Preliminary Engineering Assessment for a Comprehensive Algal Turf Scrubber® Based Nutrient Control Program for the Suwannee River in Florida

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Prepared for

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EXECUTIVE SUMMARY

The Suwannee River, with its headwaters in the Okefenokee Swamp in south-central Georgia, continues for approximately 235 miles (378.1 km) to empty into the Gulf of Mexico on the northwestern coast (Big Bend area) of Florida. Though less than 50% of the Suwannee basin is actually located within Florida., the Suwannee River is Florida's second largest river.

Research by a number of investigators has revealed a relatively recent pattern of extensive nitrate-nitrogen loading of the Suwannee River from groundwater sources, with artesian spring discharges implicated as a major nitrate source. Major contributing springs show nitrate-nitrogen concentrations ranging from 0.42 mg/l to 38.00 mg/l, with a flow-weighted average of 2.04 mg/l. Historically, background nitrate-nitrogen for springs in Florida has been suggested as <0.10 mg/l to 0.20 mg/l.

This heavy influx of nitrate-nitrogen, and to some extent total phosphorus, presents significant challenges. Not only do these nutrient loads result in ecological impairment within the surface water resources associated with the Suwannee Basin, but they impose upon the estuarine and marine waters of the Gulf of Mexico. Such impositions may include impacts upon seagrass communities stimulation of macro-algae and phytoplankton "blooms", including "red tide" organisms.

The Suwannee River Water Management District (SRWMD) has invested considerable effort conducting thorough and objective analyses of the Suwannee River system and investigating and implementing BMP's that will reduce nutrient loading from the watershed. In addition, staff with SRWMD recognizes that additional treatment efforts will be required to reduce pollutant loads to targeted levels.

This document has been prepared by HydroMentia, Inc., at the request of SRWMD, as an initial assessment of the application of the Algal Turf Scrubber® (ATS™) technology as a regional treatment system to meet nitrogen reduction goals. Review of this document must be made with recognition that it is preliminary, and that data and analyses have been prepared to facilitate an initial assessment of the feasibility of such a program. Selected sites for regional treatment systems are for conceptual purposes. More detailed review of data and design conditions would be conducted under a formal commitment to develop the program.

Algal Turf Scrubber® Based Nutrient Control Program

The Algal Turf Scrubber® (ATS™), is a biological treatment technology offered by HydroMentia, Inc., of Ocala, Florida. The ATS™ is an engineered system that harnesses the natural cleansing properties of periphytic algae through sustenance of optimal production and nutrient uptake. Unique to the Algal Turf Scrubber® technology is its ability to achieve cost effective nutrient reduction even at relatively low nitrogen and phosphorus concentrations typical of the Suwannee River.

For purposes of this conceptual level effort, the Suwannee River reduction target for the nitrate-nitrogen was set at 30%, or about 1,314 tpy. Other water quality benefits to be offered by this program will be reduction of TKN and total phosphorus loads as well as increased dissolved oxygen levels.

Aerial View of Algal Turf Scrubber®

The proposed strategy for development of an ATS™ based regional treatment program for the Suwannee River is to establish treatment sites consisting of multiple 25 MGD modules operated in parallel at strategic points between problematic portions of the river—primarily the portion known as the Middle Suwannee between Ellaville in Suwannee County to Fanning Springs in Levy County. These regional treatment sites will be sized based upon site availability, accessibility, and layout, and the water quality of the river at the site. Using this system approach, the overall program can be developed incrementally, allowing coordination with other District nutrient reduction programs.

Preliminary Technical Analysis and System Sizing

Within this preliminary assessment a total of 11 treatment sites were identified. Each site was then evaluated applying HydroMentia's ATS™ Design Model (ATSDEM), using available water quality data for the closest monitoring site. Average values were used for nitrogen, phosphorus, pH and alkalinity. Average water temperature was 25.3º C (77.5º F) for the warmer months of April through October (215 days) and 15.8º C (60.5º F) for the cooler months of November through March (150 days). The ATSDEM model was then completed for all stations for both seasonal periods.

Conceptual locations for the 11 treatment sites are included in the report. The eleven sites included a total of 120 treatment modules, with the number of modules per site ranging from 2 to 24. The total effective treatment area for the 120 modules is 1440 acres.

For the 11 treatment sites, the total projected removal for nitrate-nitrogen is 1,285 tpy or 29.3% of the total nitrate load discharge from the Suwannee River (just under the target of 30%); 1,922 tpy for total nitrogen or 23.0% of the total load; and 356 tpy for total phosphorus or 47.6% of the total load. In addition, projected changes in nitrate-nitrogen, total nitrogen and total phosphorus within the Suwannee River are also provided.

Economic Review

Provided in the report are conceptual level capital and operations and maintenance costs for the eleven regional treatment units. Capital costs include: projected module costs, land costs, engineering costs, and the cost of all peripheral support facilities, including the road network, lift stations, the influent feeder canal, the discharge manifold and structure, electrical and instrumentation, operational support, and stormwater management facilities. Land costs were included for selected sites currently owned by the SRWMD, to be consistent with federal cost assessment guidelines for water projects. Total projected capital costs based on Year 2006 dollars for 11 regional treatment units, with 3,000 MGD treatment capacity is $715M.

Present Worth Costs

Life Cycle Cost Analysis (LCCA) is provided as a measure for comparing long-term cost effectiveness to other available technologies and system processes. In the analysis provided within this report, the 2006 Federal discount rate of 5.125% has been applied. The selected analysis period is 50 years.

The Present Value Cost per pound of nitrate nitrogen, total nitrogen and total phosphorus removed were determined to be $9.76/lb-nitrate-nitrogen; $6.57/lb-total nitrogen; and $35.16/lb-total phosphorus.

Benefits and Recommendations

The proposed Algal Turf Scrubber® Based Nutrient Control Program offers a number of advantages when considering available approaches for nutrient load reduction in the watershed. These benefits include relatively low land requirements and the capacity to cost effectively recover nutrient pollutants from high flow, relatively low concentration impaired surface waters.

The proposed nutrient control program is ideally suited for phased implementation. It is recommended that a site such as the Troy Site, be selected for Phase 1 implementation. The selected site should be in an area that is readily accessible, yet adequately removed from residential or critical environmental features.

INTRODUCTION AND INTENT

The Suwannee River, Florida's second largest river, and a waterway of significant environmental, economic and cultural importance, originates within the Okefenokee Swamp in Ware and Charlton Counties of South Georgia. It flows southwest from these origins, entering Florida as the boundary between Columbia County to the east and Hamilton County to the west. At this point, even though the river has collected considerable flow from attendant tributaries, it is still a relatively modest river, and its water quality is still typical of what would be expected from a swamp riverine system, being highly colored, soft (low mineralization), low nutrient and low pH. The Florida section of the Suwannee River travels south initially, turning slightly to the southeast for about 20-30 miles, before changing directions to the northwest at White Springs in Hamilton County. Water quality at this point as noted in Table 1, remains relatively unchanged. Near White Springs the river becomes the boundary between Hamilton and Suwannee County, and continues northwest for about 25-35 miles, before turning again to the west and then southwest. Near the town of Ellaville in Suwannee County, the river connects with the Withlacoochee River, and at this point shows noticeable water quality changes, due primarily to the influence of artesian groundwater associated with a number of springs associated with the poorly confined karst topography of the region.

The Withlacoochee River, also influenced by artesian discharges by the time it reaches the Suwannee River, also contributes significantly to the Suwannee's water quality changes. As the Suwannee arrives at Ellaville then, it has not only gained flow and hence has become a major waterway, but its water quality has changed substantially, becoming more highly mineralized (hard water) with higher pH and higher nutrient loads. The nature of these changes is noted in Table 1 and Figures 1 through 5. From Ellaville the Suwannee continues its southern track through Madison, Lafayette, Dixie, Gilchrist, and Levy Counties, receiving waters from a number of springs and from the Santa Fe River along this course. Eventually, the Suwannee turns southwest, and becomes more estuarine as it approaches and then empties into the Gulf of Mexico as the boundary between Levy and Dixie Counties, in Florida's "Big Bend" region. (The general track of the Suwannee River is displayed in Figure 6).

Extensive research and evaluation by a number of investigators, including the United States Geological Survey (USGS), the Suwannee River Water Management District (SRWMD) and others has revealed a relatively recent pattern of extensive nitrate-nitrogen loading of the Suwannee River from groundwater sources, with artesian spring discharges implicated as a major nitrate source. As noted, within the section of the Suwannee River in Georgia and south to White Springs in Hamilton County in Florida, the Suwannee River is a rather typical swamp riverine system. South of White Springs, the region becomes characterized by a karst topography, with numerous springs discharging to the river. This impacts not only flow, which increases from an average of about 813 cfs at White Springs to an average of over 5,710 cfs about 124 miles downstream near Wilcox in Gilchrist County (Middle-Suwannee), but as noted, also significantly influences water quality. During this approximately 124 mile course the nutrient complexion of the river changes from a condition in which almost all of the nitrogen is bound into Total Kjeldahl Nitrogen or TKN, with the bulk of this being as organic nitrogen (ammonia levels are very low), to a nitrate-nitrogen dominated scenario. In addition, total phosphorus concentrations increase. These loads are eventually released to the Gulf of Mexico.

The high levels of nitrate-nitrogen within the Suwannee River and the associated groundwater contributions is a rather recent phenomenon which has been attributed largely to agricultural sources within the watershed. As noted in Table 2, the major contributing springs show nitrate-nitrogen concentrations ranging from 0.42 mg/l to 38.00 mg/l, with a flow-weighted average of 2.04 mg/l. Historically, background nitrate-nitrogen for springs in Florida has been suggested as <0.10 mg/l. Odum however, in his 1957 study of the Silver River found somewhat higher nitrate-nitrogen levels, averaging about 0.20 mg/l. Both however are considerably lower than the present trends, and the Silver River, like the springs associated with the Suwannee River, has shown substantially increased nitrate levels. It is reasonable then to assign these nitrate increases to anthropogenic sources.

This heavy influx of nitrate-nitrogen, and to some extent total phosphorus, into the Suwannee River presents significant water resource management challenges. Not only do these nutrient loads result in ecological impairment within the surface water resources associated with the Suwannee Basin, but they impose upon the estuarine and marine waters of the Gulf of Mexico. Such impositions may include impacts upon seagrass communities; stimulation of macro-algae and phytoplankton "blooms", including "red tide" organisms; and resultant shifts within dependent trophic levels, including important fisheries.

TABLE 1. Flow and Water Quality Trends Middle Suwannee River.

