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AERIAL PHOTOGRAPHIC MONITORING, FLORIDA POWER CORPORATION, CRYSTAL RIVER POWER PLANT SALT DRIFT STUDY

FINAL REPORT 1993 AERIAL PHOTOGRAPHY

Submitted to:

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1.0 INTRODUCTION

The annual monitoring of vegetation conditions at the Florida Power Corporation (FPC) Crystal River Plant in 1993 included the aerial monitoring of plant communities in the vicinity of the plant. The overall monitoring program has been in effect since 1981 to comply with conditions of the National Pollutant Discharge Elimination System (NPDES) permits for the plant operations.

Objectives of the aerial monitoring include seasonal photodocumentation of vegetative conditions at the site, photointerpretation to diagnose any possible patterns of change in conditions, and a groundtruthing analysis to verify the current conditions within the various plant communities.

The aerial monitoring was initiated in late spring with the first aerial mission, and completed in early fall with the third mission of the year. Interim reports were prepared to summarize the results of the three missions. This final report summarizes the overall findings of the 1993 aerial monitoring program.

2.0 METHODS

The schedule for the aerial photographic monitoring included three missions flown approximately during early, mid, and late phases of the normal growing season for the study area. As in previous monitoring years, the missions were scheduled to be flown within similar time-frames: weather conditions caused some modification to the designed schedule.

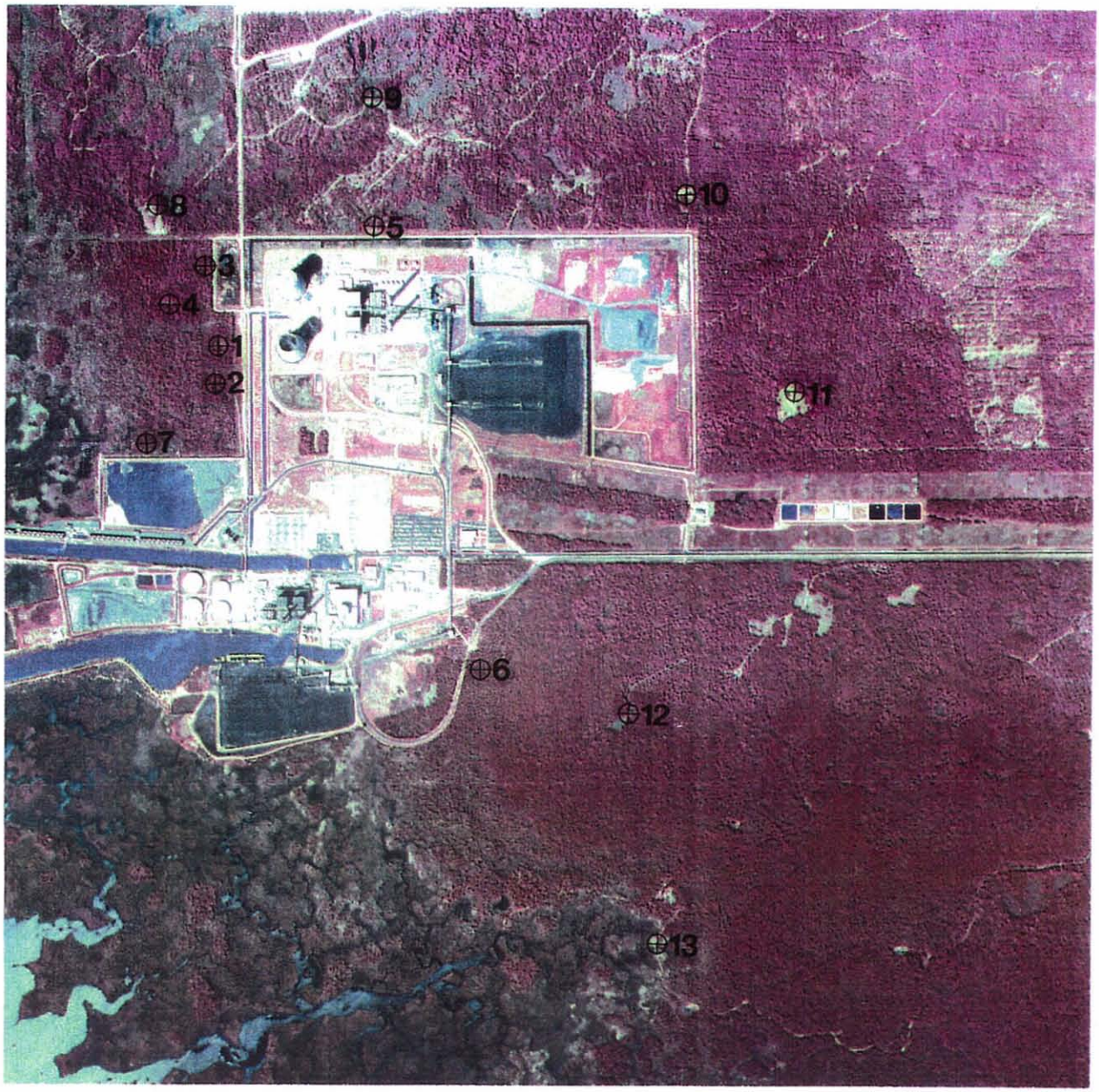
Aerial photography was shot from fixed-wing aircraft using professional camera systems. Filter combinations were used to obtain high quality exposures under varying conditions of haze, humidity, and sunlight. High- and low-altitude photographs were taken along controlled flight paths to acquire coverage of the overall plant facility and its surroundings, as well as specific areas of interest with a higher level of detail. The first and second missions were flown by Breedlove, Dennis & Associates, Inc. using a 70mm format Hasselblad camera system. The third mission was flown by Aerial Cartographics of America, Inc. using a 9 x 9 format camera system.

The aerial photographs were photointerpreted by use of a Krones LZK optical system which provides high resolution images at magnification. The images were analyzed for patterns of canopy conditions characteristic of the various plant communities, utilizing color and texture signatures and photographic coverage from previous monitoring years. The combination of these attributes provided a reliable means of assessing "normal" or "background" conditions of the plant communities within the general study area and at specific vegetation monitoring locations.

As an added complement to the annual aerial photographic monitoring, a site inspection was conducted in the early fall, as in previous monitoring years. The purpose of the inspection is to

record observations of the canopy and understory vegetative conditions at several representative locations, and correlate this data with the photointerpretation of the various plant communities. This procedure improves the accuracy of the aerial monitoring over a large area; it basically serves the purpose of year-to-year "calibration" for photointerpretation of aerial signatures and thus improving the ability to recognize potential large-scale patterns of change in the various plant communities.

