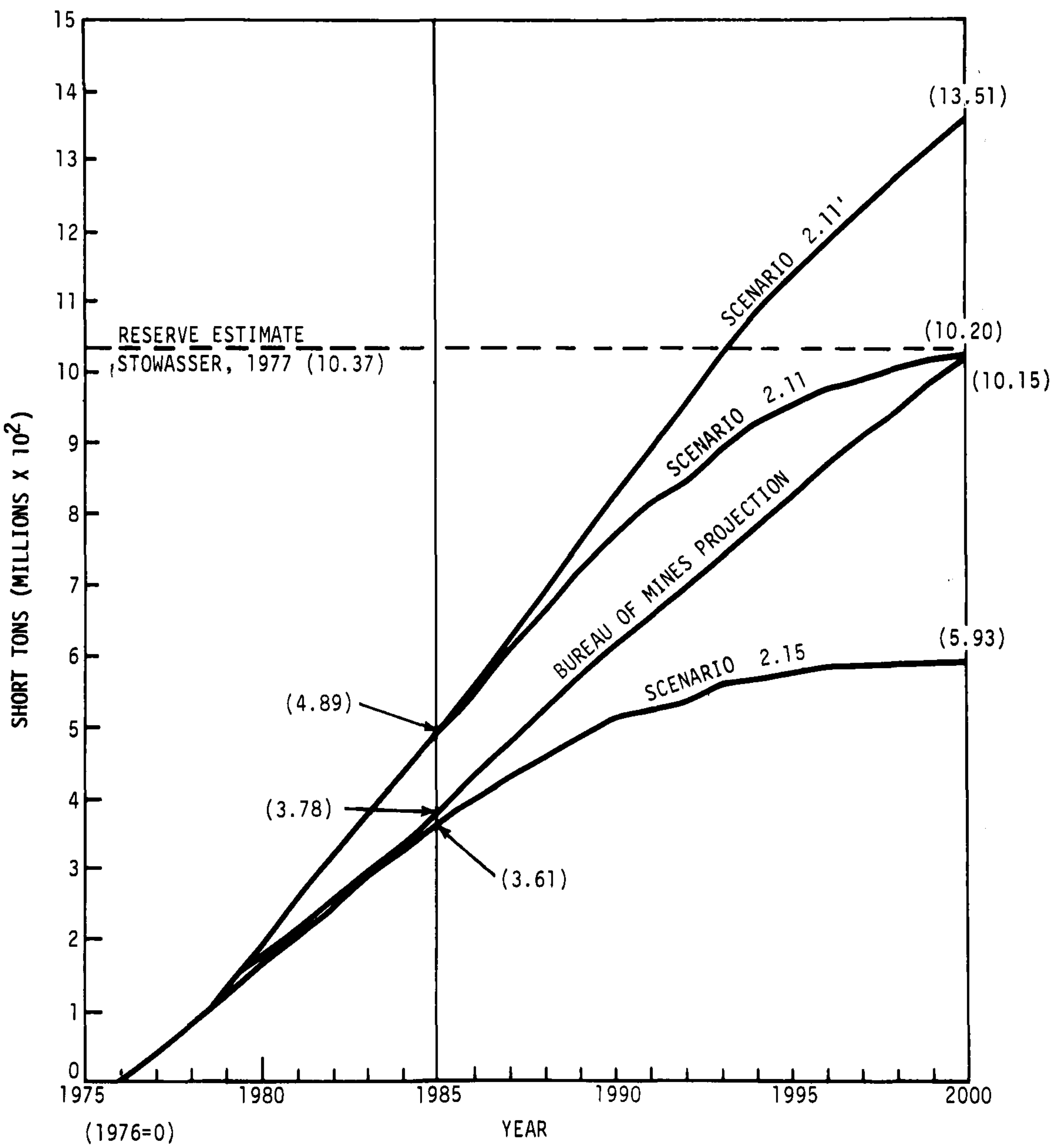


Figure 2.3. Cumulative Projected Production Estimates for Central Florida Phosphate Industry

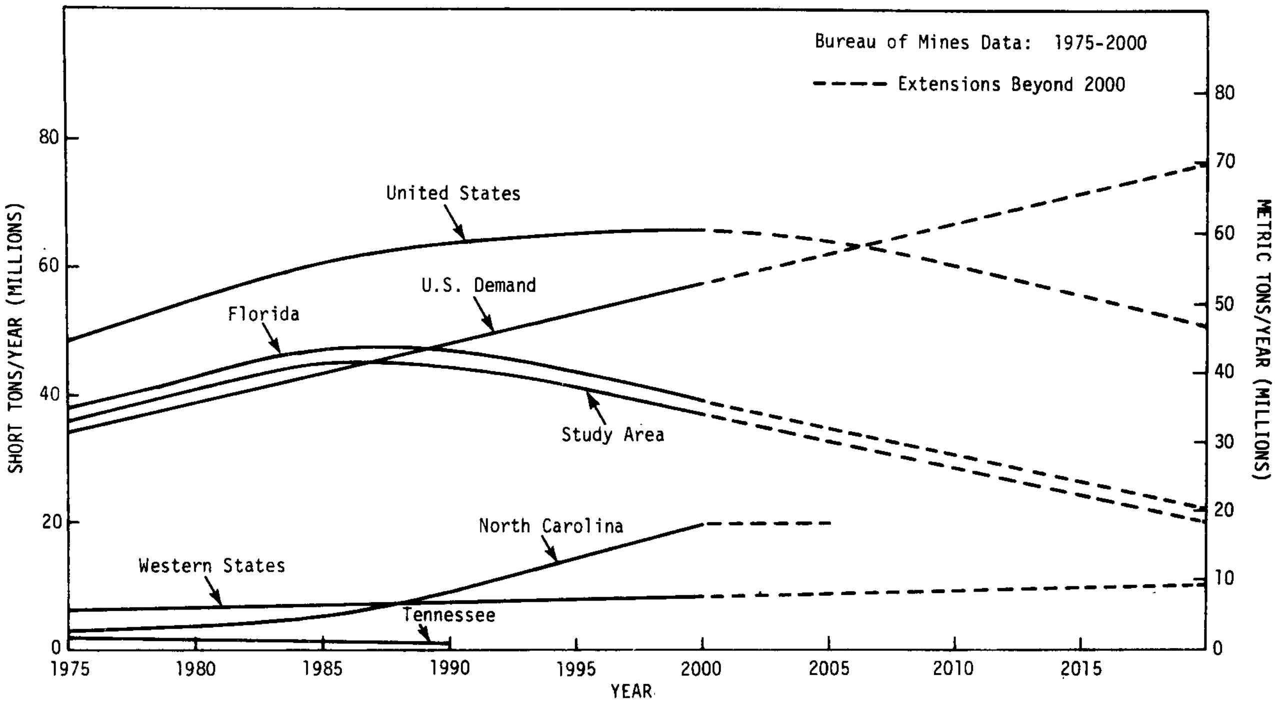


Figure 2.4. Phosphate Rock Supply-Demand Projections (Stowasser 1977a)

Mining emissions to the atmosphere are relatively minor. Particulate matter resulting from open burning during land clearing, as well as fugitive dust from mining operations, would be the primary concern. Processing plants are monitored for particulates, fluoride, sulfur dioxide, nitrogen oxide, and acid mist, depending on the type of process.

Liquid-waste discharges must meet the standards set by the National Pollutant Discharge Elimination System for existing sources as administered by the Environmental Protection Agency.

The regulation under which the Florida Department of Natural Resources regulates mine reclamation is Chapter 16 C-16 of the Florida Administrative Code. No reclamation program can include more than 640 acres, which must be contiguous. Use of reclaimed land requires consideration of the radiation environment resulting from mining and reclamation. Tables 2.4 through 2.7 present mining and reclamation acreages estimated to occur under Scenarios 2.15, 2.11, and the "industry view" 2.11'.

Table 2.1. Assessment of World Phosphate Reserves and Resources*

	Millions of Metric (Short) Tons					
	Reserves†		Other Resources		Total Resources	
North America						
U.S.	2,268	(2,500)	4,082	(4,500)	6,349	(7,000)
Other	< 2	(2)	< 2	(2)	4	(4)
Total	2,269	(2,502)	4,083	(4,502)	6,352	(7,004)
South America	73	(80)	381	(420)	454	(500)
Europe						
USSR	726	(800)	2,902	(3,200)	3,628	(4,000)
Other	27	(30)	64	(70)	91	(100)
Total	753	(830)	2,966	(3,270)	3,719	(4,100)
Africa						
Algeria	100	(110)	36	(40)	136	(150)
Egypt	181	(200)	181	(200)	363	(400)
Morocco	9,070	(10,000)‡	45,350	(50,000)	54,420	(60,000)
Senegal	118	(130)	64	(70)	181	(200)
South Africa	91	(100)	45	(50)	136	(150)
Spanish Sahara	1,542	(1,700)	1,814	(2,000)	3,356	(3,700)
Tunisia	454	(500)	1,361	(1,500)	1,814	(2,000)
Other	91	(100)	91	(100)	181	(200)
Total	11,646	(12,840)	48,942	(53,960)	60,588	(66,800)
Asia						
China	54	(60)	NA	(NA)	NA	(NA)
Israel	36	(40)	NA	(NA)	NA	(NA)
Jordan	91	(100)	NA	(NA)	NA	(NA)
North Vietnam	64	(70)	NA	(NA)	NA	(NA)
Syria	454	(500)	NA	(NA)	NA	(NA)
Other	18	(20)	NA	(NA)	NA	(NA)
Total	308	(340)	1,814	(2,000)	2,122	(2,340)
Oceania						
Australia	907	(1,000)	1,814	(2,000)	2,721	(3,000)
Pacific Islands	108	(120)	27	(30)	136	(150)
Total	1,016	(1,120)	1,841	(2,030)	2,857	(3,150)
World Total	16,065	(17,712)	60,027	(66,182)	76,092	(83,894)

NA = not available.

†Estimated recoverable reserves at $27.66 per short ton published by Phosphate Rock Export Association 70 BPL price f.o.b. Florida plant, effective July 1, 1974, and competitively marketed at this selling price.

‡Minimum; reserve may be as large as 40 billion tons.

*Stowasser(1975)

Table 2.2. Estimated Phosphate Rock Reserves and Resources in 7-County Study Area*

County	Recoverable Phosphate Rock: Measured Reserves [metric (short) tons in millions]		Measured Subeconomic Resources	
Polk	402.7	(444)	95.2	(105)
Hillsborough	181.4	(200)	13.6	(15)
Manatee	164.2	(181)	149.7	(165)
Hardee	176.0	(194)	299.3	(330)
DeSoto	16.3	(18)	63.5	(70)
Sarasota				
Charlotte				
Total	940.6	(1,037)	621.3	(685)

*Stowasser 1977b.

Table 2.3. Estimated Phosphate Industry Water Demands on Floridan Aquifer, 1976-2000*

	Million Gallons per Day (mgd)								
	Chemical Plants			Mining/Beneficiation			Totals		
Scenario	1976	1985	2000	1976	1985	2000	1976	1985	2000
2.15	93.04	94.49	94.49	259.27	260.72	101.28	352.31	355.21	195.77
2.11	Same	Same	Same	Same	304.05	124.11	352.31	398.54	218.6
2.11'	Same	Same	Same	Same	310.84	257.29	352.31	405.33	351.78

*Deviations described in Volume V, Section 1, of working papers (TI 1977e)

Table 2.4. Summary of Projected Acreage Estimates, Central Florida Phosphate Industry

	Hectares/Acres (thousands)					
	Mined		Reclaimed*		Reclaimed 2.12(1)*	
Scenario	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	19.9/49.1	32.6/80.6	19.6/48.4	39.2/96.8	22.5/55.5	40.1/99.1
2.11	27/66.7	56.3/139.1	23.7/58.5	60.3/148.9	27.7/68.5	63.1/155.8
2.11'	27/66.7	74.3/183.7	23.7/58.5	72.3/178.6	27.7/68.5	78.8/194.8

*Includes carryover acreage in slime ponds from years prior to 1977.

Table 2.5. Summary of Projected Estimates of Mining and Reclamation Acreage by River Basin

		Hectares/Acres (thousands)						
		Mined		Reclaimed		Reclaimed to Lakes		
Scenario	River Basin	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000	
2.15	Hillsborough	-	-	-	-	-	-	Existing Mines
	Peace (east)	14.1/34.9	19.5/48.3	13.9/34.4	25.4/62.8	5.2/12.9	7.2/17.9	
	Peace (west)	-	-	-	-	-	-	
	Little Manatee	.12/0.3	1.4/3.5	.12/0.3	1.7/4.2	.04/0.1	.53/1.3	
	Manatee	-	-	-	-	-	-	
	Alafia	5.8/14.4	10.0/24.8	5.5/13.7	12.1/29.8	2.1/5.3	3.7/9.2	
	Myakka	-	-	-	-	-	-	
2.11	Hillsborough	-	-	-	-	-	-	Existing, DRI Mines and USS Agrichem
	Peace (east)	16.4/40.5	27.9/68.9	15.1/37.3	32.6/80.6	6.1/15.0	10.3/25.5	
	Peace (west)	1.6/4.0	5.5/13.6	.85/2.1	4.8/11.9	.61/1.5	2.0/5.0	
	Little Manatee	.73/1.8	3.6/8.8	.45/1.1	3.6/8.9	.28/0.7	1.3/3.3	
	Manatee	.28/0.7	2.2/5.5	.16/0.4	1.9/4.7	.12/0.3	.81/2.0	
	Alafia	6.3/15.6	12.0/29.7	5.8/14.3	13.8/34.1	2.3/5.8	4.5/11.0	
	Myakka	1.9/4.6	3.6/9.0	.97/2.4	3.2/7.8	.69/1.7	1.3/3.3	
2.11'	Hillsborough	-	-	-	-	-	-	All Identified Mines
	Peace (east)	16.4/40.5	34.0/84.1	15.1/37.3	36.7/90.7	6.1/15.0	12.6/31.1	
	Peace (west)	1.6/4.0	10.9/26.9	.85/2.1	8.4/20.8	.61/1.5	4.0/10.0	
	Little Manatee	.73/1.8	4.9/12.1	.45/1.1	4.5/11.1	.28/0.7	1.8/4.5	
	Manatee	.28/0.7	2.2/5.5	.16/0.4	1.9/4.7	.12/0.3	.81/2.0	
	Alafia	6.3/15.6	13.4/33.0	5.8/14.3	14.7/36.3	2.3/5.8	4.9/12.2	
	Myakka	1.9/4.6	7.5/18.5	.97/2.4	5.7/14.2	.69/1.7	2.8/6.8	

Table 2.6. Summary of Projected Production and Reclamation Acreage Projections by County and Scenario

		Hectares/Acres (thousands)					
		Mined		Reclaimed		Reclaimed 2.12(1)	
Scenario	County	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	Polk	18.5/45.7	29.8/73.7	18.2/45.0	35.8/88.5	20.9/51.6	36.7/90.6
	Hillsborough	1.4/3.5	2.8/6.9	1.4/3.4	3.4/8.3	1.6/3.9	3.4/8.5
	Manatee						-
	Hardee					-	-
	DeSoto					-	-
2.11	Polk	20.1/49.6	33.8/83.6	19.0/47.0	39.3/97.0	22.1/54.5	40.6/100.2
	Hillsborough	2.6/6.4	4.1/10.2	2.0/4.9	4.5/11.1	2.4/6.0	6.9/17.0
	Manatee	2.6/6.5	7.2/17.8	1.4/3.4	6.2/15.4	1.9/4.7	7.0/17.3
	Hardee	.97/2.4	7.2/17.9	.50/1.2	6.3/15.5	.69/1.7	7.0/17.4
	DeSoto	.77/1.9	1.7/4.1	.40/1.0	1.5/3.6	.57/1.4	1.6/4.0
2.11'	Polk	20.1/49.6	36.8/90.9	19.0/47.0	41.2/101.8	22.1/54.5	43.1/106.5
	Hillsborough	2.6/6.4	6.3/15.6	2.0/4.9	5.9/14.7	2.4/6.0	8.8/21.7
	Manatee	2.6/6.5	11.3/27.8	1.4/3.4	8.9/22.1	1.9/4.7	10.6/26.1
	Hardee	.97/2.4	14.1/34.9	.50/1.2	10.8/26.8	.69/1.7	9.4/23.3
	DeSoto	.77/1.9	3.6/9.0	.40/1.0	2.5/6.3	.57/1.4	3.4/8.3

Table 2.7. Summary of Projected Reclamation Acreage Projections to Land and Water by County and Scenario

		Hectares/Acres (thousands)							
		Land		Water		Land 2.12(1)		Water 2.12(1)	
Scenario	County	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	Polk	11.5/28.4	22.6/55.8	6.8/16.7	13.2/32.7	13.2/32.5	23.1/57.1	7.7/19.1	13.6/33.5
	Hillsborough	.85/2.1	2.1/5.2	.53/1.3	1.3/3.1	1.0/2.5	2.2/5.4	.57/1.4	1.3/3.1
	Manatee	-					-		
	Hardee								
	DeSoto								
2.11	Polk	12.0/29.6	24.7/61.1	7.0/17.4	14.5/35.9	13.9/34.3	25.5/63.1	8.2/20.2	15.0/37.1
	Hillsborough	1.3/3.1	2.8/7.0	.72/1.8	1.7/4.1	1.5/3.8	4.3/10.7	.89/2.2	2.5/6.3
	Manatee	.85/2.1	3.9/9.7	.53/1.3	2.3/5.7	1.2/3.0	4.4/10.9	.69/1.7	2.6/6.4
	Hardee	.32/0.8	4.0/9.8	.16/0.4	2.3/5.7	.45/1.1	4.5/11.0	.24/0.6	2.6/6.4
	DeSoto	.24/0.6	.93/2.3	.16/0.4	.53/1.3	.36/0.9	1.0/2.5	.20/0.5	.61/1.5
2.11'	Polk	12.0/29.6	25.9/64.1	7.0/17.4	14.9/36.7	13.9/34.3	27.2/67.1	8.2/20.2	15.9/39.4
	Hillsborough	1.3/3.1	3.8/9.3	.72/1.8	2.2/5.4	1.5/3.8	5.5/13.7	.89/2.2	3.2/8.0
	Manatee	.85/2.1	5.6/13.9	.53/1.3	3.3/8.2	1.2/3.0	6.6/16.4	.69/1.7	3.9/9.7
	Hardee	.32/0.8	6.8/16.9	.16/0.4	4.0/9.9	.45/1.1	5.9/14.7	.24/0.6	3.5/8.6
	DeSoto	.24/0.6	1.6/4.0	.16/0.4	.93/2.3	.36/0.9	2.1/5.2	.20/0.5	1.3/3.1

2. Permit Existing and New Sources

This scenario presumes the central Florida phosphate industry in terms of the conditions of the first scenario but extends its scope to include potential new mining operations and processing plants. Considered in addition to sites that were permitted as of August 1, 1976, are potential new mines and plants that were pending review by EPA, Region IV, as of that date. Under the conditions imposed by this scenario, facility applications that were made after August 1, 1976, are not included; data are not readily available since many of the potential new mines and plants are still in the planning stage. Applicable permits, as in the scenario dealing with issuance of existing sources only, are those relating to the Federal Water Pollution Control Act (PL 92-500), Sections 402 and 404, for existing and new sources; Florida DER and EPA requirements of the Clean Air Act; and other local, state, and federal permits applicable as of August 1, 1976, including reclamation.

Under this scenario, seven new mines and no new chemical processing plants are projected (see Figure 2.2). It was assumed that all new facilities would be classified as new sources. The potential new sites are distributed throughout Hillsborough, Manatee, Hardee, and DeSoto counties, mostly along the southern portion of the Bone Valley formation, and all except three are outside the existing mining area in Polk County.

According to Stowasser (1977a), the U.S. Bureau of Mines in 1973 reported 0.943 billion metric (1.037 short) tons of recoverable reserves in the district. Present operations, which are centered around Mulberry, will inevitably be extended south. In the central Florida mining district, generally high-BPL-grade material with a pebble-to-feed ratio of 1:1 occurs along the upper periphery of the "horseshoe." Splitting the horseshoe north-south is the Lakeland-Bartow ridge, a zone containing medium-BPL-grade material with a pebble-to-feed ratio that can reach 3:1. The southern part of the deposit, extending into Hardee and Manatee counties, contains matrix of much lower grade: pebble of 55-68 percent BPL and feed heads of 12-20 percent BPL, with a low ratio of pebble-to-feed that, when mined, will send increased percentages of the matrix to flotation mills. Throughout the district, there are variations in matrix thickness and quality, pebble-to-feed ratios, slime-settling rates, and chemical qualities of plant water. Such variations have a distinct effect on recovery.

The estimated 1.037 billion tons of phosphate rock reserves in the area are also said to contain 150,000 tons of recoverable U_3O_8. Florida reserves also represent the largest known source of fluorine (averaging 3-4 percent) in the U.S. Both U_3O_8 and fluorine are now being recovered from acid plants and sold as commercial byproducts of phosphate production (Hoppe 1976). One of the new processing plants listed by EPA is to be a uranium-recovery operation. One of the new mining operations will combine the reprocessing of old tailings with the mining of virgin land.

Development of Regional Impact (DRI) application information has been utilized wherever possible in preparing projections. For activities that have not yet reached the DRI application phase, estimates have been made using information currently available about permitted mines. From DRI information currently available about predicted production rates and estimated reserves for the new mines, the probable annual mining production rates in the study area have been estimated in accordance with this scenario. These rates are compared with the projections for the scenario of issuing permits to existing sources only and the Florida curves as shown in Figure 2.3.

As previously mentioned, groundwater consumption is a matter of great concern to the residents throughout the study area. The addition of the proposed facilities would place an even greater load on the groundwater supplies of the region. It is estimated that each ton of rock makes a water demand on the Floridan aquifer of 1500 gallons; with the production tonnages indicated in Figure 2.2, water withdrawal by the phosphate mining industry was projected (Table 2.3); as in the first scenario, the projection was based on present water consumption and did not take into account any reduction in makeup water that the mining companies may achieve in the future. Again, the primary source of supply is the Floridan aquifer, although two of the future mining operations include plans for obtaining at least portions of their required supply from surface water.