River Segment	Station Number	County	Approx (Mile)	Mean Disharge (cfs)	Mean Disharge (MGD)	(pH)	Calcium (mg/l)	Mean Conductivity (mmhos/cm)	Total Kjeldahl Nitrogen (mg/l)	Nitrate-N (mg/l)	Total Nitrogen (mg/l)	Mean Nitrate-N Load (lb/day)	Mean TN Load (lb/day)	Total-P (mg/l)	Mean TP Load (lb/day)	Total Disolved Solids (mg/l)	Total Disolved Solids (lb/day)	Calcium (mg/l)	Calcium (lb/day)
White Springs	SUW040C1	Hamilton	0	813	526	4.04	2	61	1.51	0.01	1.52	44	6,664	0.108	473	125	548,025	2	8,768
Ellaville	SUW100C1	Suwanee	36	3,839	2,482	6.80	22	170	0.90	0.35	1.25	7,244	25,933	0.158	3,270	131	2,711,278	22	455,329
Dowling Park	SUW120C1	Suwanee	50	3,655	2,362	6.53	20	154	0.92	0.30	1.22	5,910	24,035	0.170	3,349	130	2,561,077	20	394,012
Luraville	SUW130C1	Suwanee	64	3,951	2,554	6.67	24	173	1.00	0.40	1.40	8,519	29,816	0.174	3,706	142	3,024,216	23	489,838
Branford	SUW140C1	Suwanee	87	4,430	2,863	6.92	26	189	1.20	0.64	1.84	15,283	43,938	0.167	3,997	145	3,462,514	26	620,865
Bell/Rock Bluff*	SUW150C1	Gilchrist	108	5,640	3,645	7.14	32	220	0.92	0.63	1.54	19,063	46,882	0.158	4,798	156	4,742,891	32	972,901
Wilcox	SUW160C1	Gilchrist	124	5,710	3,691	7.12	36	230	0.77	0.61	1.37	18,716	42,265	0.157	4,824	160	4,925,224	36	1,108,175
Gopher River (Near Gulf Discharge)	SUW275C1	Levy	164	6,353	4,106	7.23	37	241	0.83	0.70	1.53	24,041	52,432	0.132	4,521	167	5,719,193	37	1,267,127
Total Segment lb/day												23,997	45,768		4,047		5,171,168		1,258,358
Total Segment ton/yr												4,380	8,353		739		943,738		229,650

River Segment	Station Number	County	Approx (Mile)	Flow Gain (MGD/mile)	Nitrate-N Gain (lb/mile)	Nitrate-N Gain (lb/MGD)	Total Nitrogen Gain (lb/mile)	Total Nitrogen Gain (lb/MGD)	Total Phosphorus Gain (lb/mile)	Total Phosphorus Gain (lb/MGD)	Estimated Alkalinity (mg/l as CaCO3)
White Springs	SUW040C1	Hamilton	0	-	-	-	-	-	-	-	103
Ellaville	SUW100C1	Suwanee	36	54.3	200	4	535	10	78	1	107
Dowling Park	SUW120C1	Suwanee	50	-8.5	-95	11	-136	16	6	1	107
Luraville	SUW130C1	Suwanee	64	13.7	186	14	413	30	25	2	116
Branford	SUW140C1	Suwanee	87	13.5	294	22	614	46	13	1	119
Bell/Rock Bluff*	SUW150C1	Gilchrist	108	37.2	180	5	140	4	38	1	128
Wilcox	SUW160C1	Gilchrist	124	2.8	-22	-8	-289	-101	2	1	131
Gopher River (Near Gulf Discharge)	SUW275C1	Levy	164	10.4	133	13	254	24	-8	-1	137

*** Flow data is from USGS station near Bell, water quality data is from SRWMD station at Rock Bluff just to the north.**

NOTE: Flow Data is average for years 2000 through 2004. Water Quality is mean for 2005-2006 as reported by the SRWMD.