Figure 1 is a high-altitude aerial photograph taken during the 1993 monitoring year. It documents the general conditions of the overall study area, and also serves as a reference for specific areas of interest which are discussed in the Results section of this report. All of the permanently established monitoring stations are identified on this aerial, and thus correlate with data and related information from previous monitoring reports. Appendix 1 demonstrates the orientation and approximate locations of flight lines used for the third aerial photography mission. Photograph exposure index numbers for the high- and low-altitude aerials are provided on this exhibit.



Legend:

1. Pine Site
2. Hardwood Site
3. Northwest Open Test Site
4. West Open Pine Site
5. Northeast Open Test Site
6. Control Site
7. Southwest Open Hammock Site
8. Northwest Open Pine Site
9. North Open Pine Site
10. Northeast Open Pine Site
11. East Open Pine Site
12. Open Hardwood Control Site
13. Coastal Control Site

Figure 1: September 1993 High Altitude Aerial Photography of the Florida Power Corporation Crystal River Power Plant.

3.0 RESULTS

Aerial photographic missions to document conditions at the FPC Crystal River site in 1993 were flown on April 24, August 20, and September 29, 1993. The first and second missions provided a total of 111 70mm color-infrared (CIR) exposures at high and low altitudes. The third mission, using a 9 x 9 format with CIR film, provided 19 exposures at low or high altitudes. Tables 1-3 list the exposure references, altitudes and coverage represented by these aerial photographs. The 9 x 9 aerials typically provided very high quality resolution and coverage, and thus are utilized in this report to demonstrate conditions of the study area during 1993.

The use of high- and low-altitude CIR aerial photography at spaced intervals of the growing season provided a means of assessing the overall health and conditions of the natural vegetative communities in the vicinity of the power plant facility. Specific emphasis was given to the selected areas which have permanent ground-sampling stations, as in previous monitoring years. The added dimension of a groundtruth inspection allowed a better correlation with the aerial photosignatures, and documentation of general conditions in the vegetative strata below canopy level in the forested communities. The series of aerial and ground photographs presented in this report provide a good cross-section of the vegetative conditions at representative locations surrounding the plant facility, as a basis for comparison with other monitoring data taken during the study.

Figures 2 and 3 represent coverage of forested areas located west and northwest of the cooling towers; these areas have been of particular interest during the monitoring program due to the modeled pattern of salt drift from those towers. A mixture of upland and wetland hardwood forest, intermixed with stands of slash pine (*Pinus elliottii*), occur in this general area. Figure 2

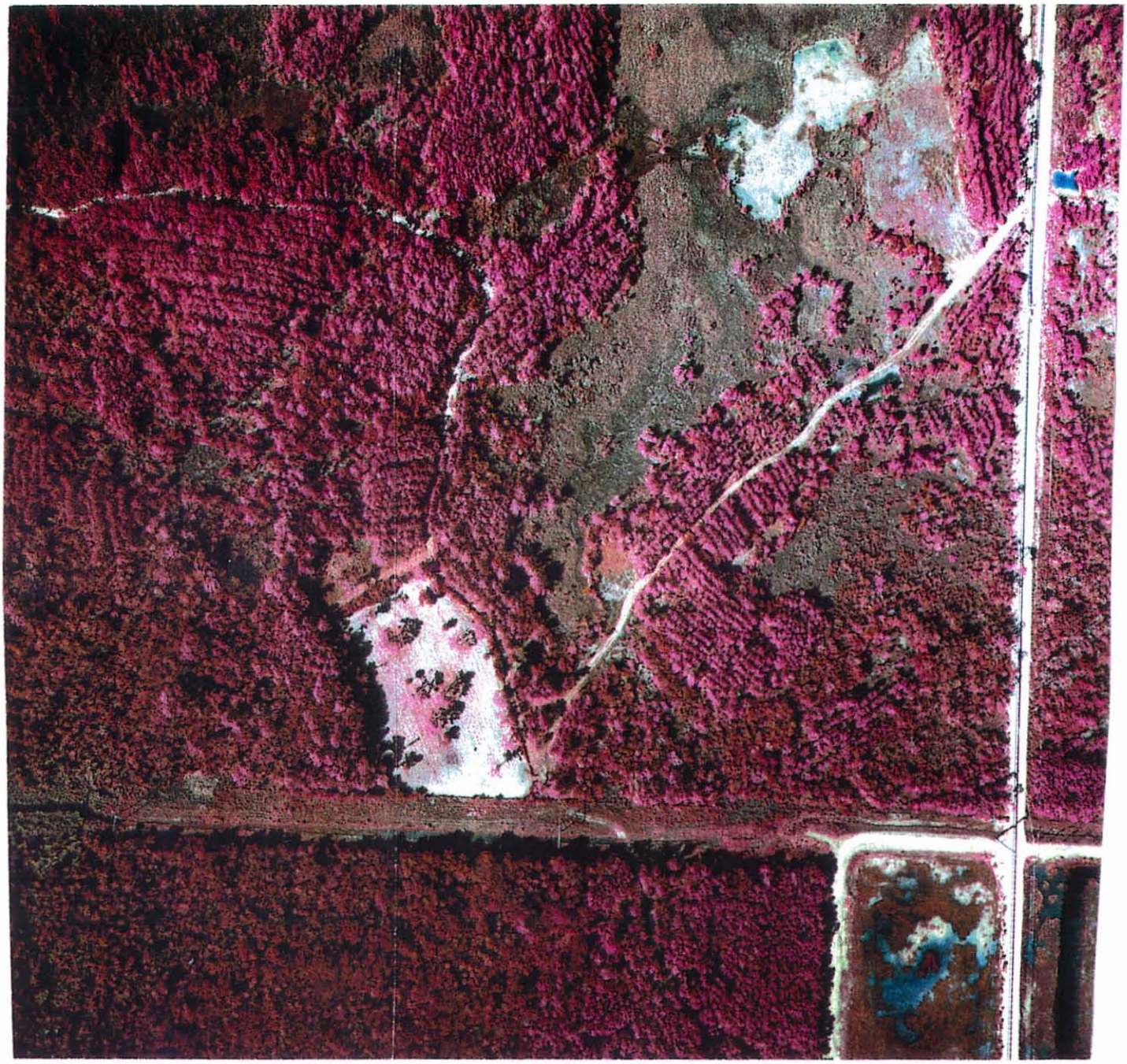


Figure 2: **Aerial Photograph of Forested and Herbaceous Communities in the Vicinity of the Northwest Open Test Site (3) and Northwest Open Pine (8) Sites, Fall 1993.**

Figure 3A: Mixed Oak/Pine Forest in the Vicinity of West Open Pine Site.