In examining water consumption by the phosphate processing plants, significant problems are encountered. As previously mentioned, not all of the mined rock is processed by local plants; furthermore, the nature of the various chemical processes makes it impractical to estimate water consumption on the basis of production rates for phosphate-related products. Based on the total consumption rate for the 15 existing plants reported by 12 of them, an average of 5,200,000 gallons per day per plant was determined (SWFWMD 1977). Calculations to include the plants under this scenario forecast a total annual consumption of 94,490,000 gallons per day by all existing and proposed plants in the study area. The processing plants are fixed operations which, in all likelihood, will continue to operate on imported phosphate rock as the central Florida mines are exhausted. Therefore, the water consumption rate probably will remain approximately at this level at least until the local mines are depleted; at that time, the cost of phosphate rock imported to fully utilize plant capacity may cause a reduction of production rates for economic reasons.

Electricity will continue to be the primary source of energy for the phosphate mining and processing industry. Currently, the main supplier is Tampa Electric Company, followed by Florida Power Corporation and then Florida Power & Light Corporation (TEC, FPC, FP&L personal communication 1977). FP&L, however, will assume larger portions of the load as mining shifts from the existing mines in Polk County southward into the new Hardee and DeSoto sites. Existing plants that continue to operate in Polk and Hillsborough counties as mining activities there decrease will require electric power. In addition, a new uranium-recovery plant that is to be constructed in Tampa (discussed earlier) will be supplied by Tampa Electric Company. The net result of the conditions set forth by this scenario will be an increase in the amount of power supplied to the study area by FP&L and gradual reduction in the amounts supplied by Tampa Electric and FPC.

Environmental, pollution-control, and reclamation measures are virtually the same as those discussed in the first scenario.

3. Require Process Modifications for New Sources

By direction of the steering and advisory committees, process modifications under this scenario were to be practical and feasible, as evidenced by their use by present phosphate industry operators. Such is the case except for the last one — impervious lining for recirculated process water ponds at chemical plants. For the purposes of the Central Florida Phosphate Industry Areawide Impact Assessment, this scenario is considered to be applicable to those operations under Scenario 2.11 not permitted as of August 1, 1976. Operational descriptions of each proposed modification for the purposes of impact assessment follow.

a. Elimination of Slime Ponds

The beneficiation of mined materials is required to separate as much phosphate as possible from the nonphosphate. The process results in two waste materials: slimes (waste clays) and tailings (sand). Control and management of tailings are not an environmental problem, but the disposal of slimes is. Conventional methods involve large settling areas (30-60 percent of mined lands); and reclamation to support agricultural uses requires 5-20 years, and the land cannot be used for industrial or commercial development involving structures larger than most single-family dwellings. Thus, the phosphate industry's temporary use of the land becomes less temporary, depending on the desired land-use category subsequent to the mining. Other environmental problems are caused by slime-pond dam breaks (the most recent in 1971 on the Peace River), pipeline or drainage breaks (the most recent in August 1977 on the Alafia River), and discharges of inadequately settled slimes. The clay particles clog the gills or other membranous surfaces of aquatic organisms, preventing oxygen transfer.

There are two lines of strategy for eliminating slime ponds: one involves a change in process procedures; the other, a change in reclamation procedures. The most recent literature regarding the former describes a dry-mining calcination-digestion process (USEPA 1976). The concept involves dry-mining the matrix, upgrading by dry methods, calcination, digestion to produce phosphoric acid, and returning gypsum and acid-insoluble byproducts to the mining pits. If successfully implemented, the process would result in closed-loop operation involving the disposal of all of the major mining and chemical plant byproducts in mine pits without aboveground dikes and ponds, utilization of at least 90 percent of the actually mined phosphate values, a major reduction in the deep-well water makeup requirements, and complete elimination of slime-pond environmental hazards and potential fluorine runoff, leaching, and evaporation from gypsum ponds.

Bench-scale studies were performed cooperatively among the EPA (Region IV and Research Triangle Park), USS Agri-Chemicals, and the Minnesota Minerals Research Center. Results using matrix samples reflecting major types of phosphate deposits found in the Florida Bone Valley formation were as follows.

- Matrix Upgrading

  This was required in order to minimize fuel costs of the calcination process and to eliminate some of the metal impurities such as iron, aluminum, and magnesium. Methods other than wet scrubbing require a nearly dry matrix. Because of the high water table found in central Florida, matrix deposits contain 30-60 percent by weight water. Drainage of the water from the matrix is generally poor, depending on the clay content. Piling aboveground results in draining to only 20 percent by weight water. Thus, to be dry-processed, matrix must be dried (a costly energy-consuming process). To remove inert components such as sand in order to reduce the mass to be calcined after drying, an electrostatic technique was used. However, clay particles coating phosphate particles caused interference. An alternative process by W.R. Grace and Company that was demonstrated to be feasible combined drying and grinding in a vertical attrition column in which a high-velocity airstream was recirculated and dust (clay) and matrix separated at the top in cyclones. Sand in the phosphate fraction was separated by electrostatic treatment.

- Calcination and Digestion

  Current processes recover about 65 percent of the total P_2O_5 value from the matrix. The calcination process did not measure up to this efficiency, primarily because of the solubility of aluminum, which responded least to the treatment but was prevalent in the tested samples.

Because of the technical problems with the solubility of aluminum and the high fuel requirements of upgrading the new matrix, it was recommended that this line of research be discontinued.

For the Central Florida Phosphate Industry Areawide Impact Assessment program, slime elimination seems to be more practically a problem of slime-pond reclamation because of the seemingly dead end reached by the strategy for modifying the processes used. Thus, attention was directed to the phosphatic-clays research program jointly sponsored by the U.S. Bureau of Mines and central Florida phosphate industry operators. Treatment and disposal methods feasible and operational to date to decrease the size and longevity of slime ponds include flocculation to decrease the time interval for settling and dewatering the clays and combining sand tailings and slimes to fill mine cuts (TI 1977h, 1977j; Bromwell 1976). The solids content of the sand-clay mixture ranges from

50 to 90 percent, resulting in landfill suitable for reclamation within 2 years for pasture that will adequately support cattle and farm vehicles. Subsequent subsidence could occur, limiting subsequent land uses to those in which overburden pressures are no greater than those resulting from agricultural production. The sand-clay mixture process is being used by Brewster Phosphates, and the flocculation method is being evaluated at mines operated by Mobil Chemical, Swift Chemicals, and USS Agri-Chemicals. The following is an excerpt from a letter written by Richard Timberlake, plant manager of Brewster Phosphates, to the EPA:

> "With regard to the sand-clay mix which we have adopted for our reclamation technique, I would not say we have 'eliminated slimes ponds,' but we are restricting our enclosing dams to about 4 feet above level ground and are attempting to confine our clay and sand waste disposal to mined-out cuts. A brief description of the Brewster Phosphates technique follows:
>
> Waste Disposal and Land Reclamation
>
> "There are three waste products generated in the mining of phosphate rock in Florida: overburden, phosphate clays, and sand. The overburden and sand tailings offer no particular disposal problem except one of volume. Phosphatic clays are approximately 80 percent minus 20 microns and enter the settling reservoirs as 3-5 percent slurry. Historically, some 65 percent of mined lands have been transformed into settling areas for disposal of waste clays. The settling areas are surrounded by high dams, and large quantities are stored above natural ground. Reclaiming of settling areas is slow, and the lands restored have very limited use — usually light agriculture or wildlife sanctuaries. In the reclamation technique employed at Brewster Phosphates, most of the waste clays are stored below natural ground, where the phosphatic clays settle to 12-15 percent quite rapidly. By spraying the tailings sand over the consolidated clays, the sand penetrates and mixes with the clays, liberating water and producing a thick sand-clay mixture. After the mixture has consolidated and the excess water is drained off, the overburden is spread over the surface with a wheel excavator and stacker and is graded in a manner which will minimize erosion and facilitate proper site drainage. The land is then fertilized and seeded with appropriate vegetation. By utilizing Brewster Phosphates' method of storing the phosphatic clays below natural ground, a greater percentage of land is available for general purpose or utility use as opposed to light agriculture or wildlife sanctuaries. The lands reclaimed have potentially higher resale value, and liability from possible dam failures is reduced significantly...

"Dr. Bromwell has followed our sand-clay reclamation work for almost 3 years at Haynsworth Mine. I believe Les can give you a thorough technical opinion of the scheme.

"Costs that are generated in disposing of tailings, water, and clay handling in the field (called circulation and settling) and land reclamation vary widely; however, I believe that the traditional method of handling and disposing of clay plus reclamation will generate a cost of from $0.70 to $1.00 per ton of rock. In our judgment, our sand-clay method will generate the same costs; we see it as a stand-off cost-wise as opposed to the traditional method."

b. Chemical Processing of Wet Rock

For purposes of effects assessment, this process is applicable to that portion of the mined and beneficiated rock to be chemically processed in the 7-county study area. Wet-rock grinding facilities are in fullscale operation in phosphoric acid plants at the Plant City complex of C.F. Industries, at Agrico Chemical's Faustina (Louisiana) facility, and at both the old and new plants of W.R. Grace's Bartow complex. Wet-rock grinding has four advantages: it

- Reduces by about half the capital expense — from receipt of unground wet rock through the point of feeding it into the acid processing system.
- Eliminates dry-rock dust pollution.
- Improves fuel economy by 2.5 gallons per ton of phosphate rock ground, which combines with electrical power savings to reduce operating costs by $3.00-$4.25 per ton of P_2O_5.
- Improves reliability, thus, reducing the required amount of surge of ground rock. If a plant is located near a mine, a rock slurry can be pumped directly to the plant from the mine, eliminating rail transportation and belt conveyors (Houghtaling 1975, Loughrie 1976).

c. Dry Conveyor for Matrix from Mine to Beneficiation Plant

The term "dry conveyor" is a misnomer, since the matrix conveyed from the mine to the beneficiation plant is wet. The system in operation at Brewster Phosphates' Lonesome Mine in Hillsborough County is the process referred to here and is described in the following excerpt from a letter to the EPA from Richard Timberlake, plant manager:

Mining

"Mining at the pit follows the conventional method where the dragline removes approximately 24 feet of overburden which is predominately (sic) fine sands with intermittent seams of sandy clay. The dragline then casts the 12-foot strata of matrix into an earthen sump where high-pressure water monitors are used to slurry the matrix for pumping. The matrix, on a dry basis, contains about one-third recoverable phosphate, one-third quartz sand, and one-third phosphatic clays. The material is transported through pipeline up to 7,500 feet to a screening station where +3-inch material is discarded. The -3-inch +3/4-inch material is crushed by a mechanical impactor and mixed with the -3/4-inch slurried matrix. The -3/4-inch material is pumped another 2000 feet to 48-inch diameter hydrocyclones where the phosphatic clays are removed and pumped to the waste disposal area. The cyclone apex product, at about 70 percent solids, discharges directly onto the conveyor belt where it is transported to the plant for processing.

Transportation

"The overland conveyor belt system consists of 14,500 feet of 54-inch wide steel cable-reinforced belt traveling at a speed of 885 feet per minute. Unlike conventional conveyors which are powered only at the end, this system is powered by intermediate drive modules spaced an average of 1200 feet apart. Energy is transferred from electric motors to the belt by steel-belted radial tires that run on and grip the edge of the belt. Fewer idlers, a less massive terminal structure, and simplified takeups are employed with the new belt system. The matrix discharges off the end of the belt into a tank where it is reslurried and pumped the final 2000 feet to a 3-section washer.

"The belt system will require substantially less electrical energy than a pipeline slurry system. Other savings include lower maintenance cost and significantly lower capital replacement cost over abrasive resistant pipe and associated pumping equipment.

Processing

"At the washer, the deslimed matrix is washed, scrubbed, and screened to produce a clean +20-mesh final pebble product which is about 50 percent of the mine's total salable phosphate values. The -20-mesh material is flotation plant feed and is prepared for flotation in the sizing section. Final preparation of the plant feed is the removal of tramp, +20-mesh material which is returned to the washer, and the remaining -150-mesh clays via bin overflows that report to two

550-foot diameter thickeners. The solids settle out in the thickener and are pumped to holding ponds. The clear water is drawn off the periphery of the thickener and reused in the plant.

"Feed to the flotation plant is dewatered to 75 percent pulp density with 24-inch diameter cyclones, then conditioned with anionic reagents. The conditioned feed flows by gravity to 500-cubic-foot mechanical flotation cells where the gangue (sands) sinks to the bottom of the cells and is removed as waste. The froth (rougher concentrate) is collected for further treatment.

"The rougher concentrate is dewatered with cyclones, mixed with water and sulfuric acid, and sent to a series of acid mixers for scrubbing and cleaning to remove the anionic reagent from the surfaces of the feed. From the wash boxes, the second flotation step occurs when cleaner (cationic) float flows by gravity to 500-cubic-foot mechanical flotation cells where the sand tailings float and the phosphate sinks. The tailings sand combines with the waste from the first flotation step and is pumped to the 54-inch overland belt conveyor where 24-inch diameter cyclones are used to remove the water from the solids. The cyclone apex product, at about 70 percent solids, discharges directly onto the bottom strand of the belt and is transported to the waste disposal area. The cyclone overflow flows by gravity into the water-holding ponds.

"That gives you a pretty good idea of how our mine and beneficiation plant is constructed and how it operates. It is not true that water conservation results from the use of the overland conveyor, since matrix is slurried at the pit and pumped to the belt in the traditional method. Desliming occurs near the mining operation, a fact which eliminates long-distance pumping."

The cost of purchasing and installing the Brewster conveyor belt system is 38 percent more than a matrix-tailings pumping system, but annual maintenance and replacement costs are estimated to be 55 percent lower, and power demand is 12 percent that of the pumping system.

d. Recovery of Fluoride from Recirculated Process Water, Including Scrubber Water

Recovery of fluoride from phosphoric acid is in use by USS Agri-Chemicals and W.R. Grace. The net environmental benefit is the recovery of an otherwise waste product as a byproduct. Fluoride emissions from gyp ponds are reduced, as is the amount which must be scrubbed from phosphoric acid reactor emissions. A description of the processes used at USS Agri-Chemicals and W.R. Grace is excerpted as follows from letters to the EPA:

> "As a result of development engineering in the late 1960s to generate a means of diluting concentrated sulfuric acid with wet-process phosphoric acid pond water and thereby eliminate production problems with respect to conventional sulfuric acid dilution coolers and simultaneously create a negative water balance in the phosphoric acid pond water system, an offshoot of this work was devised and a process resulted which would recover fluosilicic acid (FSA) from phosphoric acid.
>
> "Our (USS Agri-Chemicals) process uses 22 percent of P_2O_5 recycle phosphoric acid from the filtration wash steps as a diluent for diluting 98 percent sulfuric acid. The heat of dilution drives off silica (sic) tetrafluoride (SiF_4) from the 22 percent recycle stream, along with water vapor. The hydration product is a 25 percent H_2SiF_6 fluosilicic acid of extremely low P_2O_5 content. Conventional processes for stripping FSA during phosphoric acid evaporation produce FSA containing between 0.5 and 2 percent P_2O_5. Our process consistently produces FSA with a content well below 0.3 and frequently under 0.1 percent P_2O_5 (100 percent H_2SiF_6 basis).
>
> "We installed a commercial unit which became operational in May 1970 as a first of its kind at a total capital cost of $1.5MM. In addition to reclaiming FSA through the recycle acid dilution route, we built certain flexibilities in the commercial plant to innovate recovery of FSA from fluorine scrubber systems from the triple super phosphate (TSP) manufacture and from steam stripping of the final concentrated phosphoric acid. The latter two process adjuncts did not prove satisfactory and have since been abandoned. I cannot project accurately the capital costs of a unit designed and built for recycle acid service only on today's cost basis but would guess at least $2.5MM.
>
> "Since this was an entirely new concept and the process conditions were extremely severe, the operating costs and profit benefits have been considerably less than satisfactory. Mechanical and corrosion problems resulting from the stringent operating conditions have led to prohibitive maintenance costs. The process deals with high-temperature mixes of sulfuric acid and phosphoric acid in an atmosphere of fluoride compounds, all of which contain abrasive, precipitated SiO_2 and calcium sulphate (gypsum). The high temperatures tend to promote the anhydride formation of calcium sulphate, and scaling is a serious problem. We have learned to live with the process and, though it now performs well, it is a costly operation.

"The fluoride recovery system in the W.R. Grace phosphoric acid plant is the Swift & Co. process licensed to Grace by Swift. Fluorides are recovered in the form of hydrofluosilicic acid (H_2SiF_6) of approximate 25 percent strength. The process recovers approximately 65 percent of the fluorine in these vapors as 25 percent hydrofluosilicic acid, which calculates to approximately 25 percent fluorine recovery from the total coming in with the phosphate rock. The vapors leaving the phosphoric acid vacuum evaporators are scrubbed under vacuum with a recirculating solution of hydrofluosilicic acid whose temperature is approximately that of the vapors. Little or no water is condensed while the SiF_4 and HF are absorbed in the fluosilicic acid solution. The lean vapors from the fluorine scrubber are then passed to the usual barometric condenser for total condensation. A specific gravity controller activates a valve which discharges the H_2SiF_6 to storage when up to the desired strength. Makeup water then flows into the hot well through a float control valve."

Reported costs of fluoride recovery operations exceed prices by 25 to 36 percent. Fluoride is marketed for the fluoridation of water supplies and for use as an industrial chemical.

e. Uranium Recovery from All Phosphoric Acid

This process would result in less radioactive material in phosphate products since the uranium extraction process occurs after the initial digestion of phosphate rock by sulfuric acid, resulting in phosphoric acid and calcium sulfate (gypsum). The gypsum is a waste product and is separated from the process flow. Therefore, gyp piles at chemical processing plants contain radioactive material, as do the slimes resulting from beneficiation, as well as the leach zone overlying the phosphate rock matrix that is redistributed by the mining and reclamation activities.

Generally, the concentration of uranium in phosphate ore of the same mesh size in Florida tends to be directly proportional to the P_2O_5 concentration (Guimond 1976). As a rule-of-thumb for planning purposes, a pound of U_3O_8 per ton of P_2O_5 occurs in the types of deposits found in central Florida (Hurst 1977). At a full-capacity operation of 4,570,000 tons per year (Ross 1975), the 12 phosphoric acid plants in operation in the 7-county study area would pass 4,570,000 pounds of U_3O_8 per year (approximately 19.4 percent of

1975 U.S. uranium production). The current price of U_3O_8 is approximately $40 per pound. Cost of recovery from phosphoric acid is approximately $15 per pound. Thus, if all central Florida phosphoric acid plants used uranium recovery at 90-95 percent efficiency, an annual industry of $182,800,000 with costs of $68,650,000 would result — an attractive economic incentive with positive environmental-quality benefits — and the uranium would replace the energy equivalent of 97-129 million barrels of oil. (A pound of U_3O_8 is approximately equivalent in energy to 21.7 to 28.2 barrels of oil.)

Uranium Recovery Corporation has built a central processing plant near Mulberry with a capacity to handle six extraction modules located at phosphoric acid plants where initial extraction occurs. The concentrate is trucked to the Mulberry plant. Two modules are installed at the W.R. Grace Bartow complex, and two will be in operation soon at IMC's Mulberry complex (Ross 1975, Leaders 1977). Gardinier recently announced intentions to construct in Gibsonton a $15,000,000 plant designed to extract 200 tons of uranium per year. A subsidiary of Westinghouse is developing an extraction facility at Farmland Industries, a pilot plant is in operation at Agrico Chemical in South Pierce, and Freeport Minerals' Uncle Sam (Louisiana) plant which processes Florida phosphate rock is presently extracting uranium at commercial scale (Ross 1975, Leaders 1977).

Guimond (1976) of the EPA estimates that eight to ten 1000-megawatt (electric) (Mw[e]) nuclear power plants could be powered by uranium recovered from U.S. phosphoric acid plants; he further states that another 30 to 40 nuclear power plants (1000 Mw[e]) could be fueled annually if uranium were recovered from mining wastes (slimes and tailings). Brookhaven National Laboratory is researching a process to recover uranium from slime-pond waste dumps (Guimond 1976).

f. Impervious Lining for Recirculated Process-Water Ponds at Chemical Plants

None of the existing gyp ponds are lined; therefore, operational-scale feasibility and cost data do not exist. Surface seepage does occur, but is collected in perimeter ditches to be pumped back into the ponds. Because of the lack of data on the extent of surface and subsurface seepage and cost information on impervious linings to control this potential source of pollution, effects assessment did not include a quantitative evaluation of this process modification.

4. Require Reduced Water Usages

This scenario investigates the consequences of reduced water usage by the phosphate mining and chemical processing industries in central Florida. Existing and proposed mines and plants are as described by the conditions and limitations established in Scenario 2.11.

For existing facilities, water usage is to be reduced through the complete recirculation of all cooling and process water and containment of up to a 10-year, 24-hour rainfall with no discharge. Discharges would be allowed for conditions exceeding the 10-year, 24-hour rainfall, or equivalent, but would have to meet best practical technology (BPT) standards. Similar constraints are to be imposed on new facilities, except that a 25-year, 24-hour rainfall will be substituted for the 10-year, 24-hour storm.

In examining water usage by the phosphate industry under the conditions of this scenario, it is important to remember the variables that affect discharge rates by both mining and chemical processing. Mines vary in size, production, and mining techniques. Most employ draglines for matrix extraction, but dredging is proposed by Beker for its new mine in Manatee County. For transporting the ore from pit to wash plant, a conveyor belt system is being tried at one location as an alternative to the conventional matrix slurry pipeline, resulting in a decrease in [water use]* and electric power consumption (Hoppe 1976). Similarly, the chemical processing plants manufacture the many phosphorus-related products in varying quantities and at different production rates. These variations between mines and plants

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*An opinion not shared by Mr. Timberlake of Brewster Phosphate make it impractical to determine the amount of effluent discharged at individual sites. This scenario, then, considers only the effects of the containment of rainfall as described earlier. Since effluent discharge rates are not included, the rainfall projections apply equally to either mining or chemical processing. Storage capacities determined for rainfall containment would require enlargement to include the effluents discharged at a given mine or plant. Facilities are grouped on the basis of existing or new source classifications as designated by the NPDES permits.