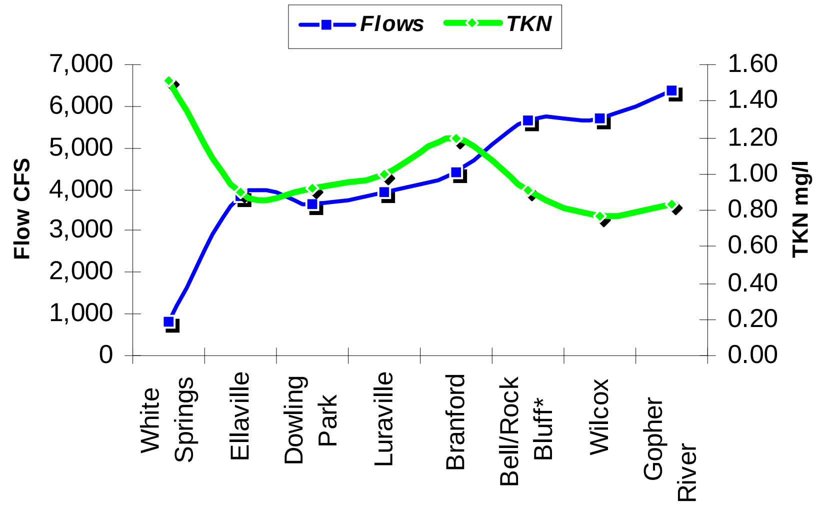


Figure 1. Flow and TKN Concentration Trends

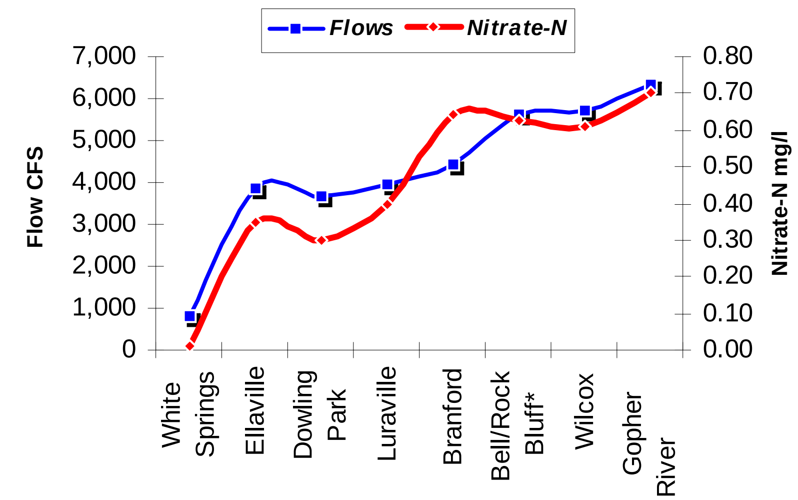


Figure 3. Flow and Nitrate-Nitrogen Concentration Trends

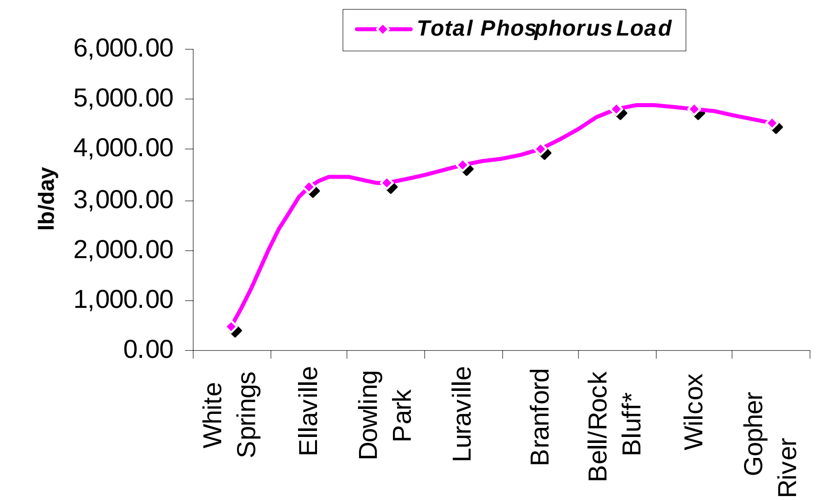


Figure 5. Total Phosphorus Loads

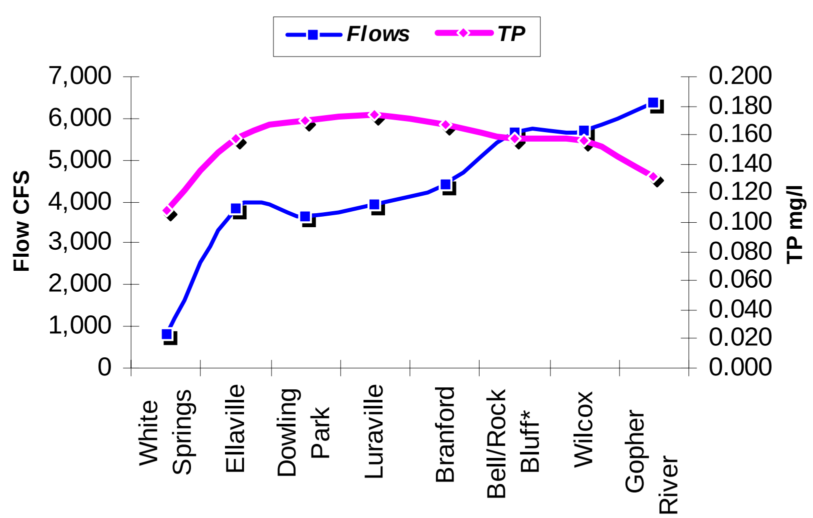


Figure 2. Flows and Total Phosphorus Concentration Trends

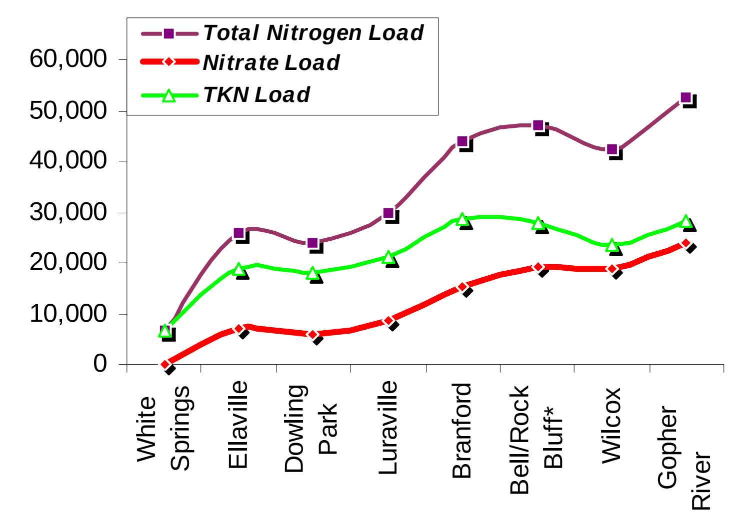
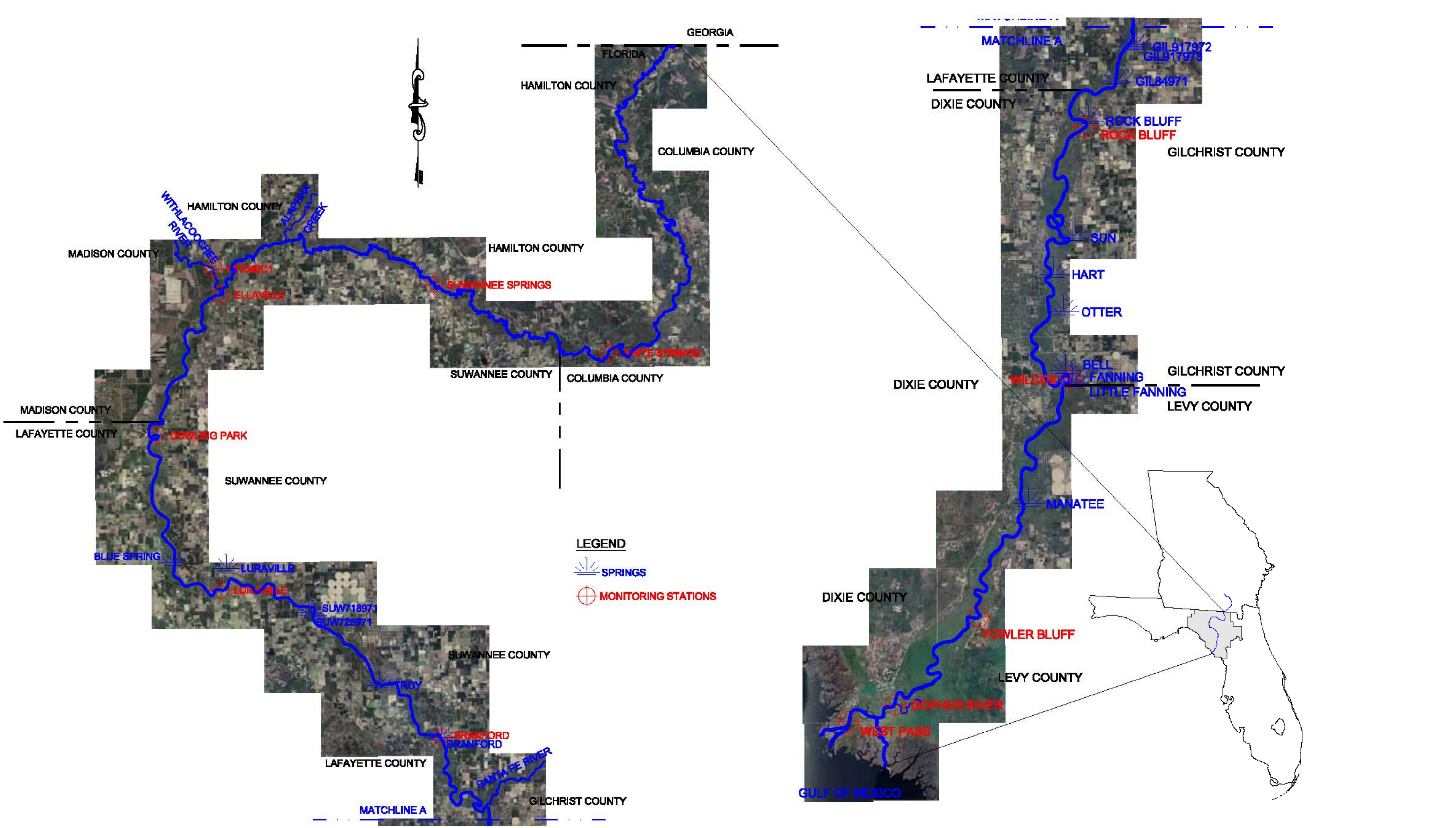


Figure 4. Total Nitrogen, TKN and Nitrate-Nitrogen Loads

With Total Maximum Daily Load (TMDL) mandates to arrive in the near future, and understanding the responsibilities associated with protecting critical water resources, such as the Suwannee River, The Suwannee River Water Management District, coordinating with Federal and other State and local agencies, has invested considerable effort in conducting thorough and objective analyses of the Suwannee River System, and in investigating and implementing BMP's that will reduce nutrient loading from the watershed. In addition, staff with SRWMD recognizes that additional treatment efforts may be required to reduce loads to targeted levels. One such treatment method which has potential as a cost-effective regional approach is the Algal Turf Scrubber® (ATS™), a proprietary biological treatment technology offered by HydroMentia, Inc., of Ocala, Florida. This document has been prepared by HydroMentia, Inc., at the request of SRWMD, as an initial review of how such an ATS™ program for the Suwannee River could be configured. Review of this document must be made with recognition that it is preliminary, and that data and analyses have been prepared to facilitate an initial assessment of the feasibility of such a program. More detailed review of data and design conditions would be included once a formal commitment was made to investigate such a program further.



NO.	REVISION	APPROVED	DATE

DSG. SCP
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Preliminary Engineering Assessment Comprehensive Algal Turf Scrubber® ATS™ Based Nutrient Control Program for the Suwannee River in Florida

FLORIDA SECTION OF SUWANNEE RIVER

E. ALLEN STEWART III P.E. NO. 29577

DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006

FIGURE 1

WATER QUALITY REVIEW

In review of Tables 1 and 2, and the associated graphs (Figures 1 through 5), it is noted that the Suwannee River may be expected to deliver an average annual load of 4,380 tons of nitrate-nitrogen, 8,353 tons of total nitrogen, and 739 tons of total phosphorus to the Gulf of Mexico, of which a significant amount is associated with the springs which are tributary to the river. To put this loading in perspective, if the background concentration were 0.15 mg/l nitrate-nitrogen and 0.050 mg/l (50 ppb) total phosphorus, the annual anthropogenic load would be calculated as approximately 3,630 tons of nitrate-nitrogen and 427 tons of total phosphorus. The implication is that 83% of the nitrate-nitrogen and 58% of the total phosphorus are from anthropogenic sources. These sources have been identified as fertilization associated with crop farming; animal farming; atmospheric deposition and septic tanks .

Within the Middle Suwannee (approximately White Springs to Wilcox) there is a major influx of nitrate-nitrogen, accounting for 2,384 tons annually, or 55% of the total annual load of 4,380 tons. The remainder is mostly contributed by the Lower Suwannee from Wilcox to the Gulf discharge (Near Gopher Creek). Of the 1,797 tons of nitrate-nitrogen attributable to the Lower Suwannee, it is estimated that 869 tons or 48% is attributable to Fanning and Manatee Springs (see Table 2). Trends in total phosphorus are similar to those noted with nitrate, but not as dramatic, with some reduction of loads observed within the lower Suwannee. It is also worth noting that not only do nitrate loads increase in the Middle Suwannee, but so do TKN loads, although not quite as severely. Also, while TKN loads increase, the concentration is actually reduced, while nitrate-nitrogen concentrations increase substantially. It appears reasonable then to target nitrate-nitrogen as the most problematic of the nutrients, particularly since nitrate is typically viewed as more available biologically than the organic nitrogen component of TKN.

TABLE 2. Flows and Water Quality Major Springs in Middle Suwannee River Basin.

Spring	County	Mean Discharge (cfs)	Mean Discharge (MGD)	Nitrate-N (mg/l)	Mean Nitrate-N Load (lb/day)	Total-P (mg/l)	Mean TP Load (lb/day)	(pH)	Alkalinity (mg/l as CaCO3)	Dissolved Solids (mg/l)	Dissolved Solids (lb/day)	Calcium mg/l	Calcium lb/day
Charles Springs	Suwanee	16.4	10.6	2.20	194	0.04	3.5	7.08	-	190	16,797	57.0	5,039
Lafayette Blue Springs	Lafayette	97	63.0	2.39	1,256	0.07	36.8	7.11	201	218	114,542	64.9	34,100
Telford Springs	Suwanee	41.6	26.9	2.50	561	0.03	6.7	7.22	-	246	55,166	63.8	14,307
Running Springs	Suwanee	22	14.2	2.10	249	0.03	3.6	7.50	-	190	22,533	54.3	6,440
SUW718971	Suwanee	5	3.0	29.00	731	0.04	1.0	7.41	-	200	5,040	58.5	1,474
SUW725971	Suwanee	6	3.6	38.00	1,141	0.02	0.6	7.42	123	200	6,005	61.8	1,855
Mearson Springs	Lafayette	62	40.1	1.70	568	0.02	6.7	7.43	-	190	63,502	59.8	19,986
LAF718972	Lafayette	11	7.1	3.00	178	0.03	1.8	7.28	-	200	11,859	66.4	3,937
Troy Springs	Lafayette	138	89.2	2.06	1,532	0.06	44.6	7.53	166	190	141,342	62.6	46,569
Ruth Springs	Suwanee	13	8.4	5.50	385	0.02	1.4	7.25	-	210	14,716	68.5	4,800
Little River Springs	Suwanee	76.1	49.2	1.50	615	0.01	4.1	7.27	-	195	79,994	61.8	25,352
Hornsby	Alachua	200	129.3	2.06	2,221	0.06	64.7	7.36	-	220	237,188	64.3	69,323
Columbia	Columbia	210	135.7	0.42	475	0.24	271.7	7.29	-	180	203,766	48.8	55,243
Poe Springs	Alachua	54	34.9	0.82	239	0.18	52.4	7.45	-	210	61,130	67.3	19,591
Ginnie Springs	Columbia	51	33.0	1.20	330	0.03	8.2	7.51	-	160	43,988	54.0	14,846
July Springs	Columbia	117	75.6	1.70	1,072	0.03	18.9	7.39	-	190	119,834	64.1	40,428
Ichetucknee	Columbia	117	75.6	0.72	454	0.04	25.2	7.39	-	150	94,606	51.0	32,166
GIL917971	Gilchrist	2	1.3	26.00	280	0.04	0.4	7.32	-	210	2,264	78.5	846
Trail Springs	Gilchrist	9	5.8	3.80	184	0.03	1.5	7.40	-	180	8,733	60.4	2,930
Pothole Springs	Dixie	32	20.7	1.50	259	0.03	5.2	7.25	-	250	43,125	78.6	13,559
Rock Bluff Springs	Gilchrist	28	18.3	0.91	139	0.08	12.2	7.43	142	160	24,420	56.1	8,562
Fanning	Levy	109	70.5	4.84	2,844	0.09	52.9	7.28	192	230	135,143	79.3	46,595
Manatee	Levy	202	130.6	1.76	1,916	0.06	65.3	7.20	201	250	272,227	83.1	90,488
Weighted Average				2.04									
Total lb/day					17,825		689				1,777,917		558,437
Total Ton/Yr					3,253		126				324,470		101,915

Another issue of interest regarding nutrient trends within the Middle Suwannee River, is that the increases in total phosphorus and TKN loads, unlike nitrate, do not appear to be dependent to any great degree upon the contributing major springs (Table 2). The TKN of course could represent a conversion of nitrate to TKN within the river, which could happen if extensive photosynthesis is occurring. The major springs in fact contribute only 17% of the observed total phosphorus load as opposed to the 74% of nitrate load. While TKN concentrations are not recorded for these springs, it can be expected that the TKN concentrations would be low, as implied by the low organic carbon and suspended solids content within these waters. In consideration of these trends, it must be recognized that surface runoff, septic tank infiltrate, localized shallow groundwater seepage, atmospheric deposition, or a mixture of these are also important to water quality dynamics, as is the dynamics of nitrogen cycling within the ecosystem. While nitrate indeed should be the principal nutrient target, the potential long term impacts of phosphorus and other nitrogen species may need future consideration as well.