Figure 3B: Pine Forest, Northwest Open Pine Site.

Table 1. Listing of Areas of Coverage for the 1st Aerial Flight Over Crystal River Power Plant.

Page	Frame (left to right)	Station/Coverage
1	1	Northeast Open Pine Site
	2-4	North of East Open Pine Site
	5+6	West of East Open Pine Site
2	7+8	West of Hatchery
	9+10	Control Site
	11-15	South and West of Control Site
3	16-18	West of Control Site
	19-21	East of Southwest Open Hammock Site
	22-24	East of West Open Pine Site
4	25	South of Northwest Open Pine Site
	26-28	West of North Open Pine Site
	29+30	Northwest Open Pine Site
	31-34	Between Northwest Open Pine Site and Northeast Open Pine Site
5	35-37	West of Northeast Open Pine Site
	38-40	Northeast Open Pine Site
	41+42	High Altitude, Entrance to Plant
6	43-45	High Altitude, Vicinity of Fish Hatchery
	46	High Altitude, Over Plant
	47+48	High Altitude, West of Plant
	49	High Altitude, North of Plant
	50+51	High Altitude, Northwest of Plant
7	52+53	High Altitude, Northwest of Plant

Page	Frame (left to right)	Station/Coverage
7 cont'd	54	High Altitude, North of Plant
	55-59	High Altitude, Entrance Road to Plant
	60	High Altitude, Over Plant
8	61+62	High Altitude, West of Plant
	63	High Altitude, Southwest of Plant
	64-66	High Altitude, North of Plant
	67-69	High Altitude, Northeast and East of Plant

Table 2. Listing of Areas of Coverage for the Second Aerial Flight Over Crystal River Power Plant.

Page	Frame (left to right)	Station/Coverage
1	1-3	Vicinity of Northwest and Northeast Open Pine Site
	4-6	Vicinity of Northwest Open Pine Site
	7-8	Area Between Northwest Open Pine and North Open Pine Sites
	9	Vicinity of North Open Pine Site
2	1-3	High Altitude, Plant Entrance Area
	4	Vicinity of Fish Hatchery
	5-6	High Altitude, Vicinity of Power Plant Facilities
	7-9	Vicinity of Northeast Open Pine Site
3	1-2	Area Between Northeast Open Pine and East Green Pine Sites
	3	Vicinity of East Open Pine Site
	4-6	Area Between Northeast Open Pine and East Open Pine Sites
4	1-3	Areas South of Open Hardwood Control Site
	4	Vicinity of Control Site
	5-6	Areas South of Control Site
	7-9	Vicinity of Control Site

Table 3. Record of 9X9 Color Infrared Aerial Photography of the Florida Power Corporation Crystal River Power Plant, September 1993.

Frame[1]	Scale	Coverage[2]
1-4	1:3000	9
1-5	1:3000	9
2-6	1:3000	10
2-7	1:3000	10
3-8	1:3000	4, 8
3-9	1:3000	4, 8
4-10	1:3000	5
4-11	1:3000	5
5-12	1:3000	5
5-13	1:3000	5
6-14	1:3000	7
6-15	1:3000	7
7-16	1:3000	12
7-17	1:3000	12
8-18	1:3000	13
8-19	1:3000	13
	High Altitude	
9-1	1:35,000	Areas East of Power Plant
9-2	1:35,000	Power Plant Centered
9-3	1:35,000	Areas West of Power Plant

[1] Correlates with flight paths depicted in Appendix 1.

[2] Correlates with monitoring sites as shown in Figure 1.

demonstrates a generally closed, healthy canopy throughout the area, with only occasional "snags" (dead trees) or stressed foliage. These conditions are comparable to observations in the previous monitoring years. The western portion of this area which transitions into the coastal brackish marshes does, however, show evidence of stress to several canopy species; this pattern has been documented at other locations west and south of the power plant.

Figures 4 and 5 demonstrate the current conditions immediately north of the fossil-fuel plant. Selective timbering of pine (little or no clear-cutting) has occurred in this area. Otherwise, conditions are generally typical of the forested and herbaceous communities observed in previous years. It is possible that a slight increase in stress or mortality of the pines, may occur following the timbering, due to their sensitivity to disturbance. The timbering disturbance may also provide an opportunity for some temporary invasion of opportunist herbaceous or shrubby species which may be reflected in slight differences of color signature in the future growing seasons. This is considered a normal vegetative response.

Figure 6 shows a large area of mixed hardwood forest located to the southeast of the power plant. This community transitions southward into the brackish marsh system, and eastward into mixed pine and hardwood forest. Depressional forested wetland areas intergrade with the upland communities. This system has continued to appear healthy during the last several years of observation. The aerial signatures reveal scattered dead or stressed canopy, most of which have been previously observed in the low-altitude aerials. Inspection of the understory vegetation along the western edge of this system near the Control Site (Figures 7A and 7B), indicate the probable occurrence of stress or mortality to some ground cover or subcanopy species (such as ironwood (*Carpinus caroliniana*)) which may have resulted from the March storm event which produced high winds and back-flooding.

Figure 4: **Aerial Photograph Demonstrating Timbering Activities Near the Northeast Open Test Site (5) North of the Plant Facility.**

Figure 5A: **Freshwater Marsh Near the Northeast Open Test Site, North of the Power Plant.**

Figure 5B: **Slash Pine Forest North of the Northeast Open Test Site.**

Figure 6: Aerial Photograph Showing Large Area of Mixed Hardwood Canopy in the Vicinity of the Control (6) and Open Hardwood Control (12) Sites.

Figure 7A: Collector Station at Control Site Adjacent to Mixed Hardwood Forest.

Figure 7B: Vegetation Sampling Area, Control Site.

Aerial coverage of the forested and brackish marsh areas in the vicinity of the Southwest Open Hammock Site (Figures 8 and 9) have consistently shown the pattern of change in the vegetative conditions, particularly several woody species. Moderately heavy stress and mortality has occurred in cabbage palm (*Sabal palmetto*), southern red cedar (*Juniperus silicicola*) and live oak (*Quercus virginiana*); however, observations during the current monitoring year indicate evidence of some regrowth of the southern red cedar. Many of the island hammocks within the marsh show this pattern of stress (Figure 9A), and relatively high densities of dead or heavily stressed trees extend eastward into portions of the forested community (Figure 9B).