To determine the net result of rainfall containment, only precipitation and evaporation are taken into account; it is assumed that the rainwater will be retained in impoundments similar to the settling ponds currently in use and that seepage through dikes or into the pond floor will be negligible and thus can be ignored. According to the Handbook of Applied Hydrology (Chow 1964), the mean annual Class-A pan evaporation rate throughout the study area is 65 inches and the mean annual lake evaporation is 50 to 52 inches; a mean annual Class-A pan coefficient of +77 percent relates the lake evaporation rate to the pan evaporation rate. Average monthly rainfall data for six locations (three on the interior and three on the perimeter of the study area) have been tabulated to yield average monthly rainfall applicable across the entire study area; based on U.S. Weather Service records from 1931 to 1960 (USDC 1965), it is 53.24 inches (Figure 2.5).

In terms of average rainfall versus evaporation, 3 years have been evaluated: an average year; an average year with a 10-year, 24-hour storm; and an average year plus a 25-year, 24-hour storm. Figure 2.6 shows the net rainfall versus the evaporation from the rainfall for each month. An average year accumulates a net surplus of 0.41 inch. Figure 2.7 is the net curve for a year in which a 10-year, 24-hour storm occurs during the month of heaviest rainfall; the result is a net surplus of 8.29 inches at the end of the year, which includes the 0.41-inch surplus from the previous year. Figure 2.8 is the net curve for a year in which a 25-year, 24-hour storm occurs during the month of heaviest rainfall; the year-end surplus of 10.04 inches includes the 0.41 inch remaining from the previous year. To comply with the conditions imposed by this scenario, an existing facility (mine or plant) would need storage capacity capable of retaining 0.41 inch of rainfall cumulatively for each year of the facility's estimated life, plus 8.29 inches for the year of the 10-year, 24-hour rainfall. A new facility would require a capacity of 0.41 inch per year of life, plus 10.04 inches for the year of the 25-year, 24-hour rainfall.

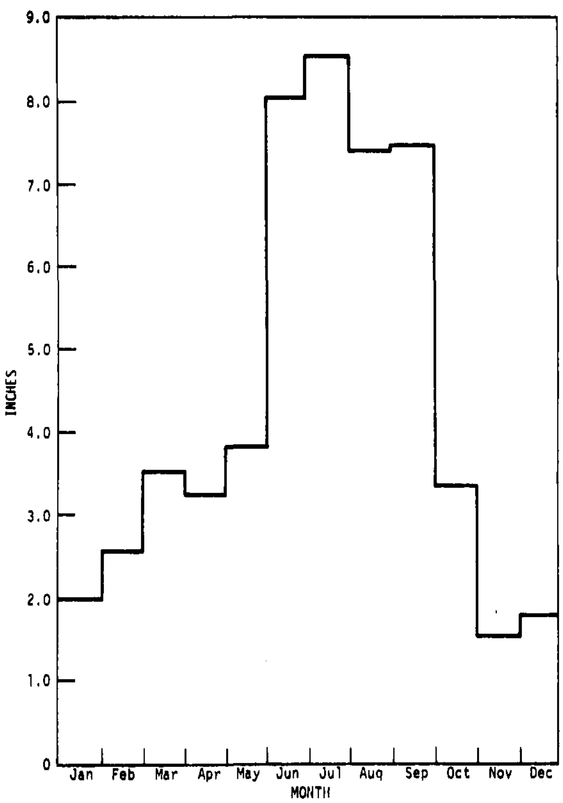


Figure 2.5. Average Monthly Rainfall at Six Locations in Study Area

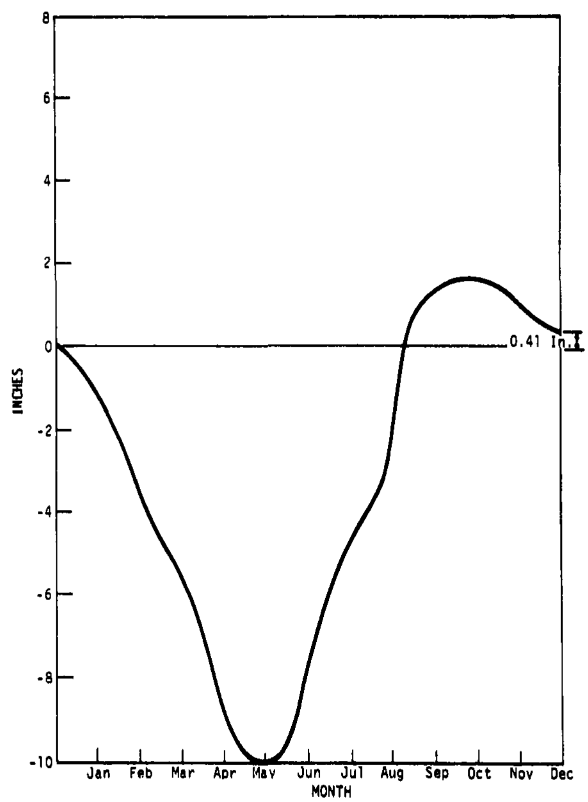


Figure 2.6. Curve of Cumulative Rainfall Versus Evaporation during Average Year in Study Area

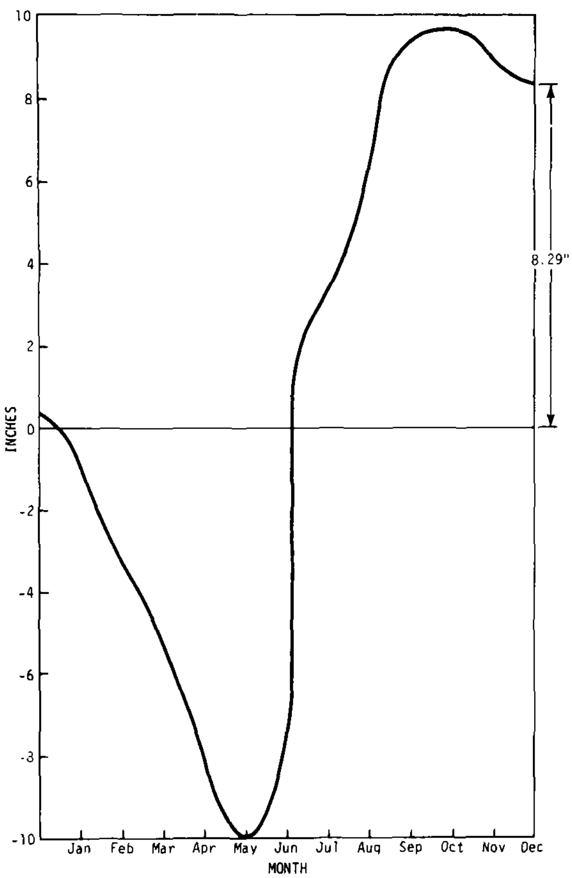


Figure 2.7. Curve of Cumulative Rainfall Versus Evaporation during Year with 10-Year, 24-Hour Storm

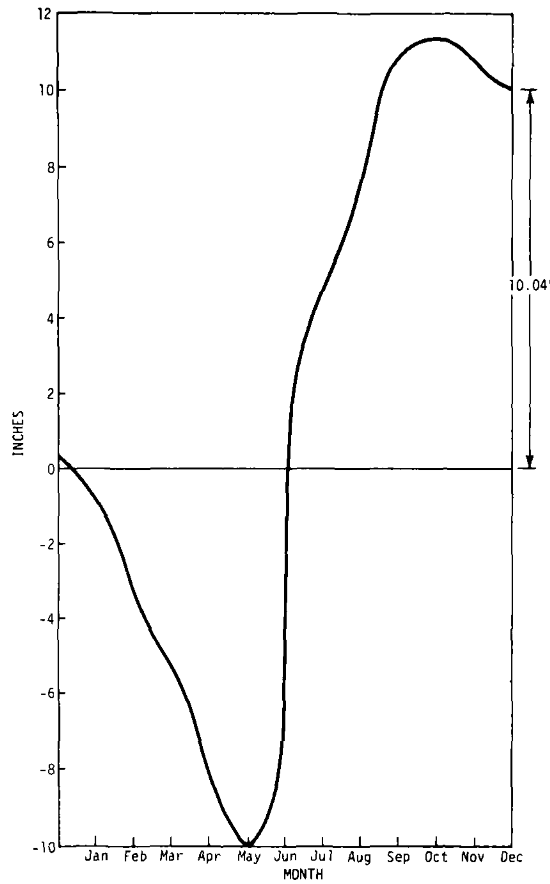


Figure 2.8. Curve of Cumulative Rainfall Versus Evaporation during Year with 25-Year, 24-Hour Storm

A hypothetical water impoundment with a surface area of 1000 acres illustrates the magnitude of the storage capacities. The average-year surplus of 0.41 inch on a 1000-acre pond would equate to a constant inflow of 21.18 gallons per minute if discharged over a 1-year period. Similarly, the 8.29-inch surplus for the year of the 10-year, 24-hour rainfall would convert to a constant discharge of 428.3 gallons per minute over a year's time. For new facilities, a 1000-acre pond would require a constant outflow of 518.7 gallons per minute to dissipate the 10.04-inch surplus following a 25-year, 24-hour rainfall.

In summary, the effect of the conditions imposed by this scenario would be the creation of impoundments for retaining the annual surplus of rainfall. The capacity of such impoundments would be determined by the life of the facility and the quantity of effluent discharged as a result of the facility's operations. Rainfall accumulated in the storage ponds could be made available for use in mining or processing, thereby reducing the groundwater withdrawal requirement.

5. Control Activities in Waters of U.S. and Wetlands

This scenario is divided into two parts. The first would prohibit mining or development of facilities in the waters of the U.S. and wetlands as defined by the regulations promulgated pursuant to administration by the U.S. Corps of Engineers of Section 404 of the Federal Water Pollution Control Act (FWPCA) amended in 1972. The second part would allow mining or facilities development in the waters of the U.S. and wetlands but require restoration to provide at least an equivalent habitat for any species on the Important Species List for which habitat existed prior to mining.

The Corps may issue permits for the discharge of dredged or fill material into the navigable waters at specified sites. The term "navigable waters" includes: coastal waters, wetlands, mudflats, swamps, and similar areas; freshwater lakes, rivers, and streams, as well as all tributaries to these waters, that are used, were used, or are susceptible to use for transport in interstate commerce; interstate waters; certain specified intrastate waters in which pollution would affect interstate commerce; and freshwater wetlands including marshes, shallows, swamps, and similar areas that are contiguous or adjacent to the above described lakes, rivers, and streams and are periodically inundated and normally characterized by the prevalence of vegetation requiring saturated soil conditions for growth and reproduction. Headwaters (defined as the point on the stream above which flow is normally less than 5 cubic feet per second) are excluded from permit requirements unless required in the interest of water quality.

The Corps of Engineers, in conjunction with the EPA, developed a 3-phase plan for implementing its administration of Section 404. Under the groundrules set for the Central Florida Phosphate Industry Areawide Impact Assessment program, only Phase I would have been described; however, since the full implementation occurred on July 1, 1977, an exception was made and impacts on wetlands were assessed in accordance with full implementation of the Corps of Engineers rules and regulations for administration of Section 404 of the FWPCA.

The Corps of Engineers of the Jacksonville District, which has jurisdiction over Florida for Corps matters, recently arrived at a joint review and processing of application procedures with the Florida Department of Environmental Regulation (DER). The latter requires permits for work on or in the waters of the state and, specifically relevant to this scenario, requires a permit whereby dredge and fill activities are to be conducted on submerged lands or in transitional zones of submerged lands in the state. The DER determines jurisdiction in a manner similar to that of the Corps and includes in its definitions that transitional zones are characterized by the dominance of certain plant species.

USGS (LUDA) land use-land cover maps representing the 7-county study area were the most comprehensive in existence at the beginning of this program, but it was known that the staff of the U.S. Fish and Wildlife Service National Wetlands Research Center, St. Petersburg, was in the process of developing maps representing all available photography of wetlands of the U.S. Unfortunately, that rendering of Florida maps was not available in time for this program. Thus, the water and wetlands land use-land cover definitions and mapping categories of the USGS (LUDA) maps had to be used (Plate 1 in map pocket). (The reader is also referred to TI 1977d.) For an areawide evaluation, this is adequate. Site-specific actions, however, require closer scrutiny. The Corps of Engineers determines for each applicant the boundaries of jurisdiction. One recent applicant was given boundaries in Hookers Prairie that encompass approximately 50 percent more area than indicated on the USGS (LUDA) map (Figure 2.9).

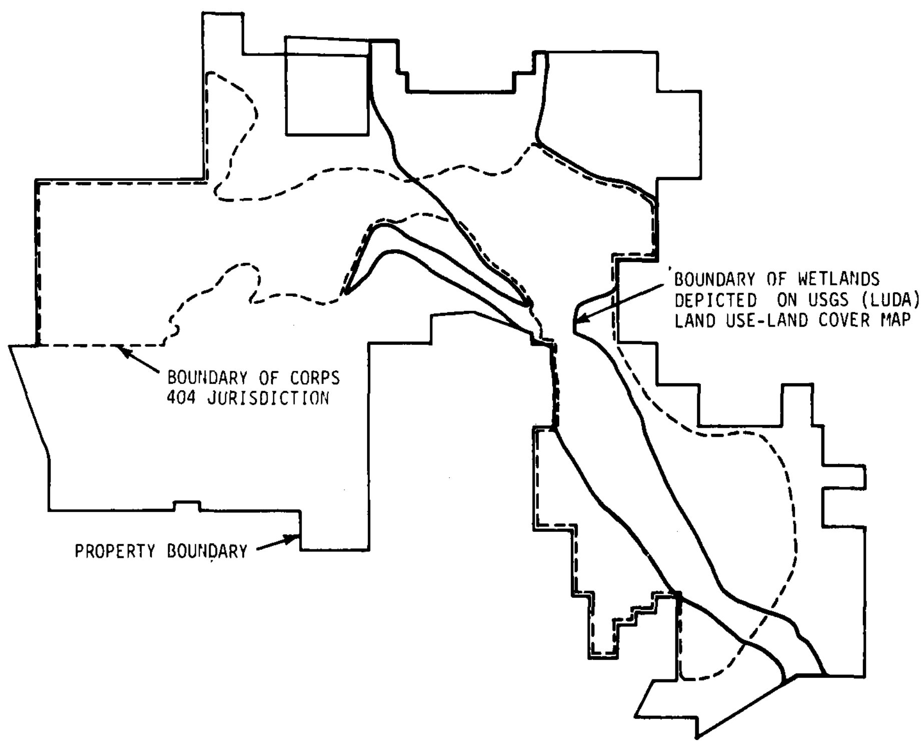


Figure 2.9. U.S. Corps of Engineers Boundary of Jurisdiction under Section 404 of FWPCA for W.R. Grace Hookers Prairie Mine

Organisms that would require restoration of at least an equivalent habitat under the second part of this scenario include species on state and federal rare, threatened, endangered, or special-concern lists; species of ecological importance; and species of significant economic benefit. Those in wetlands potentially affected by phosphate industry activities are as follows:

Southern Dusky Salamander
Dwarf Salamander
Slimy Salamander
Bronze Frog
Ornate Chorus Frog
American Alligator
Diamondback Terrapin
Southern Hognose Snake
Scarlet Kingsnake
Broad-headed Skink
Eastern Indigo Snake
Striped Swamp Snake
Red-bellied Snake
Smooth Earth Snake
Black-crowned Night Heron
Yellow-crowned Night Heron
American Bittern
King Rail
Hairy Woodpecker
Wood Duck
Sharp-shinned Hawk
Short-tailed Hawk
Florida Sandhill Crane
Limpkin
Virginia Rail
Sora
Yellow Rail
American Woodcock
Yellow-billed Cuckoo
Pileated Woodpecker
White-breasted Nuthatch
Yellow Warbler
Louisiana Waterthrush
Golden Mouse
Eastern Woodrat
Round-tailed Muskrat
River Otter
Bobcat
Wild Hog

Those in U.S. waters potentially affected by phosphate industry activities are as follows:

- Estuarine

  Striped Mullet
  Yellowfin Menhaden
  Gulf Menhaden
  Bay Anchovy
  Red Drum
  Croaker
  Black Drum
  Spotted Seatrout
  Snook
  Sand Seatrout
  Tarpon
  Southern Flounder

- Freshwater

  Largemouth Bass
  Bluegill
  Redear Sunfish
  Channel Catfish

- Both

  Alligator
  Manatee
  Suwannee Cooter

The effects of normal phosphate operations in waters of the U.S. may have no major impact if guidelines for mitigation are followed. There are no guidelines for protection of downstream and adjacent wetlands and further, no feasible means of restoring mined wetlands has been demonstrated, although reclamation can result in wet lands. To restore wetland habitat in order to protect and propagate all the wildlife just listed would require management of variables needed for the creation of wetlands - which some believe occur only naturally over a period of approximately 4000 years of natural processes (American Fisheries Society 1977). Only nature can create a wetland (Fisheries, Volume 2[4]:7). The relationship of present and projected phosphate industry activities to U.S. waters and wetlands is presented in Plate 1.

As of this date, no chemical processing plants are included in industry plans. In its DRI for a Hardee County site near the Four Corners area (see Plate 3). CF Industries described a fertilizer plant, but no engineering of that phase in currently being performed. Thus, all potential environmental effects are limited to those resulting from mining and beneficiation.

C. COMPARISONS

1. Introduction

Subsequent sections describe the effects and impacts of the central Florida phosphate industry as a part of the existing environment, a condition defined as the "Without Action" alternative (Scenario 2.15) and the baseline against which the four other alternatives were compared. Also described are the effects and impacts of four alternatives to the "Without Action" alternative.

Previously, subsection A described the process of selecting elements for inclusion in the matrix (Plate 2). This matrix was a model for effects assessment and was intended as a tool for technical direction. The absence of entries in a column or row of the matrix does not necessarily mean that the element represented by that column or row should have been omitted from the matrix. In assessing effects and impacts, it is often as important to indicate where impacts are not likely to occur as to show where they are expected — especially when preconceptions are held by vested interests.

The assessment of the significance of impacts began by identifying effects that qualify as impacts.

- An effect is a change caused by interaction between environmental and technological demand elements (here, phosphate industry activities).

- An impact is defined as an effect that alters the environmental system in which it occurs beyond the system's ability to buffer or compensate for the change, which may be either beneficial or adverse to environmental quality.

Numerical significance values based on the quantitative or qualitative considerations dictated by the environmental elements involved were assigned to each impact. Values are not directly comparable among the various categories of elements. It is essential to study the rationales governing the assigning of values if one is to fully grasp what they imply (see Volume XI of Working Papers, TI 1977j).

2. Matrix and Supporting Information

The five scenarios or alternatives used in the study are sufficiently detailed to permit desirable features to be selected from them and combined into new alternatives. The individual matrices list specific industry activities causing the impacts, and this knowledge suggests the regulatory strategy offering the highest probability of reducing or eliminating the most significant adverse impacts. After examining the summary matrix in this section the reader is urged to review the detailed matrices and rationales in and the effects assessment working paper (TI 1977j).

In addition to the raw scores or values which the environmental analysts and planners arrived at and listed in the matrices, values reached by a numerical weighting process are included. These weighting factors represent priorities applied to each element by the steering and advisory committees. Assignment of these numerical values enabled calculation of a quantitative summary of the impact assessment. The matrix (Plate 4 shows the weighting factors and the scores representing the sums of impacts on each environmental element. Subtotals for natural, social, and economic environmental elements were then multiplied by normalizing factors to compensate for the fact that the subtotals were based on unequal numbers of elements (41, 31, and 19 elements, respectively). Table 2.8 summarizes the raw and weighted scores.

Table 2.9 lists the alternatives by rank order. Scenario 2.15, the "Without Action" alternative, is absent from both Tables 2.8 and 2.9 because

Table 2.8. Environmental Impact Summary

	Environmental Elements			
	Natural	Social	Economic	Total
Alternative	Short Term/Long Term	Short Term/Long Term	Short Term/Long Term	Short Term/Long Term
		Raw Scores		
2.11	-267/ -250	-5/ -3	29/ 176	-243/ -77
2.12	-257/ -228	-4/ -3	29/ 176	-232/ -55
2.13	-269/ -226	-5/ -3	29/ 176	-245/ -53
2.14	-249/ -206	-1/ 0	29/ 176	-221/ -30
		Decision-Weighted Scores Steering Committee		
2.11	-1459/-2135	-66/-16	141/ 979	-1384/-1172
2.12	-1323/-1940	-57/-12	141/ 979	-1239/ -973
2.13	-1470/-2183	-38/-16	141/ 979	-1367/-1220
2.14	-1243/-1800	-66/ -4	141/ 979	-1168/ -825
		Advisory Committee		
2.11	-1142/-1665	-10/127	191/1175	-961/ -363
2.12	-973/-1424	-1/134	191/1175	-783/ -115
2.13	-1193/-1759	-10/127	191/1175	-1012/ -457
2.14	-980/-1442	13/143	191/1175	-776/ -124
		Combined		
2.11	-1315/-1904	-33/ 62	167/1093	-1181/ -749
2.12	-1083/-1687	-23/ 68	167/1093	-939/ -526
2.13	-1346/-1953	-33/ 62	167/1093	-1212/ -798
2.14	-1130/-1625	-7/ 79	167/1093	-970/ -453

Table 2.9. Ranked Alternatives by Least Regret

Environmental Elements			
Natural	Social	Economic	Total
Short Term/Long Term	Short Term/Long Term	Short Term/Long Term	Short Term/Long Term
	Raw Score		
2.14/2.14	2.14/2.14	All equal	2.14/2.14
2.12/2.13	2.12/2.12*		2.12/2.13
2.11/2.12	*2.11/2.11*		2.11/2.12
2.13/2.11	*2.13/2.13*		2.13/2.11
	Weighted Score Steering Committee		
2.14/2.14	2.13/2.14	All equal	2.14/2.14
2.12/2.12	2.12/2.12		2.12/2.12
2.11/2.11	*2.11/2.11*		2.13/2.11
2.13/2.13	*2.14/2.13*		2.11/2.13
	Advisory Committee		
2.12/2.12	2.14/2.14	All equal	2.14/2.12
2.14/2.14	2.12/2.12		2.12/2.14
2.11/2.11	*2.11/2.11*		2.11/2.11
2.13/2.13	*2.13/2.13*		2.13/2.13
	Combined		
2.12/2.14	2.14/2.14	All equal	2.12/2.14
2.14/2.12	2.12/2.12		2.14/2.12
2.11/2.11	*2.11/2.11*		2.11/2.11
2.13/2.13	*2.13/2.13*		2.13/2.13

*Received equal scores (Table 7.1)

it represents the baseline or zero values with which the other four scenarios were compared. When the best of the four scenarios has a net negative, or adverse value, it is still only second best to Scenario 2.15. If decision weighting factors for social and economic environmental elements had been as high as many of the weights for natural environmental elements, summary results probably would have shown net positive impacts.