Some additional insight into the water quality dynamics within the river can be found through a review of both the mass ratios of nitrogen to phosphorus, and by estimating the quality of "other source contribution waters" outside of the major listed springs. Regarding mass ratio of nitrogen and phosphorus, as shown within Figure 7, the ratio of total nitrogen to phosphorus within the river fluctuates somewhat around an average of 11.31, indicating an abundance of nitrogen and implying phosphorus could become a growth restraining factor. The ratio of nitrate-nitrogen to phosphorus within the river increases steadily from 0.09 at White Springs to 3.97 at Wilcox, implying also a shift towards a nitrogen driven, phosphorus restrained system. However, within the springs themselves the nitrate-nitrogen to phosphorus ratio is considerably higher, averaging 25.85, indicating an even more accentuated nitrogen dominated system. The implication is that this notable shift from spring water to river water is associated with either uptake and conversion to TKN of nitrate within the ecosystem; loss of nitrate- nitrogen through de-nitrification; or dilution with nitrate poor, phosphorus rich water (e.g. septic tank infiltrate); or most likely, a combination of these.

To review these dynamics in more detail, consider the river conditions between Dowling Park and Wilcox—a stretch of the Middle Suwannee River receiving major spring flows. If the major Spring flows and loads are deducted from the changes along this stretch of River, as shown in Table 3, we can get some idea of the characteristics of the "other source contribution" water. (Note that Fanning and Manatee Springs are south of Wilcox and not included in these calculations.) As noted, there is indeed a loss of nitrate-nitrogen within the river system, while

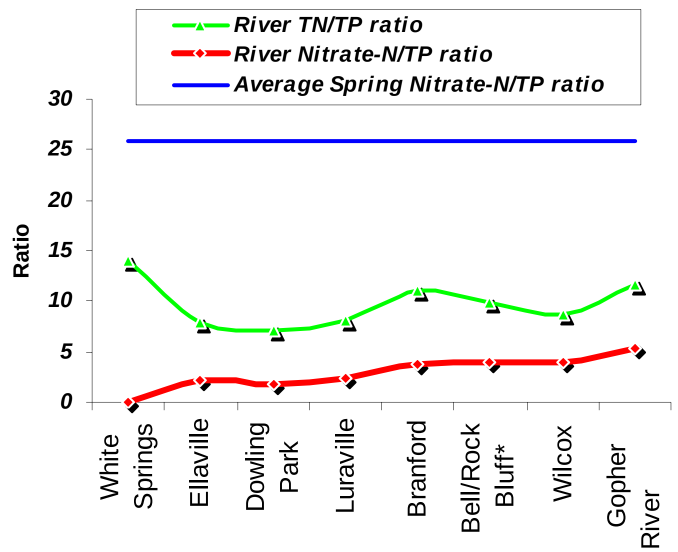


Figure 7. Nitrogen to Phosphorus Ratios within the Suwannee River and Associated Springs.

TABLE 3. Comparison of Major Spring Source Contributions to Other Contributing Water Sources Within the Middle Suwannee River.

	River Flow (MGD)	Nitrate-N Loads (lb/day)	Total Nitrogen Loads (lb/day)	Total Phosphorus Loads (lb/day)	Total Dissolved Solids (lb/day)	Calcium (lb/day)
Dowling Park	2,362	5,910	24,035	3,349	2,561,077	394,012
Wilcox	3,691	18,716	42,265	4,824	4,925,224	1,108,175
Change	1,329	12,806	18,230	1,475	2,364,147	714,163
Spring Contributions	846	13,065	13,065	571	1,370,547	421,354
Other Sources Contributions	483	-259	5,165	903	993,599	292,809
% Spring Contrubution	63.63%	102.02%	71.67%	38.74%	57.97%	59.00%
% Other Source Contributions	36.37%	-2.02%	28.33%	61.26%	42.03%	41.00%

	Estimated					
	Flow (MGD)	TKN (mg/l)	TP (mg/l)	Total Dissolved Solids (mg/l)	Calcium (mg/l)	TN/TP mass ratio
Other Sources	483	1.35	0.22	247	73	6.00

the TKN and TN increase notably. This provides some indication, although certainly not solid evidence, that perhaps nitrate conversion rather than de-nitrification may explain the nitrate reduction. As expected, the TN/TP ratio is reduced within this "other source contribution" water when compared to the major spring sources or the river—6.00 Vs. 25.85 Vs. 11.31. The dissolved solids remain comparatively high in the "other source contribution" water, as does the calcium concentration, indicating a connection with the karst associated limestone The total phosphorus concentration of the "other source contribution" water also is comparatively high, indicating this water may be more closely aligned with surface water run off, septic tank infiltrate and localized shallow groundwater seepage. Considering that the river water dissolved solids are slightly lower than the contributing waters, it can be expected that alkalinity will also be somewhat lower in the river. Unfortunately we could not find any alkalinity information on the river itself. However, there is some alkalinity information on the major springs, ranging from 123 mg/l as $CaCO_3$ to 201 mg/l as $CaCO_3$. In these cases, there is a close correlation between dissolved solids and alkalinity with the ratio of alkalinity to dissolved solids being about 0.82. Therefore, some reasonable projections regarding alkalinity within the River can be made, which as noted in Table 1, increases from 103 to 137 mg/l as $CaCO_3$. The pH within the Springs and the river from Ellaville south are initially somewhat dissimilar, with the river remaining just below neutral, and the Springs just above neutral, however as the groundwater influence becomes more dominant the pH values converge, being similar near the river discharge at the Gulf — 7.34 Vs. 7.23.

Alkalinity is important because it provides a measure of the amount of dissolved carbon available for algal photosynthesis. The performance of the ATS™ system relies upon nutrient uptake through algal production, and available carbon within the water is one of the critical factors for determining system design. Available carbon is typically in the form of dissolved total carbon dioxide, bicarbonate ion, and carbonate ion. The amount of carbon availability relies upon two parameters—total alkalinity (mg/l as $CaCO_3$) and pH.

Studies conducted by researcher such as Saunders et al. have resulted in the development of convenient methods for projecting available carbon through alkalinity and pH information. As noted in Figures 8 and 9, the higher the pH and the lower the alkalinity, the less available carbon. This shift to a higher pH results in a greater percentage of hydroxide alkalinity. In modeling the performance of the ATS™, alkalinity and pH are included as important inputs, and the change in pH down the ATS™ floway is tracked to be certain that sufficient carbon and adequate pH are available. In general, the higher the feed water alkalinity, the longer the floway can be designed. Because the Suwannee River has a rather high alkalinity compared to many surface waters in Florida, there is a considerable amount of available carbon. For example at an alkalinity of 120 mg/l as $CaCO_3$ and a pH of 7.23, from Figure 9 it can be estimated that about 34 mg/l of available carbon is present in the water. For a flow of 25 MGD (the design rate for a standard ATS™ module, as discussed later in the text) this amounts to about 7,089 lbs/day of available carbon. If the production expectations of a 12 acre module is 3,200 dry pounds of algae per day, and this production is 35% carbon, then only 1,120 lbs of available carbon is used daily, or 16%. This will reduce the available carbon concentration to 29 mg/l or 24% of the alkalinity when using the conservative assumption of no atmosphere carbon inputs.

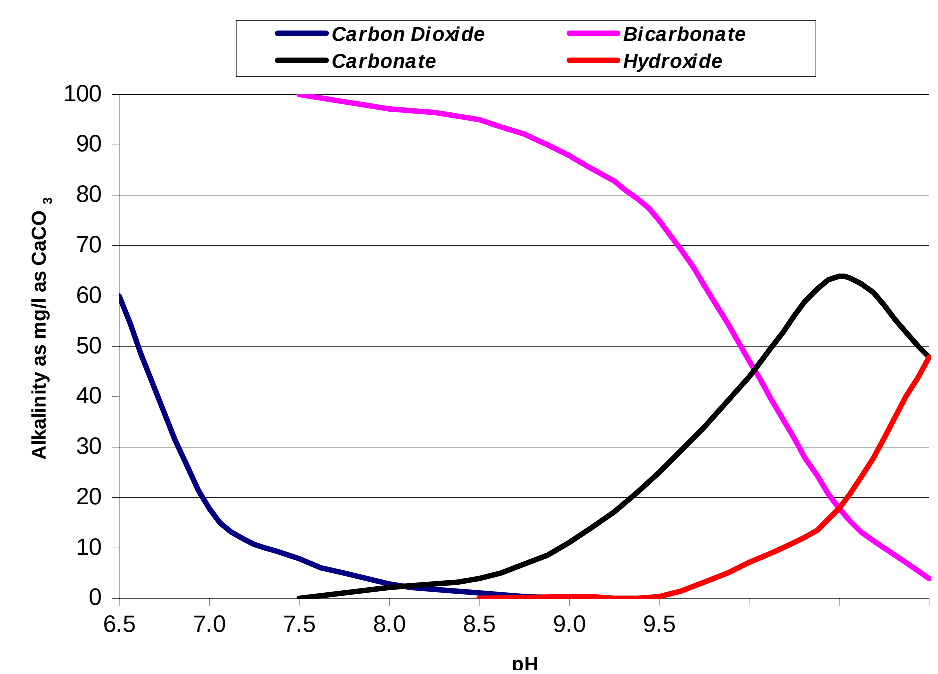


Figure 8. Alkalinity Distribution with pH Shifts

Using Figure 9 again, the effluent pH then would be expected to increase to about 7.80 during the peak photosynthetic period. This algorithm is included within the ATS™ Design Model (ATSDEM) as discussed in greater detail in the next section.

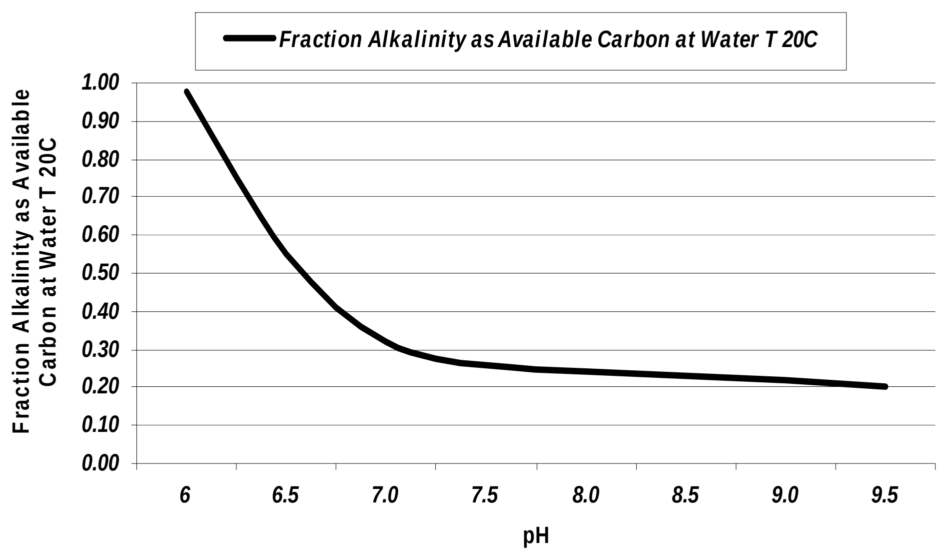


Figure 9 . Carbon Availability Proportion to Alkalinity and pH

In summary, the Suwannee River is a major U.S. river whose water quality in its middle sections transversing the Florida counties of Suwannee, Lafayette, Gilchrist, Dixie and Levy is characterized by an extensive level of nitrate-nitrogen originating largely from anthropogenic sources—primarily agriculture—which is delivered to the river through a series of springs which are associated with a region of poorly confined karst topography.