Figures 10 and 11 show the conditions of young pine forest and open herbaceous vegetation in an area between the fossil fuel plant and the limestone quarry operation, near the North Open Pine Site. In general, conditions are similar to previous observations, with the exception of occasional disturbance from the timber harvesting operations.

The East Open Pine Site (Figures 12 and 13) is in comparable condition to that observed in previous years. The mixed hardwood community to its east is healthy; planted pines dominated the canopy to the east and north. The high-altitude photography shows the occurrence of recent timbering in the area. Otherwise, there appears to be no significant change in the integrity of the remaining forested areas. Figure 14 shows the pine and hardwood forest to the northeast of the plant, in the vicinity of the Northeast Open Pine Site. Other than the small "patchy" disturbance related to the silviculture activities, this area is comparable to conditions in previous years.

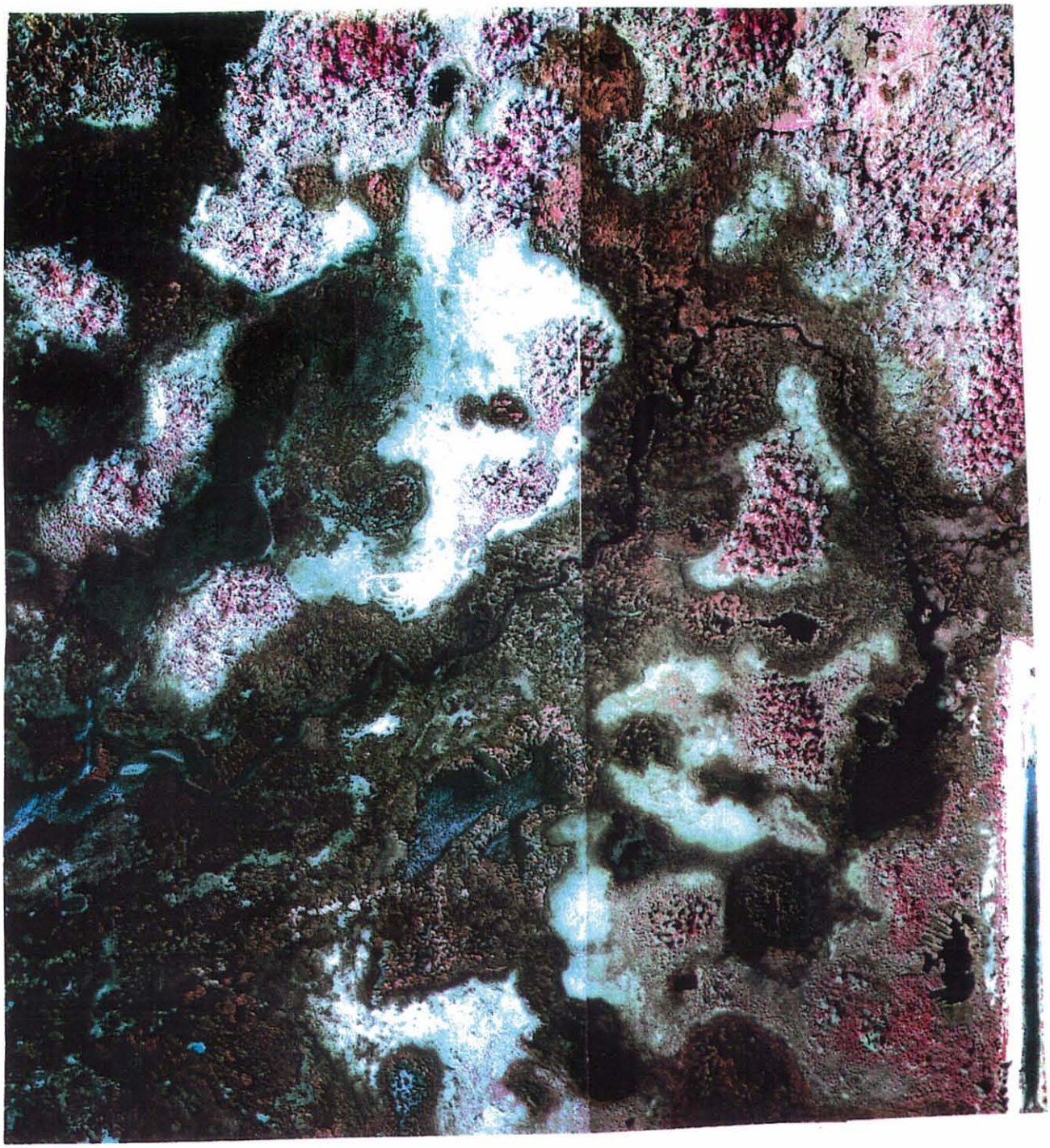


Figure 8: **Brackish Marsh Transition Area West of the Southwest Open Hammock Site (7), Fall 1993.**

Figure 9A: Brackish Marsh and Island Hammocks West of the Southwest Open Hammock Site.

Figure 9B: Cabbage Palm/Oak/Cedar Hammock Near the Southwest Open Hammock Site.

Figure 10: Aerial Photograph of Planted Pine, Mixed Hardwood, and Herbaceous Communities in the Vicinity of the North Open Pine Site (9), Fall 1993.

Figure 11: **North Open Pine Site (9) Showing Collector Station, Pine Forest and Herbaceous Opening, Fall 1993.**