D. SUMMARY OF PRIMARY EFFECTS OF THE "WITHOUT ACTION" ALTERNATIVE

1. Natural Environment

a. Atmosphere

To simulate this scenario, it has been assumed that the chemical processing part of the phosphate industry will continue to operate at 1976 levels, supplementing domestic rock with imports as the existing mines become depleted. Because of the installation of air pollution control devices during 1976-77, there will be an immediate reduction of industrial emissions independent of any scenario projections; this will be most evident in the case of sulfur dioxide (SO_2) emissions from sulfuric acid plants in Polk and Hillsborough counties. Changes in the emission inventory due to the restraints of this scenario will appear as reductions in dust as mining and drying activities decline. SO_2 emissions caused by fuel burning in the dryers will also decline as imports replace locally processed rock. Since imports will supplant exports, it is estimated that the dust generated at seaports by movement of phosphate rock and refined products will remain at the same level. Although the ambient SO_2 levels in Polk County will be reduced since no other source categories are predicted to increase enough to totally offset the decreases at the phosphate plants, the county's particulate levels (and both SO_2 and particulates in all other counties in the study area) should show a slight rise because of increases by nonphosphate sources.

Area sources were projected from population projections of the University of Florida. Point-source changes were projected to occur only in utilities and the phosphate industry.

Utilities sources are expected to operate under the same pollution control limitations existing in 1976. The following changes in capacity were used to project emissions:

- TECO
  - To add units 3 and 4 to Big Bend before 1985
  - To add a new plant on the bay near the Manatee-Hillsborough line
- FP&L
  - To have both Manatee units operational after 1977
  - To add a large plant (similar capacity to Big Bend) in DeSoto after 1985
- Lakeland Utilities
  - To add unit 3 at Plant 3 in 1982
  - To retire Larsen unit 4 in 1983

Phosphate industry point-source emissions were broken down to correspond to seven of the technological demand elements in the effects matrix. It was assumed that chemical processing would remain at 1976 production rates.

Dust emissions from mining/clearing are associated with mining activities and vary directly with the projected rock production rate in each county. Dust generated from storage/transportation is expected to remain constant in Polk and Hillsborough counties and to vary with the projected level of mining/beneficiation activity in other counties. (Under this scenario, no activity (mining) is projected outside Polk and Hillsborough counties.) SO_2 and particulate emissions caused by drying of wet rock are expected to reflect the level of mining activity in each county using 1976 as the base year. Emissions of SO_2 due to H_2SO_4 production are expected to remain constant until the year 2000 — but at levels lower than those reported in 1976 when all plants were not yet in compliance with emission regulations.

Under this scenario, it is assumed that emissions from fertilizer, feed, and phosphorus production will remain constant at 1976 levels.

b. Land and Wetlands

1) Physical Environment

The natural physical features of the study area include the sand terraces, geologic ridges (e.g., the Lake Wales ridge), solution cavities (sinkholes) and partings of the surface and subsurface, and other minor features typical of flat, low-lying terrain. Of these, the ridges and solution cavities may be considered unique. While activities of the phosphate industry do not affect the ridges per se, they potentially effect sinkhole development and collapse. Large clay-slime storage impoundments and stacking waste gypsum load the surface, causing the primary effect. No data exist, however, to support quantification of the potential for collapse of a slime impoundment or gypsum stack. Seepage of low pH process waters through the waste gypsum stack could enlarge existing percolation pathways, but the effects are insufficiently documented to allow quantitative evaluation.

The phosphate industry activity that primarily affects soil is mining: it destroys soil in terms of its original identification characteristics. Under this scenario, it is estimated that more than 4850 hectares (12,000 acres) of soil associations rates as potentially high for agriculture will be disrupted by mining from 1977 through 1985 and more than 8500 hectares (21,000 acres) from 1977 through 2000. Once reclamation replaces the soil materials, however, new soils will develop that may be better suited for certain agricultural purposes because of improved moisture-holding capacity and permeability and the absence of underlying clay pans. The newly created soils must be accessed for better understanding and solving of mining and reclamation problems. Thus, impacts of mining and reclamation on existing soils, therefore, must be judged relative to existing soils definition and upon definition and management of soils established subsequent to mining.

Constituting an irreversible positive effect are industry activities that result in information about the geologic section, including its stratigraphy and geochemistry. Principal among the activities are drilling and excavation. Under this scenario, these activities will continue through 1985 but will essentially cease by the year 2000.

Topographical effects (changes in natural surface contours) will be caused primarily by excavations to remove phosphate ore. Estimates of the surface area to be mined under this sceanrio are 19,870 hectares (49,100 acres) from 1977 through 1985 and 32,619 hectares (80,600 acres) from 1977 through 2000. However, reclamation will restore these lands to nearly their original contours.

Since no construction of chemical processing plants or washing/beneficiation plants is forecast under this scenario, both the short-term (1977-85) and long-term (1977-2000) effects of ongoing industry activity on background radiation will be essentially concentrated in areas scheduled for mining during each of the periods. Exceptions would include the continued accumulation of waste products at the chemical processing plants, continued transportation of mine and processing-plant products, and ongoing construction of dams, levees, and drainage-control systems. The effects of radium-226 radioactivity concentrations in materials associated with industry activities were estimated on the basis of change in surface materials (thus, radium-226 concentrations) geographically as a result of industry activities. Since mining exposes bedclays and residue matrix material in areas where the surface was previously native soil, the potential is to increase the "surface" radium-226 radioactivity concentration from 1.5 picocuries per gram to approximately 50 picocuries per gram. This negative effect is offset somewhat by backfilling the mining cuts with waste sand tailings (7.5 picocuries per gram) and overburden (10 picocuries per gram, excluding leach-zone material). Areas of cuts dedicated to waste clay-slime impoundments are expected to exhibit very low background radiation while the slime particles (45 picocuries per gram) are covered with decant waters (1-2 picocuries per liter); however, as these areas dewater, background radium-226 concentrations in the surface material should approach the level given for slime particles. Thus, background radiation in reclaimed mined areas will be higher than it was prior to mining unless original surface material is saved to top-dress both the reclaimed slime ponds and the lands containing the waste sands and overburden. Background radiation at chemical processing plants should remain essentially at current levels until imported phosphate rock is needed to maintain production levels; then, background radiation should decrease with increased replacement of local rock by imported rock.

Phosphate mining does not create noise levels high enough to represent an undesirable effect on area population not associated directly with the industry, but ambient noise levels increase locally during mining and reclamation, especially in the immediate vicinity of bulldozers and draglines that are in operation. However, operations personnel can be easily protected from noise through administrative or engineering controls or the use of protective equipment, and noise levels will consistently decline with the phase-out of mining.

2) Biological Environment

Mining has five major effects on uplands/wetlands biota:

- Certain existing plant communities are permanently displaced.
- As much as 30 percent of mined uplands/wetlands habitat becomes aquatic habitat.
- Habitat quality of unmined as well as mined land is degraded.
- Diversity is diminished.
- Local populations of many important species are reduced.

By the year 2000, approximately 21,052 hectares (52,000 acres) of uplands habitat will be mined in currently permitted areas. In the 7-county area, forest types are considered the most important uplands habitat. Estimates of evergreen forests are considered reliable, but it is impossible to estimate present or future areawide extents of either mixed or deciduous forests because of the paucity of data of appropriate detail. Some rather large parcels in projected mining areas are documented in land-use data presented by various phosphate companies in Developments of Regional Impact (DRIs) — and they probably are present in areas currently being mined. None of the forest types can be restored to their native condition on mined land. The deep sand soils necessary for mixed forests are irreversibly altered; the loss of an underlying organic hardpan precludes the reestablishment of typical pine flatwoods; and the configuration as well as the species composition of hammocks is destroyed, although postmining soils, if allowed to revegetate naturally, will support similar communities. The 4850 hectares (12,000 acres) of forest to be mined by the year 2000 represents more than one-half the areawide loss of the type by that year.

Less important but still unreclaimable in its native condition is mined rangeland, the extent of which is 6680 hectares (16,500 acres) in the study area. The 8660 hectares (21,400 acres) of agricultural habitat to be mined can be considered temporary displacement, since reclamation is producing improved pasture primarily with smaller extents of plantations and parklands.

More than 2990 hectares (7400 acres) of freshwater wetlands habitat within currently permitted mining areas will be destroyed by 1985 and another approximately 2140 hectares (5300 acres) by the year 2000. This is a small (3 percent) but important portion of areawide wetlands extent. There is no indication that wetlands of any kind can be restored on mined land. Not only are the low-relief topography and attendant drainage patterns of wetlands difficult to restore, but the deep, water-logged soils of many wetlands can be neither restructured nor feasibly conserved.

That the quality of terrestrial habitat generally reclaimed in mined areas is inferior is readily apparent when comparing wildlife usage of managed systems (pasture, cropland, plantation, and parkland) with that of essentially natural systems (dry prairie, forest). Mining and subsequent reclamation are producing a more uniform habitat, reducing diversity of community structure in the region. The number of plants and animals in an area is directly related to the number of vegetation types (landscape-pattern diversity): as landscape-pattern diversity increases, so does floral and faunal diversity. The habitat types that are declining in the regional landscape are those of greatest individual diversity. The diversity within these types represents a greater variety of interactions among components (expanded food webs) and biological controls that tend to preserve an equilibrium. They can be maintained at no cost to man. To maintain agricultural habitat types as such (and particularly monocultures, which are the least diverse communities), it is necessary to use external controls such as pesticides, fertilizers, and, most pertinent to the concerns of the region, irrigation.

The same factors that affect the habitat quality of uplands also affect the habitat quality of adjacent and nearby wetlands that are not mined. Both plants and animals may be stressed by noise, dust, emissions (sulfur dioxide, suspended particulates), moisture loss, and erosion — and animals particularly may be stressed by fragmentation of habitat. Although control devices apparently maintain ambient levels of emissions and minor contaminants within acceptable state and federal air quality levels, the emission standards and other standards do not enhance habitat quality or ensure optimum conditions; habitat is allowed to degrade to the tolerance limits of both industry and the environment. Habitat fragmentation will have lasting effects, likely reducing the carrying capacity of the remaining habitat for wide-ranging herbivores (e.g., deer) and carnivores (e.g., bobcat).

The effects of erosion and moisture loss may be greater in shallow wetlands than in uplands habitat. Mining into the shallow aquifer decreases the amount of soil moisture or standing water in adjacent habitat within 1000 feet for 3 to 6 months, and wetlands vegetation damage is possible, particularly during the wet season. Although erosion of mined land may be largely contained on the site, sediment load in streams increases and downstream wetlands receive part of the load, increasing turbidity and sedimentation.

Mining is likely to affect 12 threatened and endangered vertebrates and may affect six others (see Table 1.11). Adverse effects, if any, on two species, the Osprey and Caracara, likely will be short term, and the Osprey particularly may benefit in the long term. Two species, the Least Tern and Peregrine Falcon, both primarily ocastal species, may be attracted to the mining areas; however, this is an outside possibility for the very rare falcon, which was last seen in the study area 3 years ago. Habitat loss is the primary threat posed by mining except in the case of the Wood Stork; this species utilizes suitable feeding sites on land to be mined but apparently does not breed on this land. Food supply of the Florida panther and Florida black bear also will be diminished, if indeed they do range over lands to be mined.

Commercial and recreational species will be variously affected by mining. The hunting potential for most waterfowl will increase because of the creation of lake and pond habitat by mining (Table 1.16), but that of the other waterfowl species closely associated with woodlands and marshes will diminsh. However, waterfowl comprise less than 10 percent of Florida's game bag; hunter effort is directed primarily (approximately 75 percent) toward only five species · deer, squirrel, dove, quail, and wild hog. The recreational potential of hunting quail and squirrel, which often occur on lands other than in management areas, will be reduced. Deer and wild hog habitat will be reduced, but the hunting potential probably will not be affected for these species since they are most often hunted in wildlife management areas. The potential for hunting the Mourning Dove (often on private land) is expected to remain steady. he region's overall abundance of game will not be significantly affected, but continued habitat loss eventually will eliminate certain species from the game list and degrade the quality of hunting.

Mining will adversely affect more than one-half of approximately 75 ecologically significant species in the 7-county region. Most of these are closely associated with various natural or little-modified habitats, including wetlands and natural ponds and lakes that have gently sloped sides and wide littoral zones rather than the steep sides and narrow littoral zones of reclaimed lakes and ponds.

Mining activities will increase the potential of several species to reach population levels of nuisance or pest proportions. Mammal pests will proliferate around work areas and expanded urban areas. Bird pests will become more abundant in similar areas as well as on reclaimed pastures and croplands. Insect pests will proliferate around cattle, in areas devoted to monoculture, and in the nutrient-rich reclaimed lakes.

3) Water

a) Quantity

A digital computer model (Wilson 1977b) that was prepared, evaluated, and calibrated by personnel of the U.S. Geological Survey office in Tampa in cooperation with the Southwest Florida Water Management District was used in assessing the effects on the Floridan aquifer of future pumpage from existing mines under this scenario and under the conditions of a modified 2.11 (2.11', which reflects industry's view). The model is a first attempt to simulate the complexity of the interrelationships of all the essential elements of the groundwater system in the Central Florida Phosphate Mining District. Therefore, the results should be considered as preliminary and subject to revision. The USGS is continuing the task of improving the reliability of the model. These first model predictions are represented as approximate and are used only to estimate the effects of future groundwater pumpage by the phosphate mining industry on the potentiometric surface of the Floridan aquifer. Effects of the changes in total pumpage by the three major users of ground water (i.e., municipalities, agriculture, and other industry) are not predicted. Therefore, the partial effects on the potentiometric surface of the Floridan aquifer in 1985 and 2000 caused by changes in pumpage at phosphate mines exclusively cannot be compared with the effects of combined groundwater withdrawal changes by municipalities, agriculture, and other industry. This inability to do more than compare effects among the alternatives for the phosphate industry is a distinct disadvantage in the effects assessment because a simulation of the aquifer system as would exist based on projections of all uses is not provided.

The digital 2-dimentional groundwater flow model simulates the hydraulic characteristics of the Floridan aquifer and its connection with the water-table aquifer through the overlying confining beds. (More detailed information is available in the USGS open-file report Wilson 1977 from which this description is summarized.) The major assumptions upon which the design and operation of the model are based are as follows:

- Water in the Floridan aquifer moves in a single-layer isotropic medium.
- Water moves vertically into or out of the Floridan aquifer through the upper confining beds; no leakage occurs through the lower confining bed.
- The head in the water-table aquifer does not change with time or in response to any imposed stress.

The area within the model boundaries is approximately 5854 square miles. A grid divides the area into nodal blocks ranging from 2 x 2 miles to 7.5 x 2 miles and 5 x 5 miles. Each nodal area is identified by a row and column number. The model closely follows hydrologic boundaries and can simulate two types: a constant-flow boundary and a constant-head boundary. For the steady-state model calibration, a no-flow boundary was used, which is a special case of the constant-flow boundary.

The model incorporates two types of parameters: time-dependent and time-independent. The input and output parameters, which include pumpage (P) and/or recharge (R) and predicted changes in the potentiometric surfaces, are time-dependent. The other parameters, which include transmissivity (T), storage coefficient (S), and leakance coefficient (K'/b'), may vary spatially but are time-independent. The input parameter, or pumpage, consists of groundwater withdrawals for phosphate mining and processing, other industrial users, agriculture, and municipalities. The input parameter, or recharge, is the amount of water that enters the Floridan aquifer from the overlying water-table aquifer. The amount of recharge varies locally depending on the leakance coefficient and the head difference (Δh) between the potentiometric surface of the aquifer and the water table.

The model can simulate either dynamic (transient) conditions or steady-state conditions in the hydrologic system. Under steady-state conditions, the model simulates essentially a static water budget; in the transient state, it simulates a dynamic water budget.

The present model was calibrated under steady-state conditions. The entire groundwater system was assumed to be more or less in equilibrium (steady-state) at the end of September and the beginning of October 1975; at that time, there was apparent balance between pumpage, recharge, and observed altitudes of the potentiometric surface of the Floridan aquifer. It was assumed for the steady-state condition that in the September-October period no ground water was pumped for agricultural use.

The objective of the model calibration was to simulate as closely as possible the observed potentiometric surface in September 1975. During the calibration of the model, several adjustments were made in the various parameters.

Comparison of the observed and simulated potentiometric surfaces showed a similar pattern generally in the configuration of the potentiometric surfaces, but locally there were some major differences between the two. For example, the simulated altitudes of the potentiometric surface in the western half of Manatee and northern Sarasota counties were significantly lower than the observed altitudes in the same area. This was true also for the southwestern part of Polk County. The steady-state model appeared to overestimate the drawdowns in these areas, which could have been the result of the following factors: actual pumpage less than that entered in the model; leakance coefficients less than actual ones; transmissivity values less than actual ones; and possible proximity to the model boundaries. Magnitude and configuration of predicted water-level changes depend on the magnitude, duration, and areal distribution of pumpage, transmissivity, storage coefficient, leakance coefficient, and boundary conditions. The reliability of the predicted water-level changes is dependent on the validity of each parameter and the sensitivity of the model to input values. The calibration process is, in a way, a reliability assessment.

Evaluation of results was difficult because only the calibration results of the steady-state model and not the transient-state model were available. However, the predicted water-level changes were a result of transient-state model simulations.

The validity of each parameter was evaluated. The areal distribution and magnitude of the model parameters appeared to be not much different from those that might have been expected in reality, although some values of the leakance coefficient appeared to be on the low side. The magnitude and areal distribution of the transmissivity values were of major concern, especially the value of 80,000 square feet per day in the southwestern part of the study area. In reality, it seems reasonable to expect that the transmissivity should increase from north to south and from west to east. The author of the referenced report on modeling (Wilson 1977b) was contacted and indicated that the transmissivity distribution produced a fair match during the calibration process. In addition, he considered and tried other transmissivity values more along the lines suggested above but did not get a good match. The USGS is continuing to work on the calibration and will try other transmissivity values and distributions.

In summary before citing the primary effects, it can be said that the assessment is really one of trends in the water-level changes in 1985 and 2000 for Scenarios 2.15 and 2.11'. The numbers quoted are merely illustrative approximations and should not be interpreted as absolute results.

The primary effects of groundwater withdrawals as described in Scenarios 2.15 are expressed as a change in the potentiometric surface of the Floridan aquifer between September 1975 and September 1985 and between September 1975 and September 2000. Total pumpage for existing mines and chemical plants was 309,000,000 gallons per day in 1975 and is projected to be 142,000,000 gallons per day in 1985, representing a decline of more than 50 percent. Groundwater pumpage for existing mines is expected to decline to 6,000,000 gallons per day in the year 2000, with chemical-plant pumpage remaining constant throughout the period. To assess impacts attributable to the phosphate industry along the effects of Scenario 2.15 were simulated by holding constant through time pumpage by agriculture and municipalities.

According to model results, the potentiometric surface of the Floridan aquifer will generally recover in 1985. The greatest rise (approximately 10 feet) will be in Polk County just west of Fort Meade. The 5-foot contour line indicates a recovery over a larger area between Bartow, Mulberry, Agricola, and Bowling Green. The 1-foot rise in the potentiometric surface will be in the southwestern part of Polk County, extending south of Lakeland, southwest of Winter Haven, north of Wauchula, east of Keys Field, and west of Bradley Junction. The no-change line runs approximately in a north-south direction, just east of the Hardee-Manatee county line and then swings northwesterly into Hillsborough County. The only decline predicted by the model was a 1-foot decline in the Fort Lonesome area. In general, the model showed no changes in the potentiometric surface of the Floridan aquifer in the study area except in southwestern Polk County and in southeastern Hillsborough County.

By the year 2000, nearly the whole study area will experience a rise in the potentiometric surface. The greatest rise, about 30 feet between 1975 and 2000, will be centered in an area northwest of Fort Meade in southwestern Polk County, extending southwesterly into Manatee and Sarasota counties. The model predicted a 1-foot rise in the potentiometric surface southwesterly as far as the center of Sarasota County in the Lake Myakka area and also in the western part of Manatee County.

b) Quality

(1) Radiological

Kaufmann and Bliss (1977) summarized the radium-226 radioactivity concentrations in the waters of the water-table and the upper and lower Floridan aquifers in the mined regions of central Florida (Table 2.10) using two data sets — one developed by the USEPA and the other by the USGS. The mean concentration of radium-226 radioactivity in the water-table waters of mined areas was given as 0.55 picocuries per liter; for the upper Floridan, 1.61 picocuries per liter; and for the lower Floridan, 1.86 picocuries per liter. The authors state that lower Floridan waters outside the mineralized area can have higher concentrations than those in mineralized areas, apparently because of natural processes unrelated to mining, and that existing water-table radium data indicate no significant difference between mined and unmined regions within the area of mineralization. However, ground water has been and probably will continue to be locally contaminated. Specific areas of concern include the large slime impoundments, the waste-gypsum stacks, and the large process-water cooling ponds. For comparison, Table 2.11 presents radium-226 radioactivity concentrations in ground waters of central Florida's mineralized but mined areas and nonmineralized areas.