The river water in this section is relatively high in alkalinity and mineral content, through influence from the groundwater contributing sources, which include these springs. Total phosphorus levels are elevated, but not as dramatically as nitrogen, and this has resulted in a relatively high N to P ratio, indicating phosphorus could become a growth restrictive agent. Because of the comparatively high alkalinity, there is sufficient available carbon within the water to sustain an active production of periphytic and epiphytic algae upon an ATS™ floway, as required to support an effective, comprehensive ATS™ based treatment program throughout this section of the river.

(William A. Wisner, 1972)

Mining exposed this typical karst limestone surface which exhibits the characteristically enlarged porosity created by dissolution

DEVELOPMENT STRATEGY

For purposes of this preliminary effort, the Suwannee River reduction target for the nitrate-nitrogen will be set at about 30%, or about 1,314 tpy. Other water quality benefits to be offered by this program will be reduction of TKN and total phosphorus loads as well as increased dissolved oxygen levels. In addition, the program will include removal and processing of algal material, which can result in the sequestering of sizable amounts of carbon, and the production of a valuable compost/ soil amendment.

The ATS™ process is a type of biological water treatment known as Managed Aquatic Plant System (MAPS). The effectiveness of MAPS is reliant upon the purposeful cultivation of aquatic plants (including algae) through sustenance of optimal production and nutrient uptake, to include management by periodic removal of the "crop". The controlling process equation for the ATS™ sizing is the first order Monod relationship, which is typically used for monitoring and projecting biological growth. Development and calibration of a Monod based model, called ATSDEM, was completed as part of a two-year study done in cooperation by: HydroMentia, Inc., The Florida Department of Environmental Protection (FDEP), The Florida Department of Agriculture and Consumer Services (FDACS), and the South Florida Water Management District (SFWMD). The process of developing and calibrating this model was included in one of the reports submitted to and reviewed and accepted by the involved agencies. (HydroMentia, 2005)

For those familiar with the design methods used for domestic wastewater treatment systems targeted towards the removal of carbonaceous and nitrogenous biochemical oxygen demand (CBOD and NBOD), such as activated sludge or fixed film systems, the design methods applied to the ATS™ will be recognized as noticeably similar. The primary differences between such CBOD/NBOD targeted systems and ATS™ are as follows: CBOD/NBOD wastewater treatment systems are typically designed to promote the cultivation of a community of organisms, composed largely of bacteria, other protists and small invertebrates called activated sludge, when these organisms are suspended in a "Mixed Liquor"—that consume organic carbon (this collection of organisms is known as a heterotrophic community) and nitrify ammonia-nitrogen (a chemoautotrophic community) in supporting community metabolism.

The ATS™ (and MAPS in general) are designed for the removal of nutrients—primarily nitrogen and phosphorus-- through the cultivation of organisms, such as algae in the case of ATS™, that fix carbon dioxide through photosynthesis (known as photoautotrophs or primary producers) to generate organic carbon, and thereby use the resulting organic carbon in supporting community metabolism. This community, in the case of the ATS™, is called "Algal Turf". The algal turf is actually composed of a number of algae species which attach either to a non-living media (periphytic algae) or to other living organisms (epiphytic algae). Included within this algal turf community , and interacting with the photoautotrophs, are a number of other organisms, including bacteria, fungi, other protists, macro-invertebrates, and even some vertebrate participants, such as shoreline birds. To sustain this community, just as with heterotrophic communities within wastewater systems, excess production must be removed periodically. This removal in wastewater systems is called "sludge wasting". With MAPS systems it is simply referred to as "harvesting" or "biomass recovery". This harvesting is required to ensure the community is sustained at a level of optimum productivity—a process called "pulse stabilization" by ecologists. Without harvesting, the excess material would accumulate and would change the system such that production and hence nutrient removal capabilities would be reduced—just as not wasting sludge would debilitate an activated sludge system.

Compost / Organic Fertilizer produced from a Managed Aquatic Plant System .

To ensure efficiency and sustainability, the physical design of an ATS™ system needs to be such that: 1) environmental conditions are optimized for production, 2) layout and unit process design facilitates efficient harvesting, collection and processing of the harvested algal turf community, and 3) sufficient flexibility is provided to ensure effective operation during seasonal changes, and severe weather events. Hydromentia, Inc. has developed a modular design and operational approach around a hydraulic capacity of 25 MGD. Typical engineering drawings for a 25 MGD module are presented within Appendix A (Sheets 1 through 8). Critical operational and design considerations include the following:

General ATS™ Layout

The ATS™ floway should be located in an open area that ensures full sun exposure throughout the day. The floway itself (Sheet 1) is composed of a sloped (typically about 0.5%) level expanse of compacted soil overlain with HDPE geomembrane (40 mil is typical) which in turn is overlain by a nylon, polypropylene geomatrix, which serves as an attachment base for algae. The floway is served by a headworks area at the top of the sloped area which serves to deliver influent to the floway (sheets 2 through 4) and an effluent works at the bottom of the sloped area (Sheets 7 through 9). The effluent works serves to collect, concentrate and distribute effluent flows; to deliver and collect algae harvest which is removed from the floway; and to regulate effluent releases through an orifice discharge. The floway is contained by a peripheral berm designed to permit storage of a 100 year storm event within the floway, which is then allocated via the orifice to discharge or diversion units.

System Hydraulics

Linear Hydraulic Loading Rate (LHLR) is measured as the flow rate per linear width of the headworks of the ATS™ floway. It is typically expressed as gpm/ft, and is related to the velocity of flow across the floway. Velocity as well as flow pulsing has been shown to be important in the promotion of production within attached algae. This is discussed in some detail within the S-154 Pilot Single-Stage Algal Turf Scrubber® (ATS™) Final Report (HydroMentia, March 2005). Pulsing the flow is done through an automatic surging device in conjunction with an influent distribution manifold (see Sheets 2 through 4). The LHLR is an important parameter included within the ATSDEM model. It has been found that an LHLR of 20 gpm/ft represents an optimal value. Considering the modular flow of 25 MGD (17,361 gpm) at an LHLR of 20 gpm/ft, the headworks width would be 868 ft. (See Sheet 1).

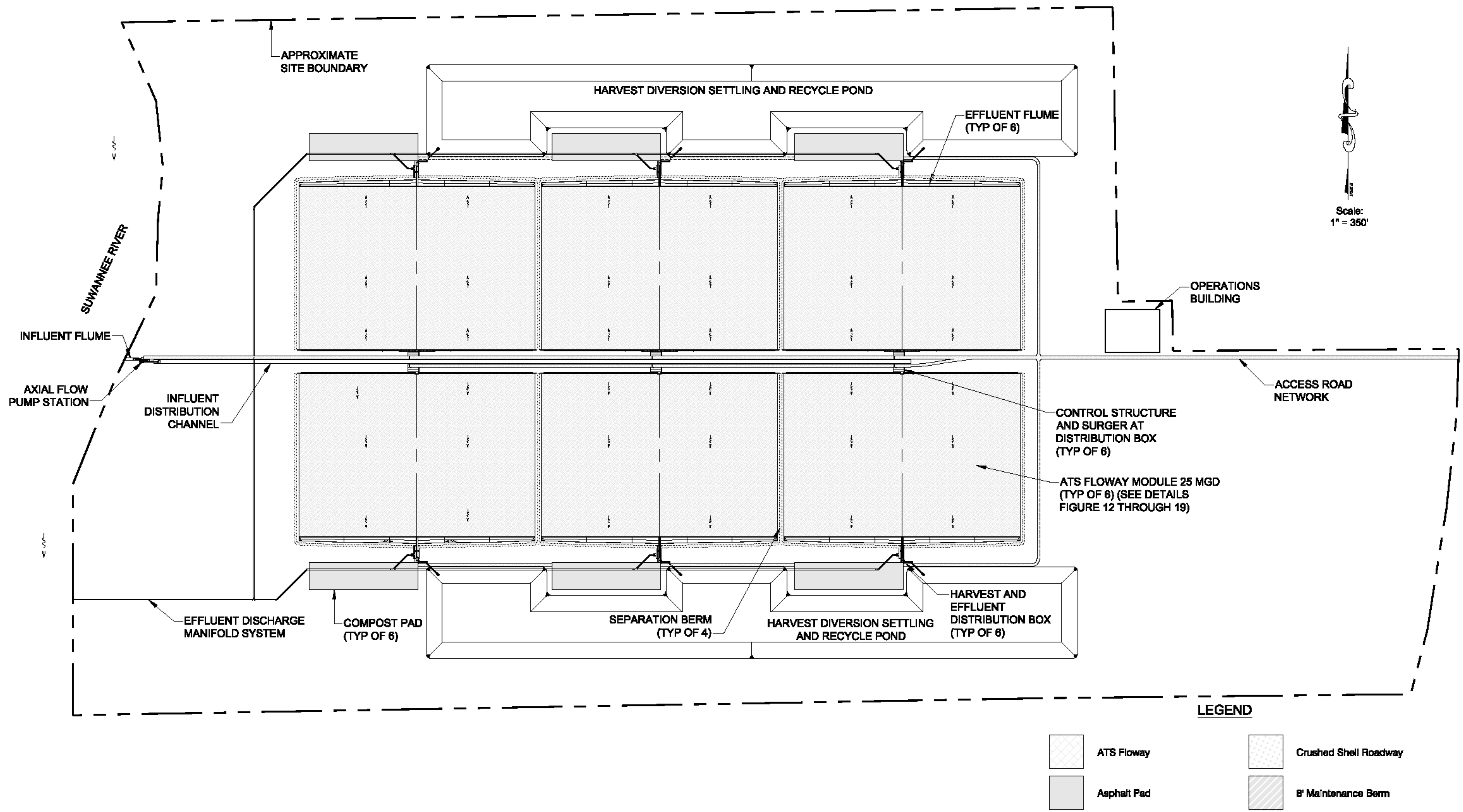
Biomass Recovery and Processing

The ATS™ has been designed to allow for efficient harvest and recovery of biomass. Biomass is severed from the floway matrix and transported via water to the Effluent Flume (Sheets 5 and 6). Harvested material is conveyed to the Harvest and Effluent Distribution Box (Sheets 7 to 9). Algal biomass (harvested algae is typically long filaments) is recovered at a centralized station using a 6 foot wide, 1/4" bar screen, with automatic self-cleaning rake (Duperon Flex-Rake or equivalent) as shown in Sheet 7. Recovered algal biomass is then transported to a compost area (Sheet 5) for windrow composting. Finish compost product is distributed off-site for agricultural/horticultural use.