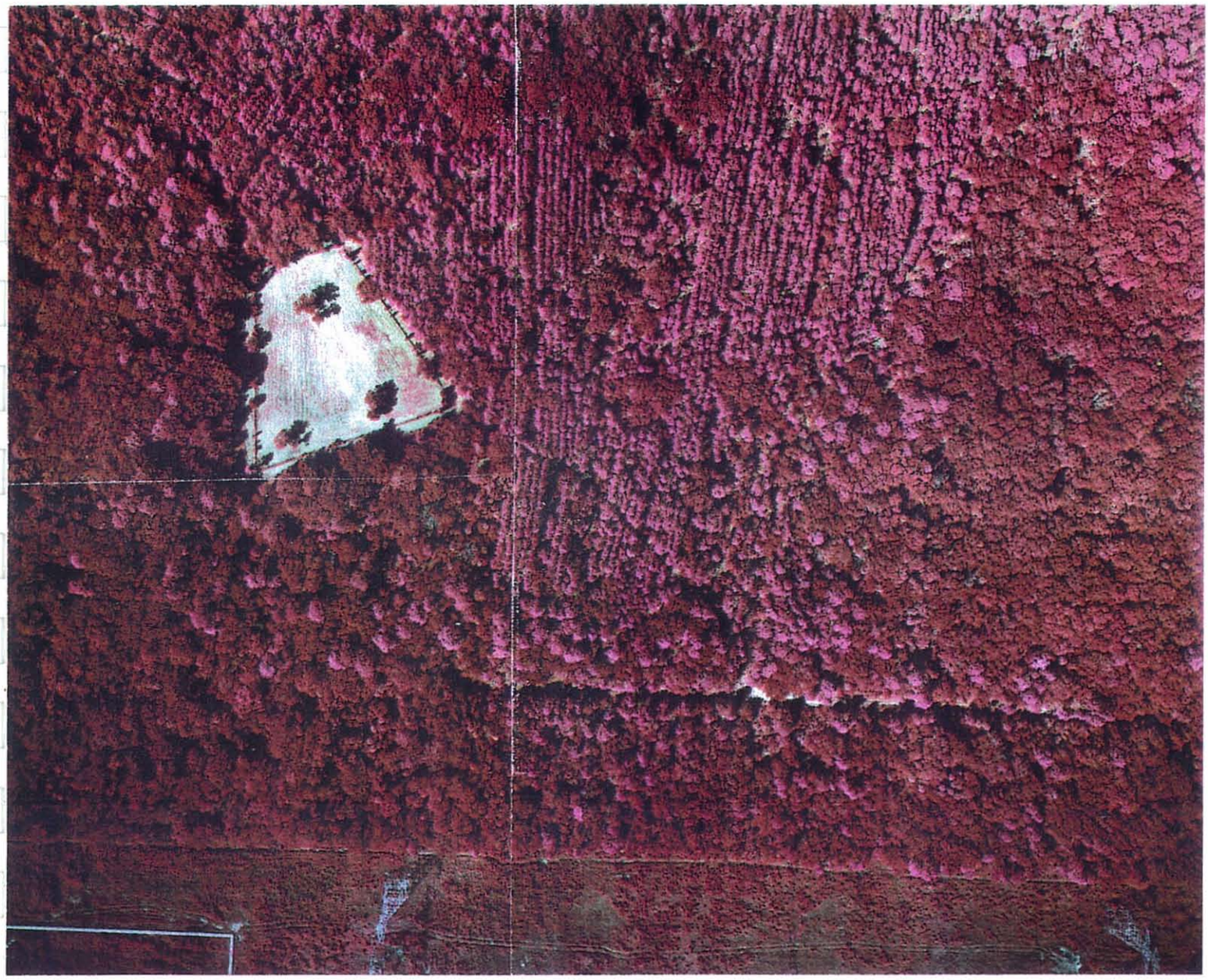


Figure 12: **Aerial Photograph (Fall 1993) of the East Open Pine Site, Located Within Planted Pine and Mixed Hardwood Forest.**

Figure 13: **Field and Mixed Upland Forest, East Open Pine Site (Fall, 1993).**

Figure 14: Aerial Photograph (Fall 1993) Demonstrating conditions of Planted Pine and Hardwoods in the Vicinity of the Northeast Open Pine Site (10)

Figure 15 demonstrates the conditions of the coastal strand forested and brackish marsh community south of the power plant, in the vicinity of the Coastal Control Site. It reveals a similar, large-scale pattern as observed west and north of the plant site. Some of the outlying island hammocks reveal stress and mortality to the woody species (including some pines); lower-lying areas along the forested edge have similar conditions of stress (particularly cabbage palm), while the higher areas appear relatively unaffected. Figure 16 is a panoramic view taken in the vicinity of the Coastal Control Site.

Finally, Appendix 2 is a high-altitude composite aerial which provides coverage of the vegetation and land-use conditions extending from U.S. Highway 19 on the East to the Gulf of Mexico to the west of the power plant facility. When compared to the aerial photography of previous monitoring years it reveals most of the major changes to the landscape in the study area.