Table 2.10. Radium-226 Concentrations in Ground Water in Mined Regions of Central Florida*

		Picocuries per Liter			
Aquifer		EPA		USGS	
Water Table	No.	4		12	
	Mean	2.8		0.55	**
	SD	1.65		3.3	
	Range	2.0-5.3		0.20-4.40	
Upper Floridan	No.	No data		10	
	Mean			1.61	**
	SD			2.0	
	Range			0.16-6.0	
Lower Floridan	No.	6		7	
	Mean	1.86	**	4.49	
	SD	1.33		6.51	
	Range	1.3-3.5		0.14-14.0	

*Kaufmann and Bliss (1977)
**Author-preferred data
Note: Drinking water standard, 5 picocuries per liter combined radium-226 and radium-228.

Industry wastewater effluents at the chemical processing plants contain soluble radium-226, but, according to Mills et al (1977):

"To prepare process water for discharge to the environment, the pH must be increased from 1.5-2.0 to 6-9. To accomplish this, slacked lime is normally added to the discharge water in a step called 'double liming.' Our studies have shown that this treatment is highly effective in removing radionuclides from the effluent. Radium-226 reduction of greater than 96 percent was observed in all situations studied. Similar reductions in uranium and thorium were also observed."

Table 2.11. Radium-226 in Ground Water in Unmined Mineralized and Nonmineralized Regions of Central Florida*

Region	Aquifer		Picocuries per Liter	
			EPA	USGS
Mineralized, Unmined	Water Table	No.	3	23 **
		Mean	1.63	0.17
		SD	1.65	12.9
		Range	0.2-3.3	0.05 - 22.0
	Upper Floridan	No.	9	5 **
		Mean	3.06	2.30
		SD	3.35	3.35
		Range	0.18 - 10.6	0.24 - 7.70
	Lower Floridan	No.	24 **	9
		Mean	2.0	1.4
		SD	2.3	1.3
		Range	0.19 - 15.3	0.06 - 4.7
Nonmineralized	Water Table	No.	No data	No data
		Mean		
		SD		
		Range		
	Upper Floridan	No.	No data	3 **
		Mean		5.1
		SD		4.3
		Range		0.2 - 7.9
	Lower Floridan	No.	14 **	2
		Mean	1.4	2.8
		SD	2.5	1.4
		Range	0.23 - 14.7	1.8 - 3.8

*Kaufmann and Bliss (1977).
**Author preferred data.

Note: Drinking water standard, 5 picocuries per liter of combined radium-226 and radium-228.

In terms of radium-226 radioactivity concentrations, effluents (primarily slime decant waters) at the mines have been shown to be below drinking-water standards (in most cases less than 2 picocuries per liter). The interim effluent guide proposed by the EPA (USEPA 1974) for the phosphate industry (phosphate chemical and fertilizer manufacturing) in terms of radium-226 is 9 picocuries per liter. However, efforts to achieve total recirculation of plant and mine waters are ongoing within the phosphate industry.

(2) Other Parameters

The primary effects on water quality because of phosphate industry activities under this scenario are:

- Combined loadings of chemical pollutional parameters (especially phosphates, fluorides, and total suspended solids) from discharges of nonprocess and process wastewaters to various stream segments
- The creation of many water impoundments that will tend to deteriorate water quality by permitting overenrichment
- Local surface-water deterioration from clearing, burning, construction, reclamation, slime spills, and seepage from contaminated ponds
- Local water-table quality deterioration because of draining and dewatering, overburden, product storage, seepage from contaminated ponds, and reclamation of mining pits

(3) Aquatic Biota

(a) Areas Affected by Phosphate Industry Activities

Over the short term (1977-85), phosphate mining is expected to occur principally in southwestern Polk County and southeastern Hillsborough County.

Aquatic habitat likely to be affected includes the upper portion of the Peace River; the upper reaches of Payne and Little Payne creeks; Horse Creek; McCollough Creek; and the north and south prongs of the Alafia River. Riparian wetlands along portions of the Peace River and the north and south prongs of the Alafia also are expected to be disturbed, as are numerous small standing waterbodies and wet depressions characteristic of the region. Over the long term (1985-2000), mining activities will be essentially limited to the same general areas described for short-term activities and will continue to affect the waterbodies discussed. Additionally, mining activities will expand into the upper portion of the Little Manatee River basin and farther down the Peace River in the vicinity of Bowlegs Creek.

(b) Threatened and Endangered Species

Of the 13 aquatic species endangered, threatened, rare, or of special concern, only the American alligator (threatened; USDI), Suwanee cooter (threatened; FGFWFC, FCREPA), and manatee (endangered; USDI) might potentially be affected by phosphate industry activities in the study area. Land preparation and mining (particularly in the riparian wetlands bordering the Peace River and the north and south prongs of the Alafia River) will cause some loss of habitat and displace the American alligator but likely will have no adverse impact on the area's alligator population. These local disturbances could be offset by reclamation of gently sloped, shallow waterbodies that would be appropriate habitat for the alligator. Over the long term, mining's alteration of surface runoff patterns and creation of numerous impoundments during reclamation will alter the Peace and Alafia flow regimes, but the alterations will be of small magnitude and are expected to have only very minor effects on the Suwanee cooter and manatee through a potentially altered distribution of food plants.

Slime placement poses a potential for the most significant adverse impact on rare and endangered aquatic species of the study area. Because of the long time interval required for reclaiming slime ponds, increasing mining activity represents increasing potential for adverse impact through spills resulting from dam failure and human error. A major spill would have substantial adverse effects on the American alligator, the Suwanee cooter (Alafia River only), and the manatee by disrupting the food chain. Although the immediate effects of such a spill are severe, the impact is reversible because stream ecosystems generally recover in 2 to 5 years (based on the spill's magnitude).

(c) Species of Commercial and/or Recreational Importance

Direct effects will be limited principally to freshwater communities. Freshwater species of recreational and/or commercial value within the study area include largemouth bass, channel catfish, bream (bluegill and other sunfishes), and blue tilapia. Short-term effects generally will be local and the result of land preparation and excavation, which alter habitat quality by changing local runoff patterns and increasing turbidity and siltation due to erosion. However, the areas affected would be small and only lightly utilized for recreational or commercial purposes.

A significant beneficial effect on freshwater sport and commercial fisheries will be the increased acreages of surface water resulting from reclamation of mining pits. This additional surface water represents significant potential for establishing good commercial and recreational fisheries. If this potential is to be fulfilled, however, present reclamation must be altered to include lakes and ponds with wide littoral zones and other areas (e.g., "marshy" islands) that would increase habitat diversity and support a viable sport fishery. The steep-sided, relatively deep lakes now predominating are of little long-term value; they quickly become degraded and/or eutrophic.

Placement and containment of large amounts of slime resulting from mining activities is a threat to recreational and commercial species of the study area. A major spill could devastate a river-based fishery for several years and, depending on location and magnitude, have significant adverse impact on estuarine fish and shellfish of recreational and commercial importance. Also, the economically important estuarine fisheries are susceptible to the long-term effects of flow-regime modification through alteration of drainage patterns and creation of impoundments, but the magnitude of the potential effects under this scenario (2.15) is considered to be small.

(d) Nuisance and Pest Species

Categories of aquatic nuisance and pest species that are expected to be affected by phosphate industry activities in the study area include exotic hydrophytes (hydrilla, water hyacinth, etc.), algae (principally filamentous green and bluegreen forms), midges and mosquitos, Asiatic clams, native nuisance fishes (bowfin, gar, gizzard shad, etc.), and exotic fishes (walking catfish, blue tilapia). Draining and dewatering low, wet areas, thus eliminating breeding areas for midges and mosquitos, will have a positive effect but will be more than offset by the industry's creation of additional surface water. The new surface-water impoundments, if not properly managed, can potentially lead to nuisance algae and aquatic hydrophytes and increase the number of midges and mosquitos and undesirable fishes.

(e) Standing-Water Communities

The standing-water, or "lentic," aquatic communities of the study area comprise natural and man-made lakes and impoundments, ponds, pits, and seasonally wet depressions. Except for some interconnection of lowland wet areas, the standing-water communities represent rather discrete ecosystems. Thus, the effects of phosphate industry activities on standing-water communities, unlike those on flowing-water communities, are highly localized.

The amount of standing-water communities expected to be directly affected under Scenario 2.15 is relatively small and involves no major lakes, ponds, or impoundments. The smaller ones will be affected principally through alteration of runoff patterns and increased siltation of cleared areas because of erosion. Also, there may be direct disruption due to land preparation and excavation. Perhaps the most important consideration will be the creation of new standing-water habitat. It has been projected that approximately 7280 hectares (18,000 acres) of mined land will be reclaimed to lakes between 1977 and 1985;

by the year 2000, this area will be approximately 11,490 hectares (28,400 acres). This area, if properly reclaimed and managed, represents a considerable increase in resource potential for sport and commercial fishing.

(f) Running-Water Communities

Of the three basic aquatic community types described for the study area, the running-water communities (streams and rivers) will experience the greatest effects from phosphate industry activities. Under Scenario 2.15, approximately 14,130 hectares (34,900 acres) of land will be mined by 1985 in the upper Peace River Basin, approximately 120 hectares (300 acres) in the Little Manatee River Basin, and 5830 hectares (14,400 acres) in the Alafia River Basin. By 2000, disturbed surface acreage will increase to approximately 31,000 hectares (76,600 acres): i.e., 19,500 hectares (48,300 acres), 1417 hectares (3500 acres), and 10,000 hectares (24,800 acres), respectively. This magnitude of activity will measurably affect runoff patterns and flow regimes of headwater streams within the three river basins and, to a lesser degree, flow regimes of the Peace, Alafia, and Little Manatee rivers. Local alterations of the flow regimes of these three major rivers will be minor and obscured in normal flow variations.

Another important factor affecting the flow regimes of streams in the study area will be the creation of large acreages of impoundments that cause loss of runoff water to the streams and a net loss of surface water from the area through evaporation. It has been projected that discharge decreases attributable to evaporation losses of impounded water in the Peace River Basin will be equivalent to about 15 cubic feet per second by 1985 and 21 cubic feet per second by the year 2000 in the Peace River, 6 cubic feet per second by 1985 and 11 cubic feet per second by 2000 in the Alafia, and 0.1 cubic foot per second by 1985 and 1.5 cubic feet per second by 2000 in the Little Manatee. Average flows near the mouths of the three rivers are 1195, 175, and 373 cubic feet per second, respectively.

The total effect of phosphate industry alteration of the flow regimes of streams in the study area through 1985 will be minor. By 2000, however, the magnitude of alteration will be sufficient to cause some noticeable community shifts from organisms preferring flowing water to those more indicative of lentic, or standing-water, habitats; this will represent an adverse effect, since shifts to lentic characteristics in a stream habitat are undesirable and result in a loss of resource value.

In addition to affecting the flow regimes of local streams, the industry's construction, land preparation, and excavation will cause some local degradation of stream habitat quality by increasing siltation and turbidity. However, such adverse effects are expected to be local, rather short-term, and only minor from a regional perspective. Community-structure alterations accompanying local habitat degradation by siltation and turbidity will be manifested as reduced algal abundance (benthic and periphyton communities), replacement of more desirable benthic forms (e.g., mussels, odonate and mayfly naiads) with forms more tolerant of silty substrate (tubificid worms, diptera larvae), poorer condition of local fish populations because of food-chain disruption and impairment of feeding activities, and reduced fish egg and larva survival.

(g) Bay and Estuarine Communities

Effects will be limited principally to mining's long-term effect on freshwater discharge patterns of the Peace and Alafia rivers (discussed in the preceding). Changes in freshwater discharge will alter salinity regimes within the river estuaries and thus affect distributions of estuarine organisms. However, the effects of the relatively small changes of freshwater discharge patterns are expected to be minor and obscured in normal discharge variations.

2. Man-Made Environment

a. Land Use

Phosphate mining's major impact on land use in the study area is the displacement of acres in the various land-use categories. Forest land, agricultural land (USGS Level-II categories "Cropland-Pasture" and "Orchards-Groves"), and open space (USGS Level-II categories "Rangeland" and "Transitional Areas") will be displaced (Table 2.12), while other land uses (residential, commercial, and industrial) will be affected areally through the economic stimulation of mining activities but will not be displaced because of their relative economic values. As an example, residential land may expand in certain areas (other than immediate mining areas) over time because of the influx of population stimulated by the presence of phosphate mining and related activities.

Table 2.12. Displacement Areas, 1985 and 2000 (Scenario 2.15)

Land Use Categories (keyed to matrix elements)	Areas (hectares/acres)				
	(a) Four River Basins, Unadjusted	(b) Adjusted	(c) 1975 Unadjusted	(d) Area Mined According to Map	(e) Difference (c-b)
Forests	55,116/136,138	56,590/139,778	69,676/172,101	3,057/7,552	13,086/32,323
Agriculture	471,763/1,052,246	430,800/1,064,076	456,908/1,128,563	3,938/9,728	26,108/64,487
Open space (includes USGS categories rangeland and other barren land	471,763/1,165,255	483,949/1,195,355	492,648/1,216,843	3,834/9,472	8,699/21,488
Forests	58,807/145,255	60,281/148,895	69,676/172,101	4,845/11,968	9,395/23,206
Agriculture	426,947/1,054,560	431,736/1,066,390	456,908/1,128,563	9,561/23,616	25,171/62,173
Open space (includes USGS categories rangeland and other barren land)	469,539/1,159,763	481,717/1,189,843	492,648/1,216,843	6,685/16,512	10,931/27,000

Compatibility of the various land uses with phosphate mining varies. Residential land is the least compatible of all categories; on the other hand, forests and open spaces provide excellent buffer zones between mining and less compatible land uses. There will be more disturbed acres of forest, agriculture, and open space by the year 2000 than by 1985. By 2000, reclamation will have increased acreages in each of the mentioned categories over 1985 acreages but will not have restored them to their 1975 extents. Projections of the Four River Basins Area Economic Base Study summarized in Table 2.12 are not realistic since most reclaimed land probably will be returned as improved pasture and lakes. Planners (and land-use plans) in the study area, most of whom agree with the fundamental philosophy of the Four River Basins Study, may have unrealistic expectations for potential uses of reclaimed land. Placing additional constraints on the variety of future land use are existing laws and regulations specifying physical requirements for reclaimed land.

Mining will not adversely affect land tenure, either public or private, since mining companies already own almost all land that will be mined through the year 2000.

b. Archeological, Cultural, Historical, and Recreational Sites

Areas to be mined in the future (Plate 1 in pocket) contain historical and archeological sites. The number of sites that will be disturbed (by scenario) is indicated in Table 2.13.

Table 2.13. Disturbed Archeological and Historical Sites*

Year	No. of Sites in Study Area	Scenarios 2.15	2.11	2.14
1985	791	6	11	1
2000	791	10	28	3

*Based on assumption of no additional sites discovered between 1976 and 2000.

Most archeological sites are considered by archeologists as fragile and, as such, would be permanently altered or destroyed if mined. Florida's Division of Archives, History, and Records Management (1976) has expressed concern that valuable sites within the study area may be lost or may suffer irreversible damage; this agency maintains that the effects will occur on a regional level and may result in the permanent loss of a sizable portion of Florida's archeological record. Unless measures to collect and preserve the artifacts are taken before mining, the state office's concerns will be valid.

As to existing and potential recreational areas, phosphate mining will have both positive and negative effects. Water-based recreation is particularly sensitive to wastewater spills. Such spills, especially the one on the Peace River in 1971, can be extremely destructive (Blakey 1973). Land-based hunting will be affected not only by habitat destruction due to mining but by the reclamation (e.g., to improved pasture) that does not restore habitat. Reclamation can provide additional recreational areas, however (e.g., Polk County's Saddle Creek Park), and should be planned with care to provide an aesthetic setting.

c. Demography, Economics, and Cultural Resources

One should be aware that all official population and economic projections that have been examined during the course of this study are based on the postulation of continued development of the phosphate industry in the study area.

The phosphate industry's existing ownership of large tracts of land on a north-south axis from Lakeland to Port Charlotte has contributed to the current crescent-shaped population concentration from Lakeland to Tampa and along the coast to Port Charlotte. Land use in the northern part of Polk County has been dramatically affected by the Disney World entertainment complex (just north of the Polk County line). Land values for residential and associated commercial development and tourist accommodations have increased at a tremendous rate in recent years, resulting in significant land-use changes. For example, land devoted to growing citrus has been removed from production and shifted to intensive development.

Without increased phosphate mining in Polk and other counties, existing land use in those areas could undergo changes in character: the industry would probably turn back (sell) some of its large landholdings, and this land would then be available to reduce population concentrations.

Table 2.14 shows the projected economic impact of the phosphate industry on the study area by scenario. The "Without Action" alternative would mean a loss of 2674 phosphate industry jobs in 1985 and 7554 by the year 2000. Phosphate industry payroll losses would be $20,700,000 in 1985 and $58,500,000 annually by the year 2000. One can see that losses in employment and payroll by phosphate industry-induced industry and business would be much greater. Since the service businesses catering to the needs of the retirement and tourist sectors are in direct conflict with the phosphate industry, however, there is good reason to believe that they could absorb surplus workers from the phosphate industry.

The study area is served by all modes of transportation. Trackage at Tampa Harbor connects to the Seaboard Coastline Railroad System. Two interstate highways, I-75 and I-4, along with other federal and state roads, connect the

Table 2.14. Projected Economic Impact of Central Florida Phosphate Industry from Domestic Mining Only on Study Area by Scenario, 1980-2000#

Year	Scenario	Production (million short tons)	Phosphate Industry Employment*	Phosphate Industry Payroll** (000,000)	Induced Employment***	Induced Payroll**** (000,000)
1975	Actual†	38.2	8,512	65.8	52,349	221.3
1980	2.11‡	41.2	9,181	71.0	56,463	238.7
	2.15ǂ	42.2	9,403	72.7	57,828	244.4
1985	2.11‡	45.2	10,072	77.9	61,943	261.9
	2.15ǂ	33.2	7,398	57.2	45,498	192.4
1990	2.11‡	44.8	9,983	77.2	61,395	259.6
	2.15ǂ	27.5	6,128	47.4	37,687	159.3
1995	2.11‡	42.0	9,359	72.4	57,558	243.4
	2.15ǂ	9.1	2,028	15.7	12,472	52.7
2000	2.11‡	36.5	8,133	62.9	50,017	211.5
	2.15ǂ	2.6	579	4.4	3,560	15.0

*Based on 1975 average of 222.84 workers per million tons produced.

**Based on 1975 average of $7,742 per worker per annum, 1967 constant dollars.

***Based on Bureau of Mines estimates of 6.155 jobs generated for each new job in the phosphate industry.

****Average of $4,228 per worker per annum, 1967 constant dollars.

†U.S. Bureau of Mines (1975) adjusted by Texas Instruments for the study area; Florida Statistical Abstract (1976).

‡U.S. Bureau of Mines (1977) adjusted by Texas Instruments.

ǂTexas Instruments projections of production from existing mines.

#To estimate total projected impact, effects from constant employment of about 3,000 chemical processing plant employees must be added.

study area with other parts of Florida and the United States. Interstate 75 is scheduled to be constructed south along the Gulf Coast through the study area to the Florida east coast. Tampa International Airport, which is served by 10 major airlines, provides domestic and foreign service. Numerous shipping lines and barge lines have facilities in Tampa Harbor and provide extensive service to waterborne commerce. Major plans are now underway to improve Tampa Harbor. A major part of the economic justification is the favorable economic impact expected on phosphate shipments. Tampa is a major port and vital to the economics of Florida as well as the nation. On a total tonnage basis, it is now the fourth largest export port and the eighth largest U.S. port. Annually, it handles more than 40,000,000 tons (36.3×10^6 metric tons) of commerce valued at more than $490,000,000. Its export exceeds 11,000,000 tons (10×10^6 metric tons) valued at more than $172,000,000. Phosphate shipments represent 97 percent of the port's outgoing cargo, and sulfur for the phosphate fertilizer industry represents an almost equal percentage of incoming cargo. In the 8-county area around Tampa Harbor, one in every seven wage-earners is employed by port-related businesses; this amounts to more than 36,000 workers and an annual payroll exceeding $210,000,000. Without the scheduled harbor improvement and concomitant increased phosphate industry shipments and receipts, the port could decline in importance, reflecting adversely on the regional economy and ultimately changing the character of current development.

d. Resource Use

Phosphate industry activities that affect the area's natural resources focus on depletion of not only phosphate but uranium (which is mined concurrently) and, to a lesser extent, timber.

Phosphate resources of the area are estimated to be 1561.9×10^6 metric (1772×10^6 short) tons; 940.6 metric (1037×10^6 short) tons are classified as known reserves. Under Scenario 2.15, it is forecast that 327.4×10^6 metric (361×10^6 short) tons will be mined during 1977-85 and 537.9×10^6 metric (593×10^6 short) tons from 1977 through 2000. This represents a reserves depletion of 34.8 and 57.2 percent respectively.

Clearing land before mining involves the total removal of vegetation, including marketable timber. It is estimated under this scenario that approximately 3056 hectares (7552 acres) of land mapped as forest land will be mined during 1977-85 and 4843 hectares (11,968 acres) between 1977 and 2000.

E. SUMMARY OF SECONDARY EFFECTS OF THE "WITHOUT ACTION" ALTERNATIVE

1. Natural Environment

a. Land

1) Soil

Secondary effects of phosphate industry activities on soil are restricted primarily to chemical alteration due to the stacking of materials (e.g., wet rock and gypsum). Water percolation through these materials tends to cause them to leach and be subsequently deposited in the soil underlying horizons. No secondary impacts could be determined for the various scenarios because of the lack of any quantitative model with which to assess the effects of leaching. The number of gypsum stacks is assumed constant among scenarios, but new wet-rock storage piles are anticipated under Scenarios 2.11 and 2.11' (Section 3).