System Sizing

The amount of harvest is a function of production rate and floway area. The practical length of the floway depends a great deal upon the amount of available carbon, as discussed previously, and the nutrient removal requirements. A typical module for waters of reasonable alkalinity and carbon availability would be 600 feet. Harvesting can be expected to be required every 5-17 days in the summer, and 21-40 days in the cooler months when production is lower. Considering a headworks width of 868 feet and a floway length of 600 feet, the 25 MGD ATS™ module would include 12 acres of effective ATS™ process area. Additional acreage would be required for influent and effluent conveyance, composting, roadway networks, infrastructure, buffer, stormwater management and diversion/settling ponds.

A reasonable development strategy for an ATS™ based regional treatment program for the Suwannee River intended to remove the targeted amount of 1,314 tpy nitrate-nitrogen is to establish clusters of these 25 MGD modules into "units", with the modules operated in parallel along convenient access points between the problematic portions of the river—primarily the portion known as the Middle Suwannee between Ellaville in Suwannee County to about Fanning Springs in Levy County. A proposed plan view of one of the selected sites (Gilchrist Unit), as discussed in subsequent text, is presented as Figure 10. These units composed of clusters of 25 MGD modules will be sized based upon site availability, accessibility, and layout, and the water quality of the river at the site. Each cluster will be labeled as a unit—which can be considered a regional treatment facility. Using this system approach, the overall program can be developed incrementally, thereby allowing coordination with other programs, as well as refinement of implementation approaches based upon documented operational performance.



NO.	REVISION	APPROVED	DATE

DSG. SCP
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CHK. -
APPV. -

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Preliminary Engineering Assessment Comprehensive Algal Turf Scrubber® ATS™ Based Nutrient Control Program for the Suwannee River in Florida

GILCHRIST UNITS

E. ALLEN STEWART III P.E. NO. 29577

DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006

FIGURE 10

PRELIMINARY TECHNICAL ANALYSIS AND SYSTEM SIZING AND LAYOUT

Preliminary Technical Analysis

Using existing information on the basin, such as LABINS (http://data.labins.org/2003/index.cfm), a website available through the FDEP, HydroMentia conducted an initial investigation of potential unit sites along the Middle Suwannee. A series of sites were identified. The locations of the selected regional sites are noted in Appendix B Sheet 9. Each site was then evaluated using the ATS™ Design Model (ATSDEM), using the water quality available for the closest Suwannee River monitoring site. Average values were used for nitrogen, phosphorus, pH and alkalinity (as estimated per previous discussions). While directly treating spring discharges with their corresponding higher nitrate concentrations would increase system treatment performance, for purposes of this assessment, all inflow water quality data was based on treatment of water withdrawn directly from the main river. Average water temperature was 25.3º C (77.5º F) for the warmer months of April through October (215 days) and 15.8º C (60.5º F) for the cooler months of November through March (150 days). The ATSDEM model was then completed for all stations for both seasonal periods.

Projected nitrogen treatment performance for warm weather (215 days) and cool weather (150 days) operational periods are provided for the eleven regional treatment units in Tables 4 and 5, respectively. Included are average daily flows for the designated river segments, treatment unit flows, upstream and downstream water quality and loads. Warm weather and cool weather projected phosphorus treatment is provided in Tables 6 and 7.

Provided in Table 8 are projected warm weather and cool weather specific algal growth rates for the eleven treatment units. Project annual algal biomass harvest volumes and compost production are provided in Table 9.

Performance projections for the full eleven unit - 120 module Algal Turf Scrubber® program are provided for nitrate-nitrogen, total nitrogen, phosphorus, and projected annual percent removal Nitrate-N, total nitrogen and total phosphorus in Figures 11 though 14. At full build out the ATS™ program would achieve a 1,282 ton/yr or 29.3 percent reduction in nitrate-nitrogen, 1,906 ton/yr or 22.8 percent reduction in total nitrogen and a 356 ton/yr or 48.2 percent reduction in total phosphorus.

Direct recovery of pollutants from the Suwannee River will result in reduced nitrate-nitrogen concentrations along the Suwannee as shown in Figure 15, with warm season and cool season concentrations at the Manatee Site to be 0.42 mg/l and 0.33 mg/l, respectively. Nitrate-nitrogen loads reductions are shown in Figure 16. Reductions in total nitrogen concentrations will also be observed with warm season and cool season concentrations at the Manatee Site to be 0.88 mg/l and 0.96 mg/l, respectively (Figure 17). Total-nitrogen loads reductions are shown in Figure 18. In addition to reductions in nitrogen concentrations, the ATS™ program will produce reductions in total phosphorus concentrations and loads as shown in Figures 19 and 20, with downstream warm season and cool season phosphorus concentrations to be reduced below levels currently reported at the upstream Ellaville Site.

In developing these projections, it was assumed that during the course of nutrient uptake within the algal turf, nitrate would be preferentially assimilated, and would be so until it is exhausted, at which time TKN would be used as a nitrogen source. This is one reason there is less difference between Warm Season and Cool Season nitrate-nitrogen removal when compared to the difference between Warm Season and Dry Season total nitrogen and total phosphorus removal. In addition, even though production can be expected to be lower in the Cool Season when all other variables are equal, in modeling this system, it is noted that because of the rapid uptake of phosphorus in the Warm Season, recognizing that phosphorus is a growth restraining nutrient, growth rates decline at a higher rate within the floway during the Warm Season, when compared to the Cool season, because of the more rapid decline of phosphorus concentrations. This is shown in Table 8, were it is noted that during the Cool Season the growth rate, while as expected is lower than the Warm Season, is nearly constant at each unit, while it declines notably during the Warm Season.

Site Selection and Layout

The regional scenario as proposed herein accommodates both seasonal conditions, while maintaining optimal removal rates. In addition, an attempt was made to locate the units, when possible, near a spring discharge, thereby talking advantage of the residual heat and high alkalinities associated with the springs, while ensuring the river influence assures adequate phosphorus availability. This initial site selection was based upon minimizing the number of land owners; proximity to residential areas; road and river access; preservation of wetlands and other protected environmental features; land ownership; and site shape. Obviously these initial selections are offered for preliminary assessment purposes only. Actual site selections will depend upon more detailed field work and evaluation of historical data; institutional investigations; and public coordination. The eleven individual units are presented with general layout; estimated pumping requirements; and model result summaries within Appendix B, Sheets 10 through 18.

Aerial View of 2.5 Acre Algal Turf Scrubber®

Table 4. ATS™ Treatment System Projected Warm Weather Nitrogen Removal Performance

NITROGEN Suwanee River ATS™ System	Approx. Average Daily Flow (MGD)	Treatment Unit Flow (MGD)	Upstream Daily Nitrogen-N Load (lb/day)	Upstream Daily Nitrogen Load (lb/day)	Downstream Daily Nitrogen (lb/day)	TN Removed (lb/day)	Nitrate-N Removed (lb/day)	Downstream Nitrate Load (lb/day)	Upstream Nitrate-N (mg/l)	Downstream Nitrate-N (mg/l)	Upstream Total Nitrogen (mg/l)	Downstream Total Nitrogen (mg/l)
Ellaville A Unit	2,482	500	7,244	25,933	23,316	2,617	1,460	5,785	0.35	0.28	1.25	1.13
Ellaville B Unit	2,456	75	5,499	22,909	22,540	369	168	5,331	0.27	0.26	1.12	1.10
Dowling Park A Unit	2,422	550	4,569	21,455	18,883	2,572	1,037	3,531	0.23	0.17	1.06	0.93
Dowling Park B Unit	2,398	175	3,332	18,896	18,247	649	243	3,089	0.17	0.15	0.94	0.91
Blue Springs Unit	2,522	125	4,766	20,724	20,239	486	236	4,530	0.23	0.22	0.99	0.96
Luraville Unit	2,604	600	5,648	23,955	21,473	2,482	1,302	4,346	0.26	0.20	1.10	0.99
Troy Springs Unit	2,765	50	7,875	28,841	28,667	175	142	7,733	0.34	0.34	1.25	1.24
Lafayette A Unit	3,212	125	9,893	30,349	29,887	462	385	9,508	0.37	0.35	1.13	1.12
Lafayette B Unit	3,249	50	9,688	30,167	29,990	177	149	9,539	0.36	0.35	1.11	1.11
Gilchrist Unit	3,324	150	9,899	30,130	29,602	528	447	9,452	0.36	0.34	1.09	1.07
Manatee Unit	3,925	600	11,827	27,376	25,196	2,179	1,808	10,019	0.36	0.31	0.84	0.77
Total		**3,000**				**12,696**	**7,377**					
					tons/yr[1]	1,365	793					

[1] Nitrogen Removal Based on 215 Day Warm Weather Operational Period.

Table 5. ATS™ Treatment System Projected Cool Weather Nitrogen Removal Performance

NITROGEN Suwanee River ATS™ System	Approx. Average Daily Flow (MGD)	Treatment Unit Flow (MGD)	Upstream Daily Nitrogen-N Load (lb/day)	Upstream Daily Nitrogen Load (lb/day)	Downstream Daily Nitrogen (lb/day)	TN Removed (lb/day)	Nitrate-N Removed (lb/day)	Downstream Nitrate Load (lb/day)	Upstream Nitrate-N (mg/l)	Downstream Nitrate-N (mg/l)	Upstream Total Nitrogen (mg/l)	Downstream Total Nitrogen (mg/l)
Ellaville A Unit	2,482	500	7,244	25,933	24,688	1,245	1,245	5,999	0.35	0.29	1.25	1.19
Ellaville B Unit	2,456	75	5,713	24,281	24,090	191	174	5,538	0.28	0.27	1.19	1.18
Dowling Park A Unit	2,422	550	4,776	23,005	21,617	1,389	1,084	3,692	0.24	0.18	1.14	1.07
Dowling Park B Unit	2,398	175	3,493	22,443	22,026	416	255	3,238	0.17	0.16	1.12	1.10
Blue Springs Unit	2,522	125	4,915	24,504	24,178	326	244	4,671	0.23	0.22	1.17	1.15
Luraville Unit	2,604	600	5,789	27,895	26,436	1,459	1,334	4,455	0.27	0.21	1.28	1.22
Troy Springs Unit	2,765	50	7,984	33,804	33,685	118	118	7,866	0.35	0.34	1.47	1.46
Lafayette A Unit	3,212	125	10,026	35,367	35,076	291	291	9,735	0.37	0.36	1.32	1.31
Lafayette B Unit	3,249	50	9,915	35,356	35,242	114	114	9,801	0.37	0.36	1.30	1.30
Gilchrist Unit	3,324	150	10,161	35,382	35,042	340	340	9,820	0.37	0.35	1.28	1.26
Manatee Unit	3,925	600	12,195	32,816	31,495	1,321	1,321	10,874	0.37	0.33	1.00	0.96
Total		3,000				7,211	6,522					
					tons/yr[2]	541	489					

[2] Nitrogen Removal Based on 150 Day Cool Weather Operational Period.