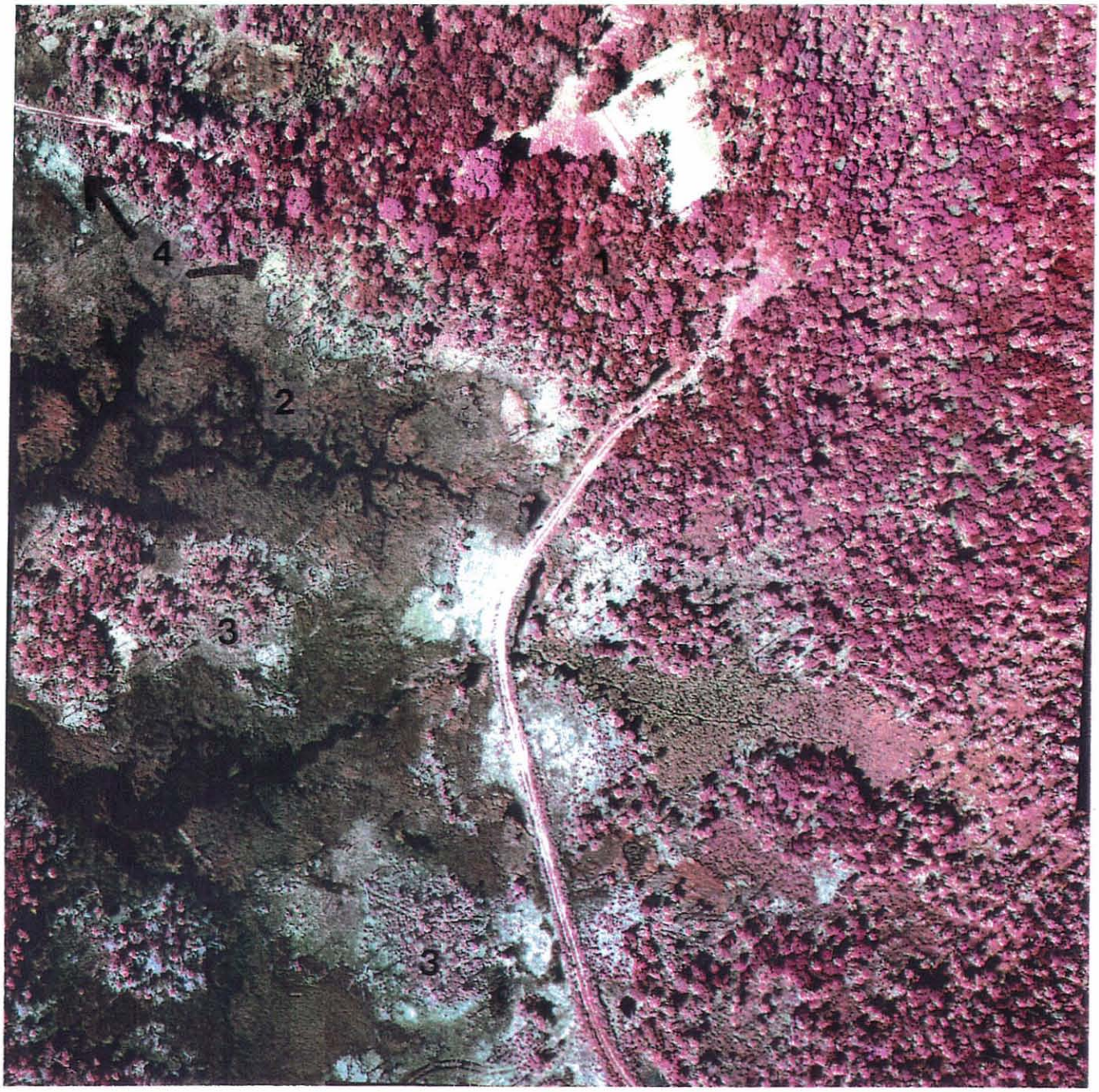


Figure 15: **Aerial Photograph (Fall 1993) Demonstrating the Coastal Brackish Transition Area in the Vicinity of the Coastal Control Site.**

Figure 16: Panoramic View of Hammock and Brackish Marsh Conditions at Coast Control Site, Fall 1993.

4.0 CONCLUSIONS

Aerial photographic monitoring at the Crystal River Power Plant was conducted at three intervals of the growing season in 1993, as a continuing component of the salt drift deposition monitoring requirements under the Special Conditions of the NPDES permits for operation of the power plant. The methods for photographic documentation, including approximate time-frames, followed those of the previous monitoring years at this site. A combination of high- and low-altitude aerial photography provided relatively good views of the plant site and surrounding landscapes, and high resolution detail of vegetative conditions in specific areas, respectively. An early fall site review provided additional information on site conditions which was correlated with the analysis of aerial photography. Representative areas of the various forested and herbaceous communities were analyzed and documented by this process. Particular emphasis was given to the areas in which permanent sample stations are located.

The high-altitude photography taken in early fall provides a broad-view perspective of the entire corridor between U.S. Highway 19 and the Gulf of Mexico. It thus gives an image of the recent changes or patterns of use during the last year. These primarily involve the timber harvesting activities, continuation of the limestone quarry operation to the north, and general evidence of the magnitude of stress to a number of tree species along the forest-marsh transition zone at the edge of the Gulf of Mexico. The low-altitude photography provides clear, detailed images of specific areas ranging from dense hardwood forest or pine forest to more open areas with herbaceous upland or wetland ground cover. When compared to the aerial photography and related data from previous monitoring years, these areas appear to have normal conditions in regard to canopy closure, vegetative ground cover density and composition, general foliage vitality, and relative

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percentage of stressed or dead individuals. In other words, large scale patterns of foliage stress or related changes in vegetative cover and conditions are not apparent, based on the 1993 monitoring results. The single exception to this conclusion is the observed pattern of tree stress and mortality along the coastal edge; this condition has been apparent for some time, and it is presumed that it may be continuing at some unknown rate. Hydrologic changes are a suspected cause of this condition.

Two other activities account for some changes to vegetative conditions within the study area. The timbering activities have resulted in substantial thinning of the pine canopy (mostly planted) in several areas north of the fossil fuel plant. This is easily observable in the high and low-altitude photography. Additionally, there were some areas of varying size which experienced windthrow damage from the major storm event in March. This has created what are commonly referred to as "canopy gaps." A normal and somewhat predictable successional process typically occurs at such sites, usually having some early invasion by opportunist herbaceous or shrubby species followed by eventual reseeding by the indigenous forested woody species. These areas are not expected to have a significant effect on the overall composition and character of the upland or wetland communities in which they occur.

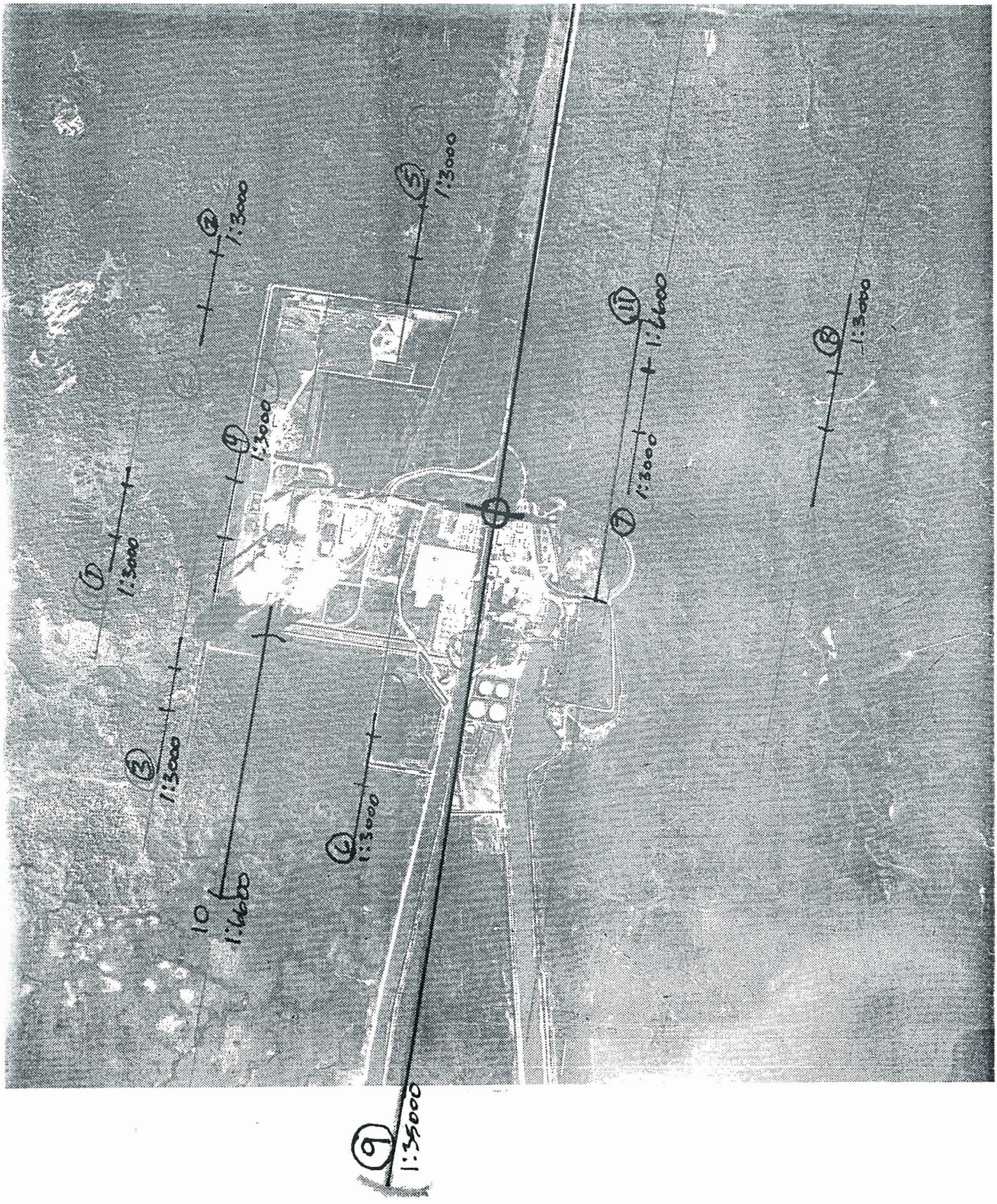
The forested communities to the immediate west of the cooling towers appear to have remained in normal, healthy condition during 1993. This is also true of the large hardwood-dominated forest community to the immediate southeast of the plant facility, and the mixed hardwood and pine areas east of the plant and north of the fish hatchery. The general "zones of interest" remain the same, in regard to noticeable changes in conditions of the vegetation (tree stress and mortality); the western edges of the forested systems, particularly in lower elevations, which transition into the