2) Background Radiation

Although there has been no proof to date that any activity of the industry causes a radiation impact on the general population, there are four potential pathways for secondary impacts of exposure:

- Air contamination by radionuclides associated with dust created when dry phosphate rock and phosphate products are transferred
- Possible contamination of ground waters by seepage of process waters at the chemical plants and slime-pond waters in the mine areas
- Radon-222 daughter-product contamination of air in structures built on land previously mined by the industry
- Consumption of foods (crop foods or beef) produced on reclaimed land

Considered the most significant is exposure from radon-222 daughter radionuclides in homes or other structures built on reclaimed land. Quantifying impacts on the general population by exposure associated with the pathways just listed was considered beyond the scope of this program.

3) Terrestrial Biota

Among possible secondary effects not implied in the discussion of primary effects are certain changes occurring in coastal areas as a result of mining. For example, if the harbor area were increased to accommodate the transportation of phosphate rock or other materials, it could affect terrestrial biota; however, the expected changes (e.g., the deepening of Tampa Bay), will have little effect.

b. Water

1) Quantity

Pumping from the Floridan aquifer will potentially (1) decrease streamflow, affect surface vegetation, and affect lake levels and (2) cause upconing of highly mineralized waters from the deeper parts of the Floridan aquifer and lateral encroachment of salt water from the coastal zone. Unfortunately, a basic assumption used in the design of the model is a constant head in the water-table aquifer, so the model cannot predict declines in the water table as a function of pumping from the Floridan aquifer; therefore, very little can be said of the effect on the vegetation and surface-water systems as a result of pumping from the Floridan aquifer. One aspect that can be evaluated indirectly, however, is the potential for saltwater encroachment in relation to the change in the potentiometric surface. For example, the 1985 potentiometric surface map (Figure 2.10) that was simulated by combining the September 1975 potentiometric surface and the predicted water-level changes under Scenario 2.15 in the year 1985 showed no change in the location of the 20-, 30-, and 40-foot contour lines in the coastal zone. Thus, it may be concluded that the gradient in the potentiometric surface has not changed, nor has the outflow of fresh water to the coast from the Floridan aquifer. This suggests that Scenario 2.15 for 1985 will have no effect on the potential for saltwater encroachment in the coastal zone. However, there are other (beneficial) effects: in southwestern Polk

County, water levels will rise 10 feet in certain areas, thereby reducing the pumping life for many wells and subsequently resulting in an economic benefit to the owners of the wells.

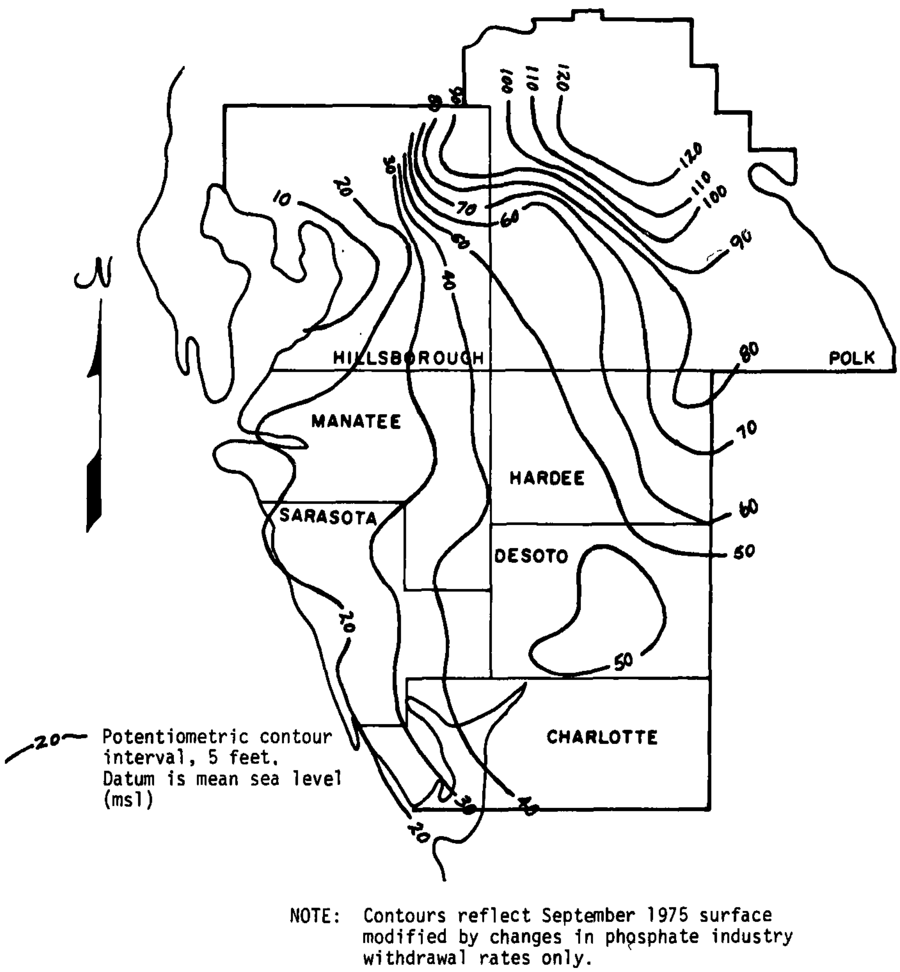


Figure 2.10. Simulated Potentiometric Surface, September 1985, under Scenario 2.15.

On the potentiometric surface map for the year 2000 (Figure 2.11), contours in the coastal zone are more closely spaced than in 1975. More specifically, the 20-foot contour line is still at the same location but the 30-foot contour line has moved somewhat to the western part, followed by the 40-foot contour line. This means that the elevation of the potentiometric surface in the coastal zone will have increased by the year 2000, thereby most likely increasing the outflow of fresh ground water to the Gulf. This will reduce the potential for lateral saltwater encroachment. Apparently, because of Scenario 2.15, more water will be lost to the Gulf in the year 2000 than was lost in 1975.

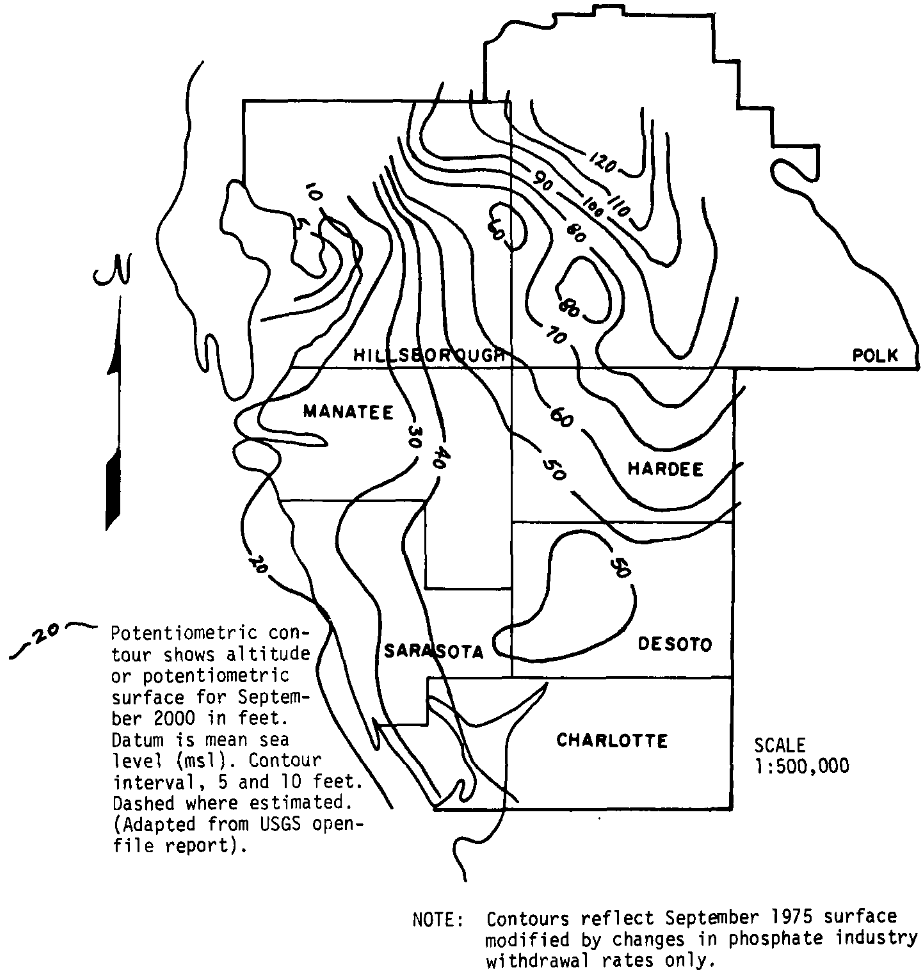


Figure 2.11. Simulated Potentiometric Surface, September 2000, under Scenario 2.15.

The sharp rise in water levels in Polk County will provide an economic benefit to owners of wells in those areas because pumping costs will be reduced. No specific information has been gathered or analyzed, but it is entirely possible in certain instances that the rise in the potentiometric surface in the southwestern part of Polk County will reinstate the free flow of springs in the area. Although there are no data showing real potentiometric surface contours that would reflect municipal, agricultural, and industrial pumpage, it is clear that completion of existing phosphate mining operations will have a beneficial effect on the water resources of the study area.

2) Quality

Secondary effects on water quality were taken to be potential effects. These effects are saltwater encroachment due to drawdown of the Floridan aquifer; contamination of the water-table and Floridan aquifers by seepage from contaminated ponds, which causes sinkholes that collapse and allow direct contamination; and radiation potential because of gyp ponds and mining-pit reclamation.

3) Biological

The phosphate industry's secondary effects on the aquatic biota of the study area involve waste discharges on receiving waterbodies, the potential for spilling hazardous materials at processing plants, and impacts of supporting activities such as electricity generation and transport (shipping). The effects of all except waste discharges are considered to be minor.

Industry discharges of high concentrations of inorganic nutrients (nitrogen and phosphorus), coupled with naturally high ambient concentrations in flowing waters of the study area, result in highly fertile water supporting rich and diverse running-water communities. Extremely productive estuarine communities occur at the mouths of the Peace and Alafia rivers where the fertile river water enters the estuary; indeed, the unusually high productivity of both Tampa Bay and Charlotte Harbor can be attributed largely to significant contributions of inorganic nutrients by the major contributing streams (Alafia and Peace, respectively). Although waste discharges can be detrimental locally (e.g., toxic concentrations of ammonia), such effects are very limited and are outweighed by the beneficial aspects of nutrient enrichment. However, coupled with decreased flow and water motion, this nutrient enrichment can potentially result in severe nuisance hydrophyte problems and degradation of habitat quality.

2. Man-Made Environment

Development of Tampa Harbor and development of the phosphate industry are synergistic: development of one presumes development of the other; and conversely, if one is not developed, the other is not likely to be developed.

Perhaps not readily apparent to the casual observer, the bulk of employment in the Tampa area is in manufacturing, construction, transportation, and communications — and the harbor (largely supported by phosphate industry shipments) contributes directly or indirectly to all these industries. Many important industries need the harbor facilities but are not important enough to support them. An example is the Disney World complex near Orlando, one of the major contributors to increased demands for products through Tampa Harbor. New industries such as optical materials and gun manufacturing, construction of prefabricated houses, assembly of foreign trucks imported through the harbor, export of citrus fruit, and processing of food caught off Florida's coast depend on a viable harbor system. Failure to develop the harbor would cause a decline in the operations.

F. SUMMARY OF PRIMARY EFFECTS OF THE "PERMIT EXISTING AND NEW SOURCES" ALTERNATIVE

1. Natural Environment

a. Atmosphere

Adding new mines to replace existing capacity will tend to keep constant the phosphate industry's areawide pollutant load on the atmosphere after 1977. Some of the emissions associated with mining, drying, and transporting will shift slightly south as these activities move into Manatee, Hardee, and DeSoto counties. Air emissions created by sources other than the phosphate industry will dominate the inventory in Hillsborough, Manatee, and DeSoto counties so that any changes in air quality will be difficult to associate with the phosphate industry. SO_2 levels in Polk County should slightly decrease as some of the rock dryers are moved south with the mines. Hardee County will exhibit an increase due to the industry move into Hardee. Sarasota and Charlotte counties should not be materially affected by air emissions from the phosphate industry.

The emission inventory will be the same for Scenario 2.11 as for Scenarios 2.13 and 2.14. Changes from the 2.15 inventory will be primarily in mining, storage/transportation, and drying, reflecting the movement of these activities from Polk County into Hillsborough, Manatee, Hardee, and DeSoto counties.

b. Land

1) Physical Environment

a) Unique Physical Features

In terms of potential impact through actions by the phosphate industry, the karst structures in the Hawthorn limestone underlying the phosphate ore zone of the area are of interest. The primary effects on these features are expected to be collapse or high-volume drainage caused by excessive surface loading and increased hydrologic head created by abovegrade storage of clay slimes and waste gypsum. The amount or distribution of the waste-gypsum stacks for this scenario are not expected to differ from those for the "Without Action" alternative, so interest is focused on the new clay-slime impoundments forecast under this scenario; it is estimated that an additional 3561 hectares (8800 acres) will be committed to slime impoundments from 1977 through 1985 and an additional 11,858 hectares (29,300 acres) from 1977 through 2000. Under Scenario 2.11', additional areas committed to slime ponds are expected to approximate 3561 hectares (8800 acres) in the short term and 20,883 hectares (51,600 acres) in the long term.

Because the precise locations of karst features underlying the proposed additional mines are not known and detailed information regarding lines of weakness (faults and partings in the underlying limestone) is generally lacking, the forecast of regional impact of these abovegrade impoundments is negative and rated as insignificant. The character of the limestone underlying the proposed slime-storage areas should be investigated on a site-specific basis to assess the precise potential for impact.

b) Soil

The 7-county study area possesses approximately 453,264 hectares (1.12×10^6 acres) of mapped soil association containing soil types rated high in their potential to produce truck crops or citrus; this represents approximately 28 percent of the study area. Under this scenario, destruction of approximately 6625 hectares (16,370 acres) of these associations is forecast for 1977-2000 and 12,906 hectares (31,890 acres) for 1977-2000. These figures represent 1.5 and 2.8 percent, respectively, of the total high-potential associations in the study area and, compared with the "Without Action" scenario, an increase in the destruction of high-potential soils (relative to the total area) of 0.4 percent (1.1 versus 1.5 percent) for the near term and 0.9 percent (1.9 versus 2.8 percent) for the long term. Based on these percentages, the impact of this scenario on the destruction of high-potential soils, compared with Scenario 2.15, is considered negative and is rated as insignificant. The percentage changes (this scenario versus Scenario 2.15) relative to the total area are 0.4 percent (1.1 versus 1.5 percent) and 1.4 percent (1.9 versus 3.3 percent) for the respective time periods.

c) Exposure

This scenario assumes that an additional seven mines will be in operation through 2000, representing an increase of 41 percent numerically over the "Without Action" alternative. Mining plans for six of these imply significant knowledge of the geologic section in the areas, and it is assumed that information from prospect drilling is available also for the seventh location. Thus, the additional information that mining (excavating) would provide by exposing the geologic section is expected to be insignificant.

For Scenario 2.11' (the "industry view"), 12 new mines (excluding one scavenger operation) are forecast in addition to those simulated under Scenario 2.11; all are expected to come on line between 1985 and 2000 (Plate 5 in pocket). Compared to the "Without Action" scenario, 2.11' represents an increase of 112 percent numerically in lands affected. Section information needed to prepare for these additional mines will constitute a significant, though unquantifiable, addition to current knowledge, especially in terms of phosphate reserves and resources for these areas.

d) Topography

Land excavation, material and waste storage, and the earthen structures associated with these activities impart primary effects on topography. Land excavation predominates. This scenario, compared with 2.15, is expected to add 7160 mined hectares (17,600 acres) from 1977 through 1985 and 23,810 hectares (58,500 acres) from 1977 through 2000, representing an increase of 35.8 and 72.6 percent, respectively. However, comparing area increases to the total study area (an estimated 1.6 x 10^6 hectares [4.0 x 10^6 acres]), the differences are 0.4 and 1.5 percent for the respective time periods. Because of these low net percentage changes, this scenario's impact on topography is considered insignificant in both the short and long terms. Under Scenario 2.11', the net percentage changes would be 0.4 and 2.6 percent respectively.

e) Radiation

Under this scenario, current radiation levels at the chemical processing plants should remain constant through the year 2000 because of the continued use of locally mined phosphate ore and the constant level of throughput that is forecast. Therefore, industry effects on radiation are keyed to activities at the mining sites. Mining and reclamation increase radiation levels. The magnitude has been estimated on the basis of radium-226 radioactivity concentrations in surface materials expected to exist at various stages for a hypothetical mining unit. Based on the conversion factor that an individual will be exposed to 1.85 microroentgens per hour of gamma radiation for each picocurie per gram of radium-226 radioactivity concentration of a surface, the maximum annual dose equivalent for continuous occupancy in the mining pit (an absurd situation) would be less than the guide for the general population. Occupational guidelines state that employees should not receive a whole-body exposure (external exposure from gamma radiation) of more than 5 rem (5000 millirem) per year or lung exposure (inhaling airborne radionuclides in the form of dust) of more than 15 rem (15,000 millirem) per year. Guidelines for the general population are one-tenth of these values. To date, no activity of the phosphate industry has been proved to cause a radiation dose to the general population in excess of the guideline. Furthermore, when industry average time-weighted values are used, it is anticipated that no phosphate workers will receive doses of radiation exceeding the guideline established for the general population.

Based on the preceding, the impact on the general population and on phosphate workers by the increase in gamma radiation resulting from the forecasted increase in mining activity under Scenarios 2.11 and 2.11' through the year 2000 would be insignificant compared with that under Scenario 2.15.

f) Noise

Increased mining activities under Scenarios 2.11 and 2.11' will increase ambient noise levels locally, particularly in the immediate vicinity of operating engines or machinery (e.g., bulldozers, draglines, and washing/beneficiation plants). These increases will not impact the general population, and employees may be readily protected from these noises.

2) Biological Environment

Mining in wetlands, mixed forests, and deciduous forests, because of their importance to surrounding ecosystems and their uniqueness, is considered worst-case. Approximately 6 percent (10,850 hectares, or 26,800 acres) of the present areawide wetlands extent will be mined by the year 2000. Although unrealistic projections of future areawide wetlands extent preclude estimating areawide change attributable to mining, there are indications that greatest depletion will occur in the mining area. The loss of only several hundred acres of mixed and deciduous forest types (sandhills, sand pine scrub, and hammocks) will severely deplete the unknown but undoubtedly limited extent of these important habitats.

By 2000, mining will account for 69 percent of the projected 18 percent areawide loss of forest (primarily evergreen), 62 percent of the projected 4 percent areawide loss of rangeland, and 85 percent of the projected 7 percent loss of pasture and cropland. The severe impact of mining in pine flatwoods is tempered by the projected remaining areawide extent of the type, as well as by the fact that unmined, unmanaged rangelands possibly could succeed to pine forest. The level of impact associated with mining rangeland will depend on the amount of true dry prairie included — and apparently, there is little. The impact of mining pasture and cropland is considered to be negligible. Of the 55,789 hectares (137,800 acres) of uplands/wetlands habitat to be mined by 2000, as much as 16,599 hectares (41,000 acres) will be permanently displaced by water. As wildlife habitat, waterbodies created during reclamation are, like terrestrial habitat, generally inferior to those that could develop naturally were the mining areas merely abandoned.

The impact of noise, dust, and gaseous and particulate emissions is largely unquantifiable, as is the impact of surface- and groundwater changes and erosion. Of prime concern are the effects that the alteration of water regime and sedimentation will have on the remaining wetlands; these are not addressed to the extent of similar effects on waterbodies. Although most effects pertinent to habitat quality are claimed to be temporary and not of sufficient magnitude to prevent recovery, long-term effects (e.g., reduced carrying capacity) that preclude complete recovery are quite possible.

Since phosphate mining will account for most of the expected areawide change in inland land use by the year 2000, it will account also for most of the change in community structure. Particularly will the modified habitat types replacing forests and wetlands support a smaller variety of biota and be considerably less productive in terms of life support. Mining will expand within or into the five counties that are already most highly modified by urbanization, industrialization, and agriculture (Polk, Manatee, Hillsborough, Hardee, and DeSoto). There will be an increase in the proportion of managed systems that require expenditure of energy to natural systems that do not.

The greatest impact on threatened and endangered species that likely will be affected by mining will come primarily from loss of uplands forested habitat. Actual or potential impacts that are considered worst-case involve the Florida mouse, short-tailed snake, sand skink, and Florida Scrub Jay because of their endemic status, limited distribution in the study area and state, and restricted habitat (scrub). Impacts on the Florida gopher frog and Southeastern American Kestrel could be severe: the widespread frog may be seriously affected by loss of favored habitat (scrub), and the widespread but local kestrel could be eliminated from the region if major concentrations within or or near the mining areas were substantially reduced. Six other species - the gopher tortoise, eastern indigo snake, Sherman's fox squirrel, Wood Stork, Florida Sandhill Crane, and Southern Bald Eagle - are expected to be moderately to substantially impacted. Mining will directly reduce populations of some of these species and, coupled with reclamation, will limit opportunities for all of them. They generally are widespread in the study area and equally or more abundant in areas not affected by mining.

Loss of forests (and in this case, particularly wetlands) will have the greatest impact on ecologically significant species. Some of the water-oriented species may utilize shallow mining pits and vegetated slime ponds, but these habitats are displaced during reclamation. Permanent population declines are expected among most of the affected species.

The impact on the hunting and trapping potential of commercial and recreational species is considered minimal, as is the impact of increased abundances of nuisance and pest species. There is intense management in both of these categories, and increased costs of management undoubtedly will accompany changes in land use. The impacts could be greater than minimal, but a more accurate assessment is difficult without cost estimates.

c. Water

1) Quantity

To simulate "worst-case," Scenario 2.11' was substituted for 2.11 in the USGS model. The model predicted water-level changes in 1985 and 2000 with respect to the September 1975 potentiometric surface of the Floridan aquifer. These water-level changes will also affect the hydrologic system by increasing induced recharge from the water table to the Floridan aquifer, for example, and possibly causing subsequent reductions in streamflow. There will also be an economic effect: a rise in level will reduce pumping costs; a decline will increase pumping costs. A change in the potentiometric surface in the coastal zone might also affect the movement of the saltwater/freshwater interface in that area. Another change may be decreasing upward leakage in coastal areas and upconing.