Table 6. ATS™ Treatment System Projected Warm Weather Phosphorus Removal Performance

PHOSPHORUS Suwannee River ATS™ System	Approx. Average Daily Flow (MGD)	Treatment Unit Flow (MGD)	Upstream Daily Total Phosphorus Load (lb/day)	Downstream Daily Phosphorus Load Load (lb/day)	Total Phosphorus Removed (lb/day)	Upstream Total Phosphorus (mg/l)	Downstream Total Phosphorus (mg/l)
Ellaville A Unit	2,482	500	3,270	2,766	504	0.158	0.134
Ellaville B Unit	2,456	75	2,772	2,703	69	0.135	0.132
Dowling Park A Unit	2,422	550	2,709	2,196	513	0.134	0.109
Dowling Park B Unit	2,398	175	2,253	2,111	142	0.113	0.106
Blue Springs Unit	2,522	125	2,162	2,070	92	0.103	0.098
Luraville Unit	2,604	600	2,223	1,762	461	0.102	0.081
Troy Springs Unit	2,765	50	1,914	1,884	30	0.083	0.082
Lafayette A Unit	3,212	125	2,341	2,260	81	0.087	0.084
Lafayette B Unit	3,249	50	2,299	2,267	31	0.085	0.084
Gilchrist Unit	3,324	150	2,344	2,289	55	0.085	0.083
Manatee Unit	3,925	600	2,885	2,494	391	0.088	0.076
Total		3,000			2,368		
				tons/yr[1]	255		

[1] Phosphorus Removal Based on 150 Day Cool Weather Operational Period.

Table 7. ATS™ Treatment System Projected Cool Weather Phosphorus Removal Performance

PHOSPHORUS Suwanee River ATS™ System	Approx. Average Daily Flow (MGD)	Treatment Unit Flow (MGD)	Upstream Daily Total Phosphorus Load (lb/day)	Downstream Daily Phosphorus Load Load (lb/day)	Total Phosphorus Removed (lb/day)	Upstream Total Phosphorus (mg/l)	Downstream Total Phosphorus (mg/l)
Ellaville A Unit	2,482	500	3,270	3,026	244	0.158	0.146
Ellaville B Unit	2,456	75	3,032	2,995	37	0.148	0.146
Dowling Park A Unit	2,422	550	3,000	2,729	272	0.149	0.135
Dowling Park B Unit	2,398	175	2,785	2,704	81	0.139	0.135
Blue Springs Unit	2,522	125	2,755	2,693	63	0.131	0.128
Luraville Unit	2,604	600	2,845	2,568	277	0.131	0.118
Troy Springs Unit	2,765	50	2,720	2,698	22	0.118	0.117
Lafayette A Unit	3,212	125	3,156	3,101	54	0.118	0.116
Lafayette B Unit	3,249	50	3,139	3,118	21	0.116	0.115
Gilchrist Unit	3,324	150	3,194	3,168	26	0.115	0.114
Manatee Unit	3,925	600	3,764	3,510	254	0.115	0.107
Total		3,000			1,351		
				tons/yr[2]	101		

[2] Phosphorus Removal Based on 150 Day Cool Weather Operational Period.

Table 8. Projected Specific Growth Rate Pattern for Warm and Cool Seasons ATS™

Suwanee River ATS™ System	Warm Season Specific Growth Rate 1/hr	Cool Season Specific Growth Rate 1/hr	Ratio Warm Season Growth Rate to Cool Season Growth Rate
Ellaville A Unit	0.0126	0.0058	2.19
Ellaville B Unit	0.0115	0.0057	2.03
Dowling Park A Unit	0.0115	0.0057	2.02
Dowling Park B Unit	0.0103	0.0056	1.85
Blue Springs Unit	0.0101	0.0054	1.87
Luraville Unit	0.0094	0.0055	1.71
Troy Springs Unit	0.0083	0.0053	1.58
Lafayette A Unit	0.0083	0.0053	1.58
Lafayette B Unit	0.0083	0.0053	1.58
Gilchrist Unit	0.0083	0.0052	1.59
Manatee Unit	0.0083	0.0052	1.59

Table 9. Projected Annual Algal Harvest and Compost Production

Suwanee River ATS™ System	Annual Harvest Wet Tons	Annual Harvest Dry Tons	Annual Compost Production Tons	Modules
Ellaville A Unit	251,809	12,590	15,738	20
Ellaville B Unit	36,602	1,830	2,288	3
Dowling Park A Unit	266,482	13,324	16,655	22
Dowling Park B Unit	76,091	3,805	4,756	7
Blue Springs Unit	52,042	2,602	3,253	5
Luraville Unit	252,270	12,614	15,767	24
Troy Springs Unit	18,096	905	1,131	2
Lafayette A Unit	47,359	2,368	2,960	5
Lafayette B Unit	18,323	916	1,145	2
Gilchrist Unit	54,739	2,737	3,421	6
Manatee Unit	227,122	11,356	14,195	24
Total	1,300,935	65,047	81,308	120

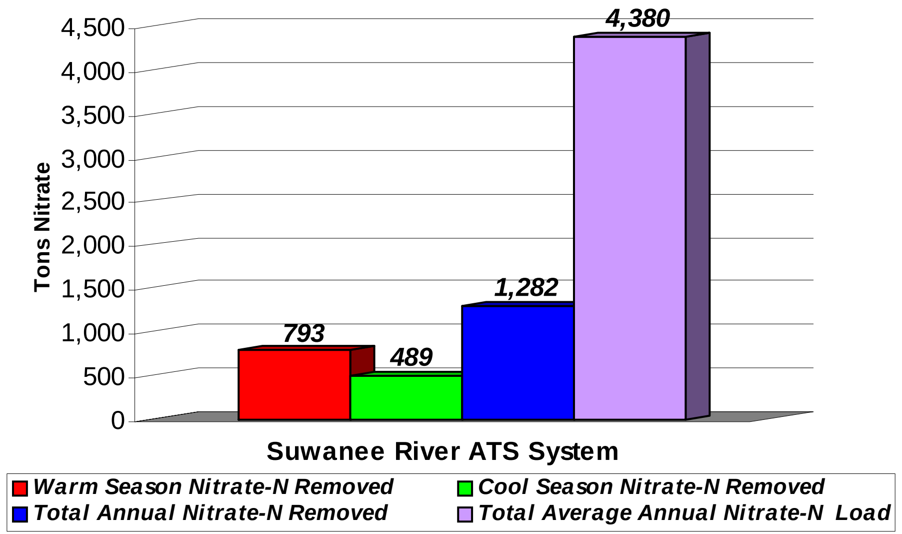

Figure 11. Projected Annual Nitrate Removal

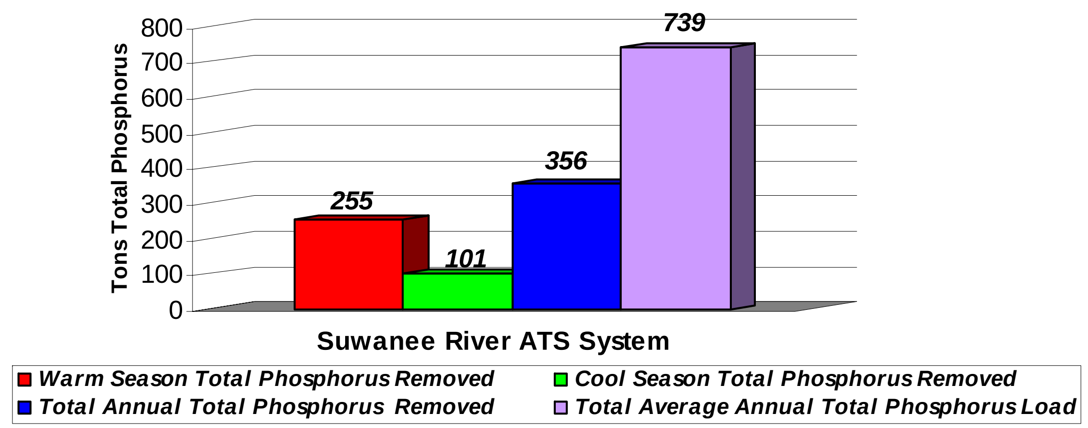

Figure 13. Projected Annual Total Phosphorus Removal

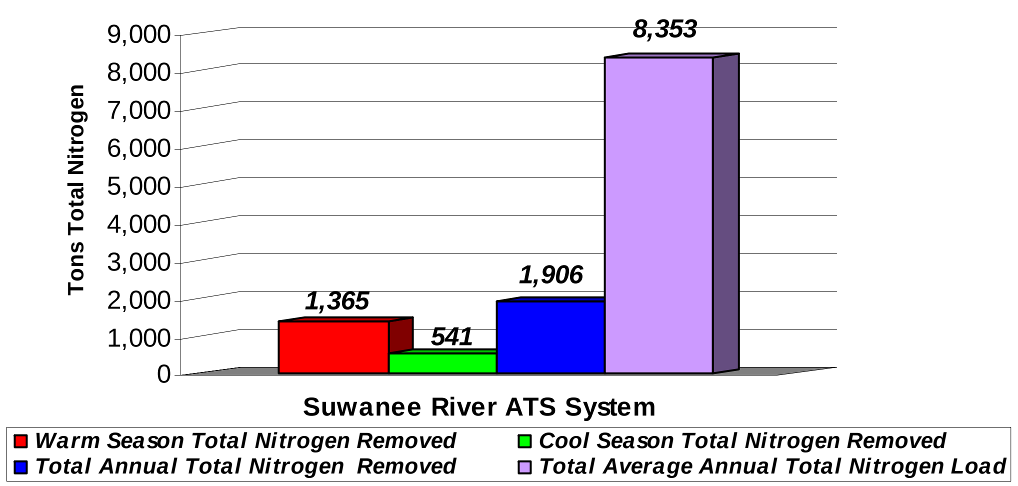

Figure 12. Projected Annual Total Nitrogen Removal

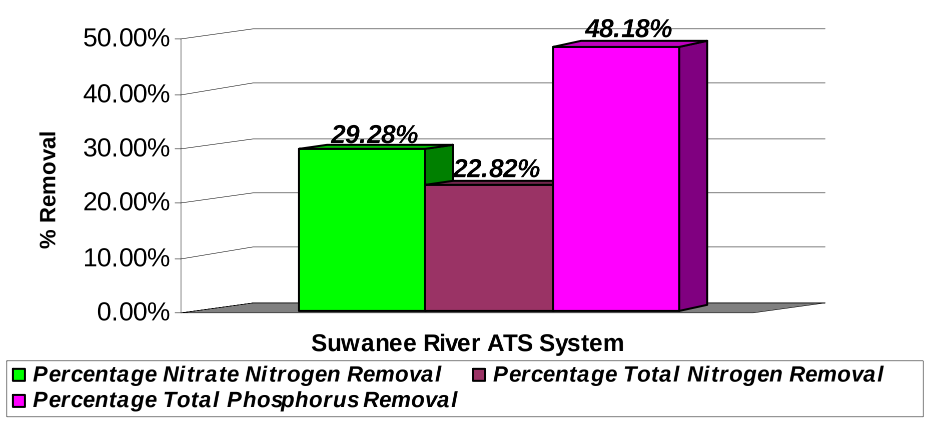

Figure 14. Projected Annual Percent Removal Nitrate-N, Total Nitrogen and Total Phosphorus