brackish marshes and outlying islands of cabbage palm/cedar/pine. These conditions have been observed primarily from the vantage points of the Southwest Open Hammock Site and the Coastal Control Site, in combination with analysis of the aerial photography images.

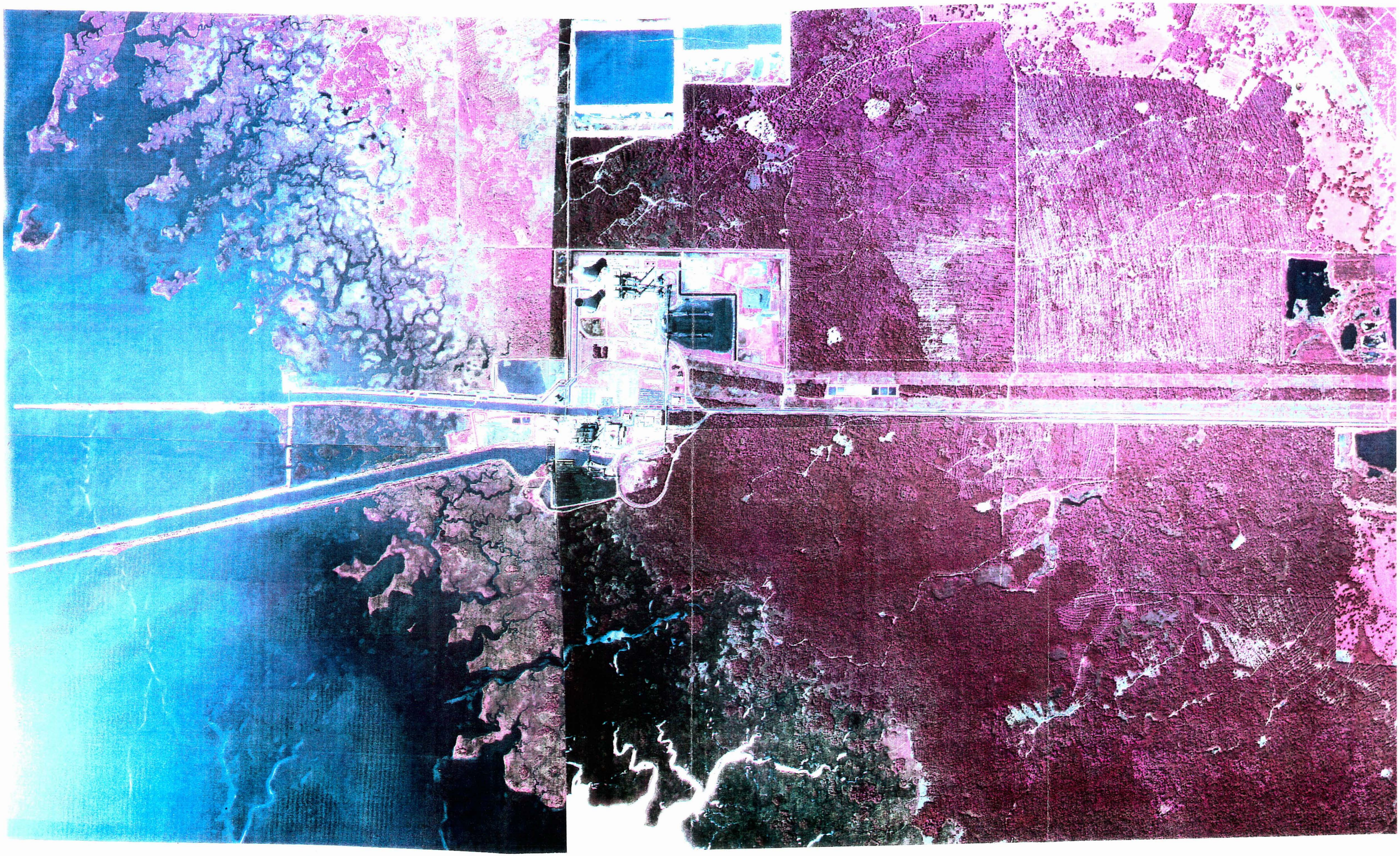
The present (1993) aerial monitoring analysis, in combination with trends from the previous monitoring of the study area, results in a conclusion that there are no recognizable effects to the natural plant communities stemming from salt drift deposition. Although some vegetative changes of varying magnitude (small to very large) are observed, these are clearly explainable from known or highly suspected causes.