The water-level change for 1985 indicates an approximate 2-foot rise in the potentiometric surface in the Bartow area and a decline of about 10 feet in the Four Corners area. This pattern of decline is quite likely, since phosphate mining activities are expected to shift from southwestern Polk County in a south-southwesterly direction toward Manatee and Hardee counties. Not only will there be a 10-foot decline in the Four Corners area, but also in small areas near Myakka Head, Bowling Green, and Ona. A 5-foot decline will extend from southeastern Hillsborough County through the middle and western parts of Manatee County into and across the middle of Hardee County and the southern half of Polk

County. A 1-foot decline will parallel most of the coast in Hillsborough, Manatee, and Sarasota counties, extending as far south as Port Charlotte. Thus, the effect of proposed and existing phosphate mining generally will be over the whole Central Florida Phosphate District, a decline ranging from 1 and 10 feet compared with the September 1975 potentiometric surface level.

The water-level change for the year 2000 indicates an approximate 20-foot rise in the potentiometric surface in southwestern Polk County relative to the September 1975 levels. This rise will occur in an area south of Bartow. The rise is explained by the fact that a large number of present phosphate mines in the area will be phased out by the year 2000 and that the major mining will shift in a southerly and southwesterly direction into western Manatee County, middle and southern Hardee County, and northern DeSoto County. This movement will be reflected by a decline of approximately 10 feet in western Manatee County and eastern Hardee County. Additionally, two small 10-foot declines are predicted near Ona and Sandy. Comparing 1985 and 2000, it is interesting that the predicted 1-foot decline in the potentiometric surface is still at the same location (i.e., along the coast in Hillsborough, Manatee, and Sarasota counties) despite the increase of phosphate mining.

Again, it should be emphasized that the water-level changes reflect only the changes in activities of the phosphate industry. The results might be quite different if pumpage changes caused by municipalities and agriculture were entered into the model.

In summary, it appears that the worst-case effect under Scenario 2.11' will be a drawdown of approximately 10 feet (relative to 1975 levels) in eastern Manatee County by the year 2000.

2) Quality

There are no data with which to determine the radiological impact on the general population as a result of any changes in the radionuclide content of surface, water-table, or aquifer (upper and lower Floridan) waters due to industry activities. As far as other water quality parameters are concerned, the primary effects under the conditions of this scenario are essentially the same as those discussed in conjunction with the "Without Action" alternative but with increased concern for surface-water degradation caused by clearing, burning, and dam and levee construction.

Biologically, the primary effects projected will be similar in types and magnitudes to those described for Scenario 2.15.

2. Man-Made Environment

a. Land Use

Assessing the impacts of mining on the environmental elements (in this case, land tenure, community/regional plans, and land use) is largely judgmental but is in the same direction (positive or negative) in almost every case as the effects listed for the "Without Action" alternative (Scenario 2.15). Impacts on land uses are measured both by areal displacement by mining and overall effects on the total land system by displacement and subsequent reclamation.

Forests, morderately managed rangeland, dry prairies, and other land classified as open space will be areally displaced, resulting in negative impacts These land uses are as important from the standpoint of wildlife and general habitat as for the economic value of their potential products (timber, cattle, etc.). Therefore, the impact of their removal has been based on the loss of their economic as well as ecological values. Current reclamation practices have a negative impact on forests and open space, since these are not usually replaced; reclaimed land is most commonly used for improved pasture. This reclamation pattern will have a positive (economic) impact on agricultural land.

Increased mining under this scenario will stimulate economic growth, which will probably result in areal expansion of residential, commercial, and industrial lands. Residential is probably the land use most sensitive to any pollution, noise, or aesthetic degradation created should mining be located in close proximity. If mining occurs within several miles of residences, negative impacts are likely.

The "Permit Existing and New Sources" alternative will have a positive impact on the land use "Mining." Compared with the "Without Action" alternative, the conditions of the scenario include a projected 39 percent increase by 1985 and a 60 percent increase by 2000. (See Plate 5.)

b. Archeological, Cultural, Historical, and Recreational Sites

More archeological and historical sites would be destroyed under the conditions of this scenario than under those of the "Without Action" scenario: five more sites would be destroyed by 1985; 18 more by the year 2000 (Table 2.13). The impact would be catastrophic, since irreplaceable historical resources would be lost.

Recreation would be both positively and negatively impacted. The increased mining under this scenario would increase the possibility of accidental waste spills and resultant water pollution — and negative impact. Reclamation would increase hunting potential for most waterfowl — a positive impact. Loss of habitat associated with current reclamation practices would have a negative impact on the hunting potential of land-based game species.

c. Demography, Economics, and Cultural Resources

The conditions of this scenario would impact the area's economics and the demographic and cultural elements, as described for Scenario 2.15. With respect to transportation, a special note is worthy of repeating as reported in the Final Environmental Impact Statement, Tampa Harbor Project (U.S. Army Corps of Engineers 1974):

> "From available data and coordination with the state geologist, it is estimated that there are from 26 to 30 billion tons of phosphate rock deposits in Florida, of which about 2.5 billion tons are considered marketable reserves using existing mining methods and present market and price conditions. About 1.5 billion tons of the marketable phosphate is in Polk County and adjacent areas. This estimate is substantiated by the Florida Phosphate Council. Another billion tons of marketable phosphate is located in Hernando, Citrus, Marion, Levy, and Alachua counties, which, if developed, would require use of facilities at Tampa Harbor for shipment to areas of consumption. It is estimated that about 1.65 billion tons of phosphate would be shipped from Tampa Harbor during the 50-year life of the project — an average of about 33,000,000 tons per year. In addition, there would be production of phosphate for domestic consumption of about 7,000,000 tons per year which would not use facilities at Tampa Harbor."

A letter from the Florida Department of Transportation (March 24, 1974) included in the referenced environmental impact statement points out that "... with larger vessels utilizing the harbor facilities, there could be a significant increase in both truck and rail traffic, as well as additional auto traffic generated by the enlarged labor force." The letter also points out the existing condition of "the situation of long freight trains bringing phosphate to Port Sutton, delaying traffic on SR 45 (US 41). This expansion can only augment the present problem."

d. Resource Use

1) Timber

The 7-county study area possesses approximately 69,650 hectares (172,100 acres) of land mapped as forest. This study classifies timber as a secondary resource; it is lost when forests are cleared in preparation for phosphate mining and attendant activities. Under this scenario (2.11), it is estimated that these activities will involve more than 3966 hectares (9800 acres) of forest lands during 1977-85 and more than 7366 hectares (18,200 acres) from 1977 through 2000, an increase over the "Without Action" scenario (2.15) of 27 and 53 percent, respectively. Under the worst-case condition of Scenario 2.11', mining in forest lands during 1977-85 is forecast to equal that under Scenario 2.11. For the 1977-2000 time period, an increase of 67 percent over the "Without Action" scenario is forecast.

Under this scenario, mining from 1977 through 1985 will involve the destruction of an estimated 5.7 percent of the total timber resources of the study area; from 1977 through 2000, 10.6 percent. This will increase depletion over the "Without Action" alternative by 1.3 percent in the short term and 3.7 percent in the long term. Under worst-case (Scenario 2.11') projections, the percentage of forest resources of the study area destroyed will be 5.7 and 11.7 percent, respectively, for the 1977-85 and 1977-2000 time periods, representing depletion increases over the "Without Action" alternative of 1.3 percent for the short term and 4.8 percent for the long term. Such a loss will not cause a significant impact, however, since the timber area to be mined under this scenario is small relative to the total timber area.

2) Phosphate

The study area's total phosphate resources have been estimated to be 1596 x 10^6 metric (1722 x 10^6 short) tons, including known reserves totaling 940.6 x 10^6 metric (1037 x 10^6 short) tons. Phosphate ore to be mined under this scenario is estimated at 0.444 billion metric (0.489 billion short) tons during 1977-85 and 0.925 billion metric (1.020 billion short) tons during 1977-2000 (Table 2.15). Compared with the "Without Action" scenario, total tonnage mined under this scenario represents an increase of 35.5 percent for the short term and 72.0 percent for the long term. Conditions consistent with the "industry view" (Scenario 2.11') would increase production over the "Without Action" scenario by an estimated 35.5 percent by 1985 and 127.8 percent by the year 2000. In terms of depleting the area's known phosphate resources, this scenario poses an increase over the "Without Action" alternative of 7.5 percent in the near term and 24.8 in the long term; for Scenario 2.11', the increased depletion percentages would be 7.5 and 44.1 percent, respectively.

Table 2.15. Phosphate Rock Production Forecast for Scenarios 2.15, 2.11, and 2.11'

	Tons Mined x 10^6		% of Resources*		% to 2.15**	
Scenario	1977-85	1977-2000	1977-85	1977-2000	1977-85	1977-2000
2.15	361	593	20.9	34.4	–	–
2.11	489	1,020	28.4	59.2	7.5	24.5
2.11'	489	1,351	28.4	78.5	7.5	44.1

*Resources = 1,722 x 10^6 short tons (Reserves = 1,037 x 10^6) short tons).

**Change in percentage value relative to Scenario 2.15.

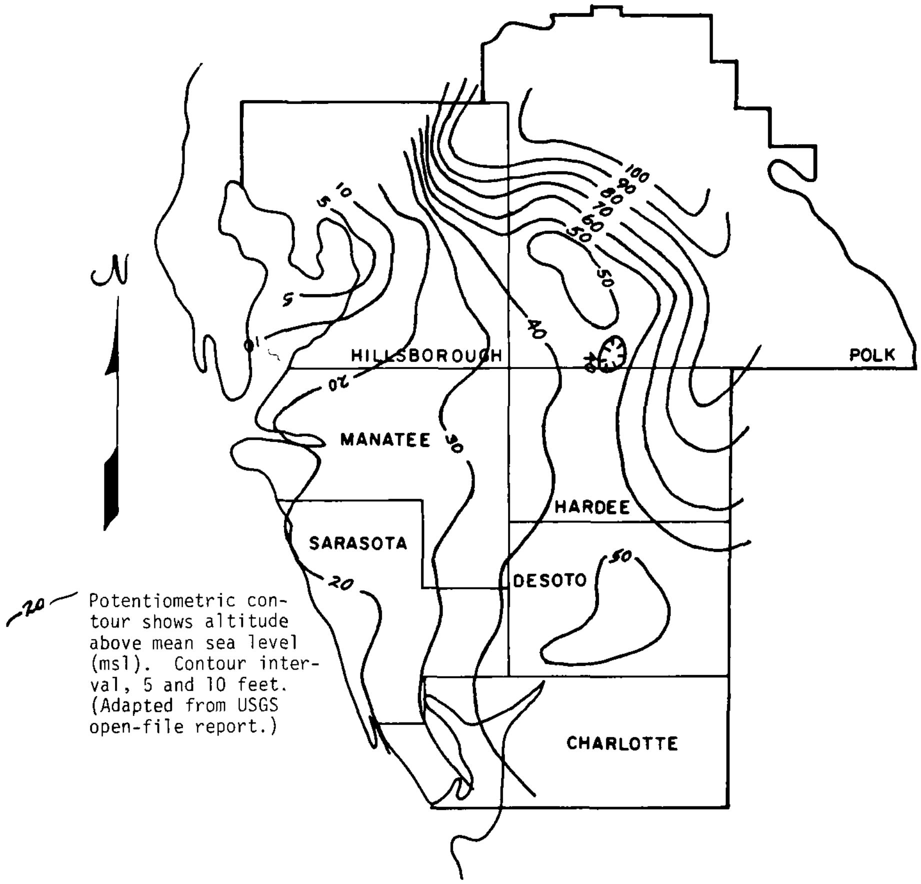
G. SECONDARY EFFECTS OF "PERMIT EXISTING AND NEW SOURCES" ALTERNATIVE

1. Natural Environment

Quantifiable significant secondary effects on the natural environment under this scenario compared with Scenario 2.15 are described in the following paragraphs.

a. Water Quantity

To assess the worst-case (Scenario 2.11') secondary effects on the hydrologic system, a potentiometric surface map for September 1985 was prepared (Figure 2.12) by combining calculated water-level changes for that period with a September 1975 potentiometric surface map. These changes were calculated using the USGS model.



NOTE: Contours reflect September 1975 surface modified by changes in phosphate industry withdrawal rates only.

Figure 2.12. Simulated Potentiometric Surface, September 1985, under Scenario 2.11'.

The 20-foot contour will be in the same location in the coastal zone in September 1985 as it was in September 1975, indicating that no change in the potentiometric surface will have occurred in the coastal area. The 30-foot contour line will have moved farther to the east, thereby creating a somewhat large spacing between the 20- and 30-foot contours. This indicates a flattening of the gradient of the potentiometric surface toward the coast, suggesting a decrease in groundwater flow toward the Gulf of Mexico. This potential effect suggests direction for additional investigations by SWFWMD and the USGS. In southwestern Polk

County, there will be a positive effect: the area encompassed by the 50-foot contour will increase considerably, indicating that the water level has risen in those areas. This rise will have a beneficial secondary effect inasmuch as well-owners in the area will be spending less money on pumping because pumping lifts will have decreased.

As mentioned previously, the model has a constant source and does not predict changes in the head of the water-table aquifer itself. Therefore, the impact of proposed phosphate mining activities on the water table and on water-dependent vegetation cannot be assessed. However, experience has indicated that the effects can be expected to be minimal because the confining beds are relatively impermeable and thicken toward the south. An adverse economic effect of the proposed development in Sarasota, Manatee, and to some extent in southern Hillsborough County in 1985 will be the increased costs to well-owners because of increased pumping lifts. Also, there will be increased potential for upconing of mineralized water from the deeper zone of the Floridan aquifer, especially in old wells that have been drilled into the lower, more mineralized zone of the Floridan aquifer and have been abandoned without being plugged.

In regard to the problem of saltwater encroachment in the coastal zone, the flattening of the hydraulic gradient between the 20- and 30-foot contours suggests a reduction in groundwater outflow and, theoretically, an increase in the potential for landward movement of the salt/freshwater interface.

The potentiometric surface of the Floridan aquifer for September 2000 (Figure 2.13) was constructed by using the September 1975 potentiometric surface map in combination with water-level changes between 1975 and 2000. There will be some changes in the inner parts of the Central Florida Phosphate District and, again, shifts will be in the location of the 20-foot contour in only a few places along the coast. The 30-foot contour line, however, will move farther eastward and be in the western part of Hardee County near the town of Ona. In eastern Manatee County, the potentiometric surface will have a plateau-like appearance, as shown by the 20-foot contour line. The flattening of the potentiometric surface will reduce groundwater outflow toward the Gulf, and this most likely will increase the potential for the inland movement of the salt-/freshwater interface. There will also be an economic effect, because the reduction in the potentiometric surface will result in increased pumping lifts and costs in certain areas.

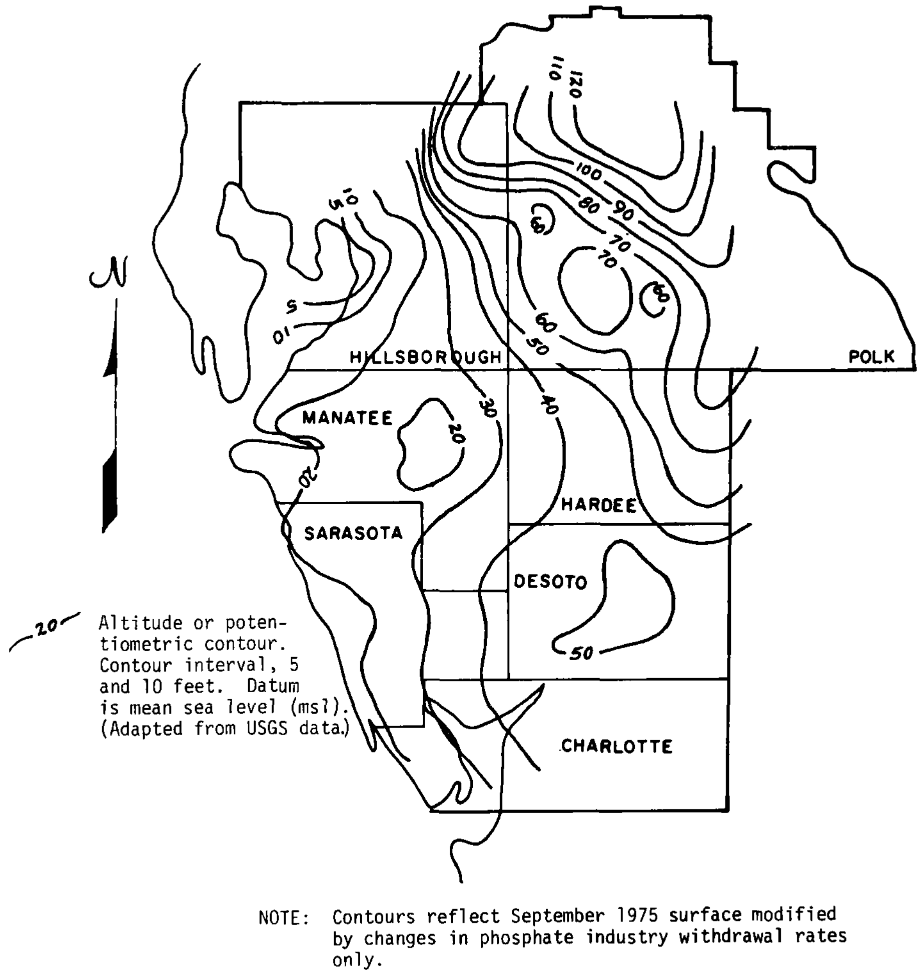


Figure 2.13. Simulated Potentiometric Surface, September 2000, under Scenario 2.11'.

In summary, future development of the phosphate industry under Scenario 2.11' will generally lower the potentiometric surface of the Floridan aquifer in the western part of the Central Florida Phosphate District. To assess the impacts predicted declines must be compared with the total thickness of the freshwater zone (i.e. the depth of the "reservoir") (e.g. 10-foot decline compared with a thickness of 1500 feet in the interior of the simulated area). No adverse effects except the small increase in pumping costs and the increased potential for saltwater encroachment are expected from future pumping of the Floridan aquifer by the phosphate industry. The validity of these predictions, of course, depends on the validity of the water-level changes predicted from the aquifer model designed and constructed by the U.S. Geological Survey.

The difference between the two scenarios' (2.11' and 2.15) effects on the potentiometric surface will be, at most, 20 feet at the Manatee-Hardee county line north of the Myakka head. Comparison of this value with average seasonal fluctuations of 30 to 40 feet in the area leads to the conclusion that a 20-foot difference is not a major effect. To estimate the economic difference between the two scenarios, it was assumed that the cost of lifting 1 acre-foot of water (325,900 gallons) a distance of 1 foot is 2.6¢ for a pump working at 80 percent efficiency. For example, the difference in economic costs to pump at a rate of 10,000,000 gallons per day in the northeastern corner of Sarasota County was calculated: the difference in water levels is approximately 7.5 feet and the difference in the cost of lifting the water is $2184 per year (the year 2000); the annual cost difference for a well-owner pumping at the same rate in the area north of Myakka head is $5824.

b. Water Quality

A secondary effect under the conditions of this scenario (2.11) is the increased potential for pollutional loads from failure of slime-pond dikes. This potential is particularly significant since, under this scenario, a slime-pond break would threaten the water quality of Class-I waters.

2. Man-Made Environment

Attention is invited to previous comments on effects under the "Without Action" alternative (Scenario 2.15). Accelerated phosphate mining under Scenario 2.11 could increase already inflated land values, deplete nonrenewable resources, and further reduce the amount of land in agricultural production. Adverse environmental damage such as despoiled landscapes or incompatible land usage could result. There is every reason to believe that increased mining activity could also impact unfavorably on the multimillion-dollar tourist/ recreation industry by reducing or altering the scenic attraction of the area.

On the positive side for the phosphate industry, industry holdings of land will effectively prevent large-scale development of the held land for at least the next 25 years. This reclaimed land will then be available for phased development at a time when it is most needed to relieve coastal population congestion.

Table 2.16 projects by scenario the economic impact of the phosphate industry on the study area. As indicated, the industry's continued development will result in about 10,000 direct and almost 62,000 induced jobs in the study area by 1985, declining to about 8100 direct jobs and 50,000 induced jobs by 2000. Total payroll attributable to the phosphate industry will be about $340,000,000 in 1985, declining to about $274,000,000 by 2000.

Table 2.16. Projected Economic Impact of Phosphate Industry on Study Area by Scenario, 1980-2000

Year	Scenario	Production (million short tons)	Phosphate Industry Employment*	Phosphate Industry Payroll** (000,000)	Induced Employment***	Induced Payroll**** (000,000)
1975	Actual†	38.2	8,512	65.8	52,349	221.3
1980	2.11‡	41.2	9,181	71.0	56,463	238.7
	2.15‡	42.2	9,403	72.7	57,828	244.4
1985	2.11‡	45.2	10,072	77.9	61,943	261.9
	2.15‡	33.2	7,398	57.2	45,498	192.4
1990	2.11‡	44.8	9,983	77.2	61,395	259.6
	2.15‡	27.5	6,128	47.4	37,687	159.3
1995	2.11‡	42.0	9,359	72.4	57,558	243.4
	2.15‡	9.1	2,028	15.7	12,472	52.7
2000	2.11‡	36.5	8,133	62.9	50,017	211.5
	2.15‡	2.6	579	4.4	3,560	15.0

*Based on 1975 average of 222.84 workers per million tons produced.

**Based on 1975 average of $7,742 per worker per annum, 1967 constant dollars.

***Based on Bureau of Mines estimates of 6.155 jobs generated for each new job in the phosphate industry.

****Average of $4,228 per worker per annum, 1967 constant dollars.

†U.S. Bureau of Mines (1975) adjusted by Texas Instruments for the study area; Florida Statistical Abstract (1976).