APPENDIX 1

Appendix 1: **Flight Paths Used for the September, 1993 Aerial Photography of the Florida Power Corporation Crystal River Plant.**



APPENDIX 2



APPENDIX 2: September 1993 High-Altitude Aerial Photograph of the Florida Power Plant Corporation Crystal River Power Plant.

APPENDIX B

DEPOSITION DATA

FM	FD	FY	TM	TD	TY	ST	NA1	NA2	CL1	CL2
9	16	92	10	15	92	16	93.2	106.5	189	189
9	16	92	10	15	92	17	79.4	79.4	161.4	174.6
9	16	92	10	15	92	25	107.2	107.2	324.2	310.8
9	16	92	10	15	92	28	327	334.7	767.3	741.5
9	16	92	10	15	92	29	329.1	329.1	754.3	729
9	16	92	10	15	92	30	0	0	1.9	1.9
9	16	92	10	15	92	41	335.4	346	670.7	644.1
9	16	92	10	15	92	42	107.8	123.2	259.3	259.3
9	16	92	10	15	92	50	80.4	80.4	176.8	176.8
9	16	92	10	15	92	51	105.8	105.8	214.3	214.3
9	16	92	10	15	92	55	79.8	79.8	162.4	175.7
9	16	92	10	15	92	56	74.5	74.5	149.1	149.1
9	16	92	10	15	92	57	75.7	75.7	191.8	204.4
9	16	92	10	15	92	82	.	.	.	.
9	16	92	10	15	92	90	.	.	.	.
9	16	92	10	15	92	96	.	.	.	.
9	16	92	10	15	92	97	.	.	.	.
10	15	92	11	16	92	16	82.8	82.8	161.9	153.7
10	15	92	11	16	92	17	101.2	101.2	171.1	166.5
10	15	92	11	16	92	25	169.8	169.8	322.7	322.7
10	15	92	11	16	92	28	115.8	106.9	200.4	200.4
10	15	92	11	16	92	29	89.1	84.6	165.6	161.2
10	15	92	11	16	92	30	0	0	1.9	1.9
10	15	92	11	16	92	41	316.9	335.5	566.6	566.6
10	15	92	11	16	92	42	84.5	82.8	172.6	172.6
10	15	92	11	16	92	50	82.2	88.2	155.7	164.3
10	15	92	11	16	92	51	97.5	105	195.1	198.8
10	15	92	11	16	92	55	84.5	90.8	163.5	163.5
10	15	92	11	16	92	56	92.9	94.8	203.8	199
10	15	92	11	16	92	57	143.2	148.8	279	269.7
10	15	92	11	16	92	82	47.6	51	115	118
10	15	92	11	16	92	90	50.6	52.8	108	108
10	15	92	11	16	92	96	11.5	11.9	25.5	25.4
10	15	92	11	16	92	97	5.1	5.7	17.9	17.6
11	16	92	12	15	92	16	130.3	130.3	238.9	251.9
11	16	92	12	15	92	17	128.5	128.5	227.1	227.1
11	16	92	12	15	92	25	212.3	212.3	416	416
11	16	92	12	15	92	28	114	114	196.4	206
11	16	92	12	15	92	29	123	123	206.5	206.5
11	16	92	12	15	92	30	0	0	0	0
11	16	92	12	15	92	41	342.8	342.8	594.7	582.7
11	16	92	12	15	92	42	135.1	135.1	234.1	229.6
11	16	92	12	15	92	50	104.3	104.3	182.4	182.4
11	16	92	12	15	92	51	106.8	106.8	172.5	172.5
11	16	92	12	15	92	55	78.9	78.9	162.2	179.7
11	16	92	12	15	92	56	81.7	81.7	149.9	158.9
11	16	92	12	15	92	57	147	147	259.5	263.8
11	16	92	12	15	92	82	.	.	.	.
11	16	92	12	15	92	90	.	.	.	.
11	16	92	12	15	92	96	.	.	.	.
11	16	92	12	15	92	97	.	.	.	.
12	15	92	1	18	93	16	71.6	71.6	178.9	184.9
12	15	92	1	18	93	17	84.3	84.3	180.7	186.7
12	15	92	1	18	93	25	302.1	326.3	616.3	616.3
12	15	92	1	18	93	28	171.8	171.8	326.4	320.7

6	18	93	7	15	93	97	6138.3	6045.2	1168	1158
7	15	93	8	16	93	16	122	162.7	406.8	406.8
7	15	93	8	16	93	17	162.7	162.7	447.4	447.4
7	15	93	8	16	93	25	253.1	284.7	553.6	537.7
7	15	93	8	16	93	28	153.8	184.6	323	307.6
7	15	93	8	16	93	29	123.8	154.7	309.4	309.4
7	15	93	8	16	93	30	-3.8	0	0	0
7	15	93	8	16	93	41	260	292.5	520	520
7	15	93	8	16	93	42	186.7	186.7	389	389
7	15	93	8	16	93	50	118.5	118.5	335.7	355.4
7	15	93	8	16	93	51	122	203.4	305.1	325.4
7	15	93	8	16	93	55	151.2	211.7	347.9	363
7	15	93	8	16	93	56	143.4	143.4	401.7	416
7	15	93	8	16	93	57	145.2	145.2	290.5	290.5
7	15	93	8	16	93	82	.	.	.	.
7	15	93	8	16	93	90	.	.	.	.
7	15	93	8	16	93	96	.	.	.	.
7	15	93	8	16	93	97	.	.	.	.
8	16	93	9	16	93	16	72.2	72.2	243.6	220.2
8	16	93	9	16	93	17	53.5	53.5	141	173.1
8	16	93	9	16	93	25	128.2	128.2	608.9	606.7
8	16	93	9	16	93	28	287.3	287.3	741.2	727.8
8	16	93	9	16	93	29	289.7	309	755.1	824.6
8	16	93	9	16	93	30	0	0	9.6	9.6
8	16	93	9	16	93	41	173.8	173.8	453.5	413.5
8	16	93	9	16	93	42	367.9	367.9	937	906.8
8	16	93	9	16	93	50	53.9	71.9	141.9	165.3
8	16	93	9	16	93	51	56.3	56.3	105	127.6
8	16	93	9	16	93	55	81.2	101.5	274	176.6
8	16	93	9	16	93	56	101.7	101.7	337.6	303
8	16	93	9	16	93	57	126.3	126.3	391.5	351.5
8	16	93	9	16	93	82	295	312	491	562
8	16	93	9	16	93	90	575	596	945	907
8	16	93	9	16	93	96	681	720	1006	969
8	16	93	9	16	93	97	1199	1178	2150	2013