‡U.S. Bureau of Mines (1977) adjusted by Texas Instruments.

‡Texas Instruments projections of production from existing mines.

H. SUMMARY OF PRIMARY EFFECTS OF THE "REQUIRE PROCESS MODIFICATIONS FOR NEW SOURCES" ALTERNATIVE

1. Natural Environment

a. Atmosphere

Of the proposed process changes, only wet-rock processing will affect air quality — and it will have little effect on the pollutant load in the study area outside of Polk County, site of most of the existing drying capacity. However, air quality is not expected to improve because of offsetting utility emissions.

General remarks about inventory projections appeared earlier. This scenario affects emissions under the drying category and fertilizer production (grinding). The changes will be negligible other than in Polk County where existing activity is concentrated.

b. Land

1) Physical Features, Soil, Topography

Of the new process modifications considered under this scenario, only one is significant relative to the unique physical features of the area: the elimination of aboveground slime-storage impoundments. Where conventional impoundments result in dams that are as much as 12.2 meters (40 feet) abovegrade, modification No. 1 (elimination of slime ponds) will result in containment dikes that are only about 1 meter (3.3 feet) abovegrade. This reduction of abovegrade loading should effectively reduce the risk of slime-pond collapse into underlying karst features.

The proposed process modifications are expected to have no significant effect on the soil of the area except for the fact that the principal technique for slime-pond elimination will accelerate the date on which slime areas will become available for the start of natural soil development. Instituting this process modification under Scenario 2.11 is expected to "make available" an additional 4047 hectares (10,000 acres) by 1985 and 2792 hectares (6900 acres) by 2000; under Scenario 2.11', the estimates are 4047 hectares (10,000 acres) and 6556 hectares (16,200 acres), respectively. The impact of making these soils available at an earlier date cannot be accurately assessed, because soil quality relative to the eventual production of truck crops or citrus (the criteria for assessing impacts on soils of the area) cannot be forecast. However, because of the relatively small number of acres involved, the impact should be insignificant.

Eliminating slime ponds through the sand/slime mix technique will result in a topographic surface approximating the original surface over one-half of the mine area; the overall elevation will be only slightly higher and generally flatter than the original surface. Final contouring of the slime/sand mix area will depend on the specifics of the reclamation plan for each area, which will dictate both average elevation and local slope.

2) Radiation

Slime disposition using the sand/clay mix technology is not expected to result in a final surface that is significantly different in radionuclide content from that in conventional slime ponds; primarily, both techniques require final top dressing with sand and overburden in the final configuration. There may be slight differences in background radiation during slime fill and cover operations using the sand/clay mix technique, but the impact of such an increase will be insignificant. Specific radiation data with respect to the mix technique have not been collected.

Uranium recovery under this scenario will not appreciably alter radiation levels in the study area. The process modification will reduce radioactivity concentrations in phosphate products that are shipped out of the area, while waste products that generally remain in the area will not show a decline in radionuclide concentration. Radiation levels may increase slightly in the immediate vicinity of the uranium-recovery modules, but these increases will be insignificant. However, the operation of each module will have to be in accordance with occupational and health safety regulations for radiation workers.

Eliminating dryers and dry grinders through the implementation of this process modification is expected to reduce airborne radionuclide concentrations in the immediate vicinity of the replaced process equipment. The impact of such a change on exposure to phosphate workers and the general population is expected to be small; i.e., dose projections for phosphate workers have been shown to be small and well within guidelines.

3) Noise

Any increase in noise levels as a result of implementing the new process modification under this scenario will not affect the general population of the area. Any potential impact on phosphate workers will be readily controllable through the use of restricted access to noisy areas or through personal noise-protection devices. Noise levels within facilities required for the process modification are expected to be within occupational and health safety regulations for workers.

c. Water

1) Quality

The sand/clay mix technology applied to the elimination of slime ponds is expected to have no appreciable impact on the background radiation (radionuclide concentration in ground waters). The technology could favorably impact surface waters, however, since it eliminates the conventional slime impoundment and hence the potential for a disastrous break and slime spill (with the attendant increase in radionuclide concentration, particularly radium-226). Current practices applied to dam construction, maintenance, and inspection have significantly reduced the failure potential in the last 10 years, but no model exists to quantitatively express this reduction.

Lining gypsum stacks and cooling-water ponds at the chemical processing plants is expected to protect ground water from radionuclide contamination, but insufficient data exist to quantify seepage from those already established. Thus, the impact of establishing impervious membrane linings in new ponds cannot be projected. It can be said, though, that the potential for adverse localized impact would be significantly reduced if practical lining methods were developed.

The primary effects of this scenario on other water quality parameters include less concern about slime-pond breaks contaminating surfact-water systems than under Scenario 2.11, but equal concern about slime-pond breaks relative to the "Without Action" alternative since only "new sources" are to incorporate the modification.

2) Aquatic Biota

The effects of phosphate industry activities on regional aquatic biota are expected to be essentially the same under this scenario as those described for Scenario 2.11. Slime-pond elimination would benefit local aquatic biota; but according to all indications, this is not technically achievable during the 1977-2000 period.

2. Man-Made Environment

Eliminating slime ponds with the sand/clay slime-mix technique of reclamation will significantly complicate the secondary recovery of sand and phosphate in the clay. However, impact on the area's mineral resources by making secondary recovery improbable is considered insignificant.

I. SUMMARY OF SECONDARY EFFECTS OF THE "REQUIRE PROCESS MODIFICATIONS FOR NEW SOURCES" ALTERNATIVE

The only secondary effects under this scenario that are significantly different from those under Scenario 2.11 will be the reduction in the potential for gyp piles to contaminate surface waters and the water-table aquifer and Floridan aquifer systems with radiation.

J. SUMMARY OF PRIMARY AND SECONDARY EFFECTS OF THE "REDUCE WATER USAGE" ALTERNATIVE

The following paragraphs describe the primary and secondary effects of significance under this scenario compared with Scenario 2.11.

1. Water Quantity

This scenario evaluating the mining and beneficiation operations utilizing recirculated water assumes that makeup water will be pumped from the Floridan aquifer. The only source of water for the containments will be rainfall on the areas being mined. This, then, is a surface-water problem, although it indirectly reflects on the groundwater system of the Floridan and water-table aquifers. In many instances, current pumpage from the Floridan aquifer for mining purposes can be considered an augmentation of surface-water flows. Prime examples of such augmentation are the Alafia and Peace rivers. Although there has been neither a clear-cut definition of the groundwater contribution to those river systems nor quantification of the contribution, the phenomenon has been observed.

As mentioned previously, the conditions of this scenario will be very beneficial to the Floridan aquifer in that the reduction in pumpage will raise its potentiometric surface. At the same time, however, the reduction in pumpage can be considered to be a reduction in overall water input to the water-table aquifer; as less water reaches the water-table aquifer, less water will emerge as surface-water runoff. Thus, this scenario will affect flows of rivers presently draining mining areas — primarily the Alafia, Little Manatee, Manatee, and Peace. If surface-water flows in those areas are reduced, the effects will certainly be felt by aquatic flora and fauna that depend on the flows.

2. Aquatic Biota

Reducing the phosphate industry's water usage will have little effect on aquatic biota, as was described earlier for Scenario 2.11, because the vast majority of the water used by the industry is ground water. The additional containment requirement for new sources (25-year, 24-hour maximum rainfall event) will represent potential for increased standing surface-water resource, although it is unlikely that these impoundments will be filled. In any event, they represent only a small proportionate increase in standing-water habitat for the study area.

K. SUMMARY OF PRIMARY AND SECONDARY EFFECTS OF THE "CONTROL ACTIVITIES IN WATERS OF THE U.S. AND WETLANDS" ALTERNATIVE

Primary and secondary effects of significance under this scenario as a modification of the effects of Scenario 2.11 ("PERMIT EXISTING AND NEW SOURCES") are described in the following paragraphs.

1. Water Quantity

This scenario prohibits (part A) or limits (part B) mining or the development of beneficiation or chemical processing facilities in either waters of the United States or wetlands. It can involve some very significant hydrological consequences.

If wetlands were undisturbed while the surrounding areas were mined, keeping the wetlands in a biologically healthy state would require a number of steps. The drainage of nearby areas associated with the mining would deprive the wetland of contributions of water from the surrounding water-table aquifer, causing it to dry up. Measures to prevent this may include augmentation by pumpage from a distant surface-water body. However, if the wetland were augmented with water pumped from the Floridan aquifer, the chemical quality of the water introduced into the wetland might affect the biological health of the local biota.

If the wetlands were adjacent to U.S. waters such as streams and rivers, mining activities in the basins located upstream from the wetlands could alter the hydrologic regime to some extent. The hydrologic regime would certainly be changed during the mining period and, on a long-term basis, might revert to its original state. Thus, even if wetland adjacent to water courses were not disturbed by mining operations, such operations in upstream basins could alter the flow regime of the stream and also slightly alter its chemical quality — and these two changes could have an effect on the adjacent wetland. If the wetland received water from bank storage during high flow stages of the stream, a controlled water outlet system (as is stated in mining ordinances and other regulations) would smooth out flood peaks but deprive the surrounding water-table aquifer of inflows from the stream as bank storage during periods of high flow. This could alter the local hydrologic regime in the water table directly beneath the wetland. If increases in dissolved solids in the streams were found, this might also affect the biological health of the plants that tap the water-table aquifer, receiving the surface water containing the higher content of dissolved solids. Although the chemical content in waters discharged from mining operations is tightly controlled by regulations (e.g., the NPDES program), the levels prescribed might be higher than would have occurred naturally in the stream. If that were the case and the root system were sensitive to the increase of particular constituents, there could be a detrimental effect on vegetation. One substance that is very critical in this respect is boron.

If it were assumed that the wetland had not been disturbed and had been kept wet and that the mining operations were finished, reclamation would take place. It would be very difficult to reclaim the mined land surface to the previous level, however, because materials would have been removed from the area; also, the wetland that once occupied the lowest elevation in the area could have become a comparatively high area. Consequently, the mining operation will have significantly altered the gradients and the materials in the water-table aquifer. The wetland would remain temporarily as a sort of pedestal but would eventually dry up.

Mining in the uplands will reduce the overall volume of earth materials by the approximate volume of marketable rock removed from the area. Although part of the void will be filled by an expanded volume of clay slimes, a net void is still expected. The net void will have serious implications if an inland-isolated wetland is involved. Most likely, the wetland will be in a low-lying part of the property and possibly at the lowest elevation.

Mining's potential and actual effects on remaining or "undisturbed" wetlands should be addressed in greater detail than is now required in DRIs.

2. Resource Use

Restricting mining activities from waters of the U.S. and wetlands will preserve phosphate (and uranium) resources only if production lost by such restrictions is not made up by mining upland areas. Since it is assumed that potentially lost tonnage will be made up through changes in mining plans, the preservation of these resources is not expected to be affected. This restriction on mining may have some effect also on timber resources of the area. Since the exact location of relocated mining activities is not known, the effect is not quantifiable.

SECTION 3

CITED REFERENCES

American Fisheries Society. 1977. Only nature can create a wetland. Fisheries 2(4):7.

Adams, J.K. 1972. The origin of some phosphatic minerals in coastal plain sediments. Proc. 7th Forum on Geo. of Ind. Min., Apr 28-30, 1971, Tampa. DNR Spec. Pub. 17 (H.S. Puri, ed).

Altschuler, Z.S., J.B. Cathcart, and E.J. Young. 1964. Geology and geochemistry of the Bone Valley formation and its phosphate deposits, westcentral Florida. GSA (Nov 19-21):1-61.

Altschuler, Z.S., E.B. Jaffe, and F. Cuttitta. 1956. The aluminum phosphate zone of the Bone Valley formation, Florida, and its uranium deposits (Florida). p. 495-504. In: Contributions to the geology of uranium and thorium by the United States Geological Survey and Atomic Energy Commission for the United Nations International Conference on Peaceful Uses of Atomic Energy, Geneva, Switzerland, 1955. USGS Prof. Paper 300.

Anderson, J.R. et. al. 1976. A land use and land cover classification system for use with remote sensor data. USGS Prof. Paper 964.

Beckenbach, J.R. 1973. Principal soil areas of Florida — a supplement to the general soil map. Univ. Fla. Inst. Food & Ag. Exp. Sta., in cooperation with USDA, Bull. 717.

Blakey, A.F. 1973. The Florida phosphate industry: a history of the development and use of a vital mineral. Harvard Univ. Press.

Bromwell, L.G. 1976. Dewatering and stabilization of waste clays, slimes and sludges. Phosphatic Clays Res. Prog., Lakeland, FL.

Cathcart, J.B. 1971. Phosphate deposits in Florida. Phosphate Chem. Assn.

Chow, Ven Te (ed). 1964. Handbook of applied hydrology. McGraw-Hill Book Co.

Cooke, C.W. (Department of Conservation). 1945. The geology of Florida. Fla. Geo. Sur. Bull. 29.

Darnell, R.M., W.E. Pequegnat, F.J. Benson, and R.A. Defenbaugh. 1976. Impacts of construction activities in wetlands of the United States. U.S. Off. of R&D, EPA 600/3-76-045.

Dragovich, A., J.A. Kelly, and H.G. Goodell. 1968. Hydrological and biological characteristics of Florida's west coast tributaries. USFWS Fish. Bull. 66(3):463-477.

Guimond, R.J. 1976a. Phosphoric acid — the new nuclear fuel. USEPA Off. of Rad. Prog., Washington, D.C.

Guimond, R.J. 1976b. The radiological impact of the phosphate industry — a federal perspective. UEPA Off. of Rad. Prog., Washington, D.C.

Florida Department of Health and Rehabilitative Services. 1978. Study of radon daughter concentrations in structures in Polk and Hillsborough counties.

Florida Division of Archives, History, and Records Management. 1976. Master Site File. Tallahassee.

Fountain, R.C. and M.E. Zellars. 1972. A program of ore control in the central Florida phosphate district. Geology of phosphate, dolomite, limestone, and clay deposits. Proc. 7th Forum on Geo. of Ind. Min. Geo. Div. Int. Res. DNR Spec. Pub. 17 (H.S. Puri, ed).

Hoppe, R.W. 1976. Phosphates are vital to agriculture and Florida mines for one-third the world. Eng. Min. J. 177(5):79-89.

Houghtaling, S.V. 1975. Wet grinding of phosphate rock holds down dollars, dust, and fuel. Eng. Min. J.

Hurst, F.J., W.D. Arnold, and A.D. Ryan. 1977. Recovering uranium from wet-process phosphoric acid. Chem. Eng.

Kaufman, R.F. and J.D. Bliss. 1977. Effects of the phosphate industry on radium-226 in ground water of central Florida (draft). USEPA Off. of Rad. Prog. 87 p.

Leaders, W. 1977. Personal communication at Lakeland, Florida, Sep 23, 1977.

Loughrie, G.D. 1976. Wet grinding of phosphate rock. AICE.

McKelvey, V.E. 1956. Uranium in phosphate rock. USGS-AEC Contri. to Geo. of Uranium and Thorium, UN Int. Conf. on Peaceful Uses of Atomic Energy, Geneva, Switzerland.

Mills, W.A. 1974. Population exposure from concentrations of radioactive materials in non-nuclear industrial processes, effluents, residuals, and products; category 1 — phosphate mining, milling, and fertilizer manufacturing. USEPA Off. of Rad. Prog., Washington, D.C.

Mills, W.A., R.J. Guimond, and S.T. Windham. 1977. Radiation exposures in the Florida phosphate industry. USEPA Off. of Rad. Prog., Washington, D.C

Parker, G.G. 1951. Geologic and hydrologic factors in the perennial yield of the Biscayne aquifer. Am. Water Works Assn. J. 43(10).

Parker, G.G. and V.T. Stringfield. 1950. Effects of earthquakes, trains, winds, tides, and atmospheric pressure changes on water in geologic formations of southern Florida. Eco. Geo. J. 45(5).

Parker, G.G., G.E. Ferguson, and S.K. Lane. 1955. Water resources of southeastern Florida, with special emphasis on the geology and ground water of the Miami area. USGS Water-Supply Paper 1255.

Reichenbaugh, R.C. 1972. Seawater intrusion into the upper part of the Floridan aquifer in coastal Pasco County, Florida. Fla. Bur. Geo. Map Ser. MS 47.

Ross, R.C. 1975. Uranium recovery from phosphoric acid nears reality as a commercial uranium source. Eng. Min. J.

Ruhlman, E.R. 1956. Phosphate rock. p. 681-693. In: Mineral facts and problems. U.S. Bur. Mines Bull. 556.

Shampine, W.J. 1965. Dissolved solids in the water from the upper part of the Floridan aquifer in Florida. Fla. Geo. Sur. Map. Ser. 14.

Southwest Florida Regional Planning Council. 1977. Section 208 water quality management program. Final Water Quality Rpt., Charlotte Harbor Study Area.

Stowasser, W.F. 1977a. Phosphate rock, the present and future supply and demand. Letter from U.S. Bur. Mines to R.E. McNeill, USEPA Region IV, Feb 18.

Stowasser, W.F. 1977b. Marketable phosphate rock - December 1976. Mineral industry surveys, phosphate rock, monthly. U.S. Bur. Mines. 4 p.

Sutcliffe, H. Jr. 1975. Appraisal of the water resources of Charlotte County, Florida. Fla. Bur. Geo. Rpt. 78.

Sweeney, J.W. and R.N. Hasslacher. 1970. The phosphate industry in the southern United States and its relationship to world mineral fertilizer demand. U.S. Bur. Mines Info. Circ. 8459:1-76.

Tessitore, J.L. 1976. An estimate of total fluorides emitted in the Polk-Hillsborough County area. DER. 13 p.

Texas Instruments Incorporated. 1977a. Archeology, history, and recreation. Central Florida Phosphate Industry Areawide Impact Assessment Program. Vol. I.

Texas Instruments Incorporated. 1977b. Laws and regulations. Central Florida Phosphate Industry Areawide Impact Assessment Program. Vol. II.

Texas Instruments Incorporated. 1977c. Demography, economics, and culture. Central Florida Phosphate Industry Areawide Impact Assessment Program. Vol. III.

Texas Instruments Incorporated. 1977d. Existing land use. Central Florida Phosphate Industry Areawide Impact Assessment Program. Vol. IV.

Texas Instruments Incorporated. 1977e. Water. Central Florida Phosphate Industry Areawide Impact Assessment Program. Vol. V.

Texas Instruments Incorporated. 1977f. Land. Central Florida Phosphate Industry Areawide Impact Assessment Program. Vol. VI.

Texas Instruments Incorporated. 1977g. Atmosphere. Central Florida Phosphate Industry Areawide Impact Assessment Program. Vol. VII.

Texas Instruments Incorporated. 1977h. Phosphate industry and resource usage. Central Florida Phosphate Industry Areawide Impact Assessment Program. Vol. VIII.

Texas Instruments Incorporated. 1977i. Future land use. Central Florida Phosphate Industry Areawide Impact Assessment Program. Vol. X.

Texas Instruments Incorporated. 1977j. Impacts on social, economic, and natural environmental systems. Central Florida Phosphate Industry Areawide Impact Assessment Program. Vol. XI (includes Vol. IX and XII).

Texas Instruments Incorporated. 1978. Environmental land use (a report on the land use seminar sponsored by EPA, Region IV, and Texas Instruments Incorporated in conjunction with preparation of the Central Florida Phosphate Industry Areawide Impact Statement). Bartow, FL, Jul 27-28, 1977.

United States Army Corps of Engineers. 1977. Water resources management study: hydrologic engineering evaluation of the Four River Basins area, westcentral Florida. Jacksonville Dist.

United States Army Corps of Engineers. 1974. Floodplain information, Saddle Creek-Peace River, Polk County, Florida. Polk County Bd., Jacksonville Dist.

United States Bureau of Mines. 1975. The Florida phosphate slimes problem, a review and a bibliography. Info. Circ. 8668:1-41.

United States Department of Commerce. 1965. Climatological data, Florida. Annual Summary, 1964. Vol. 68, No. 13.

United States Department of Health, Education, and Welfare. 1974. U.S. cancer mortality by county, 1950-1969. Natl. Cancer Inst.-HEW Pub. (NIH)74-615.

United States Department of the Interior Bureau of Land Management. 1974. Final environmental impact statement, phosphate leasing on the Osceola National Forest in Florida. USDI Int. FES 74-37.

United States Environmental Protection Agency. 1977. Population radiation dose estimates from phosphate industry air particulate emissions. Off. of Rad. Prog., Eastern Env. Rad. Facility, Montgomery, AL.

United States Environmental Protection Agency. 1976. Mineral mining and processing point source category effluent guidelines and standards: interim rule and notice of proposed rule making. Fed. Reg. 41(13):23552-23573.

United States Environmental Protection Agency. 1974. Reconnaissance study of radiochemical pollution from phosphate rock mining and milling. Natl. Field Investigation Cntr., Denver, CO.

Vernon, R.O. 1973. Top of the Floridan artesian aquifer. Fla. Bur. Geo. MS 56.

White, W.A. 1970. The geology of the Florida peninsula. Fla. Bur. Geo. Bull. 51:1-164.

Williams, E.G., J.C. Golden Jr., C.E. Roessler, and U. Clark. 1965. Background radiation in Florida. Fla. St. Bd. of Health, Div. of Rad. and Occupational Health, RH-00054-02, Oct.

Wilson, W.E. 1977b. Simulated changes in groundwater levels resulting from proposed phosphate mining, west central Florida -- preliminary results: U.S. Geo. Survey Open-File Report 77-882.

Wright, A.P. 1974. Environmental geology and hydrology, Tampa area. Fla. Bur. Geo. Spec. Pub. 19:1-94.

Layne, James N. Jerry A. Stalcup, Glen E. Woolfenden, Melinda N. McCauley and David J. Worley. 1977. Fish and Wildlife inventory of the South county region included in the Central Florida phosphate industry areawide environmental impact study. Archhold Biological Station. Submitted to U. S. Fish and Wildlife Service under contract 14-16-0009-77-005, September, 1977.