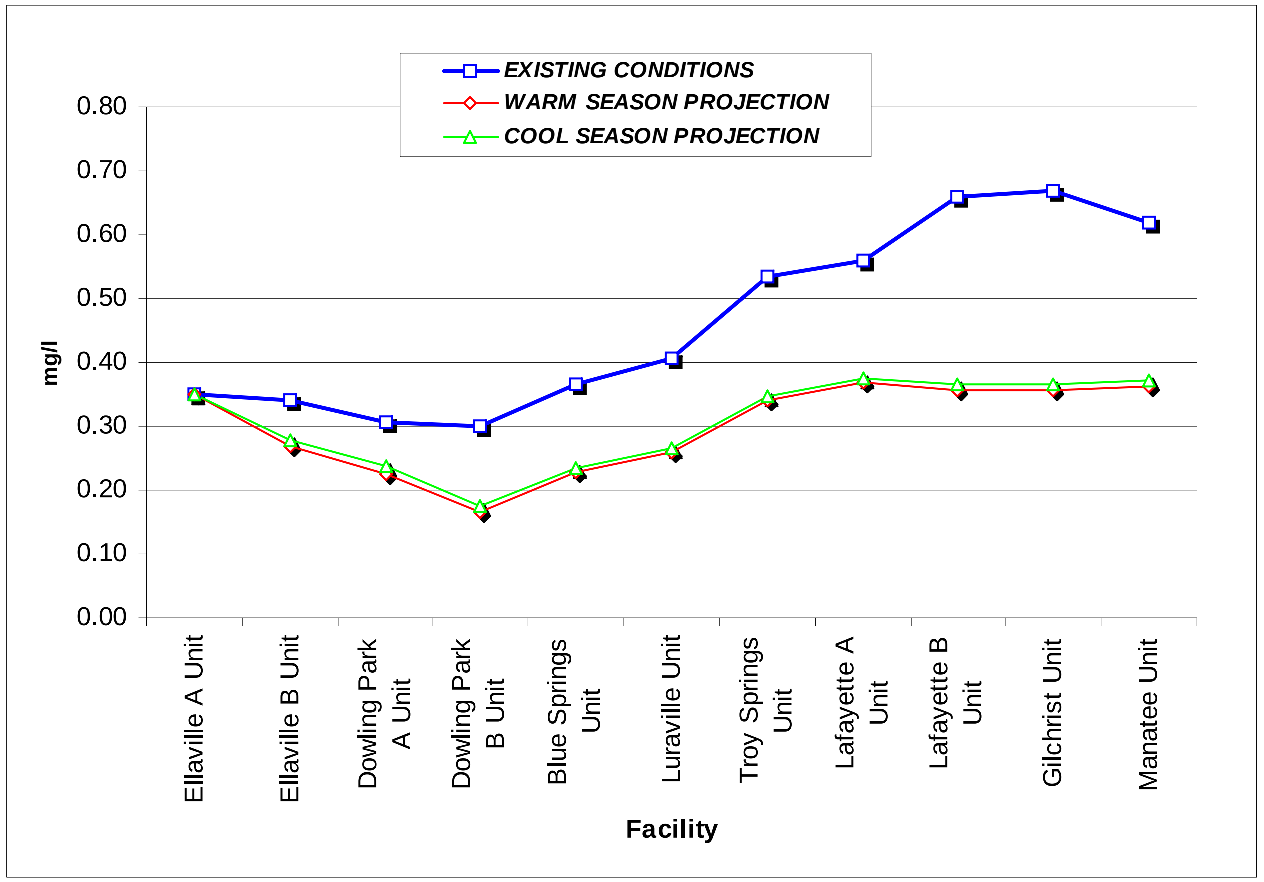

Figure 15. Existing and Projected Nitrate Concentrations Middle Suwannee River

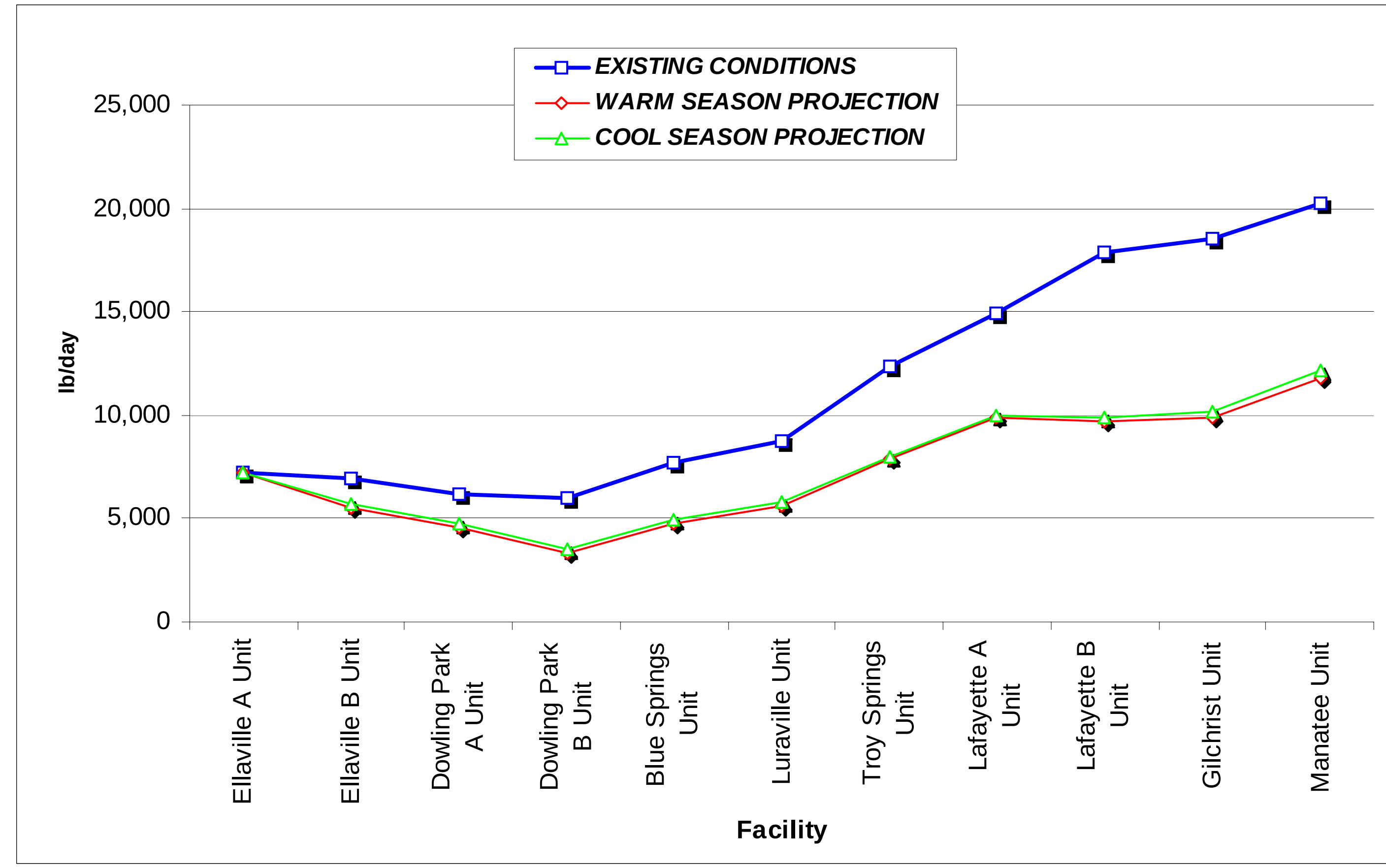

Figure 16. Existing and Projected Nitrate Loads Middle Suwannee

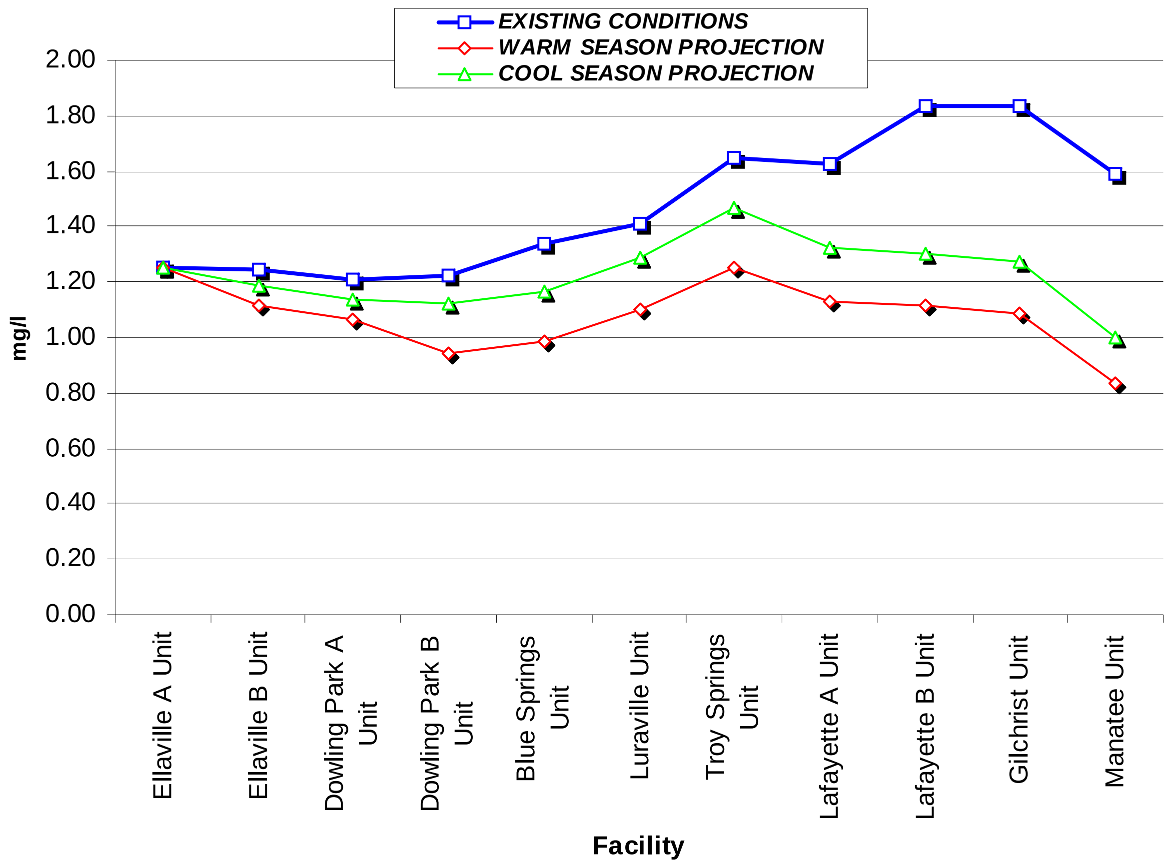

Figure 17. Existing and Projected Total Nitrogen Concentrations Middle Suwannee River

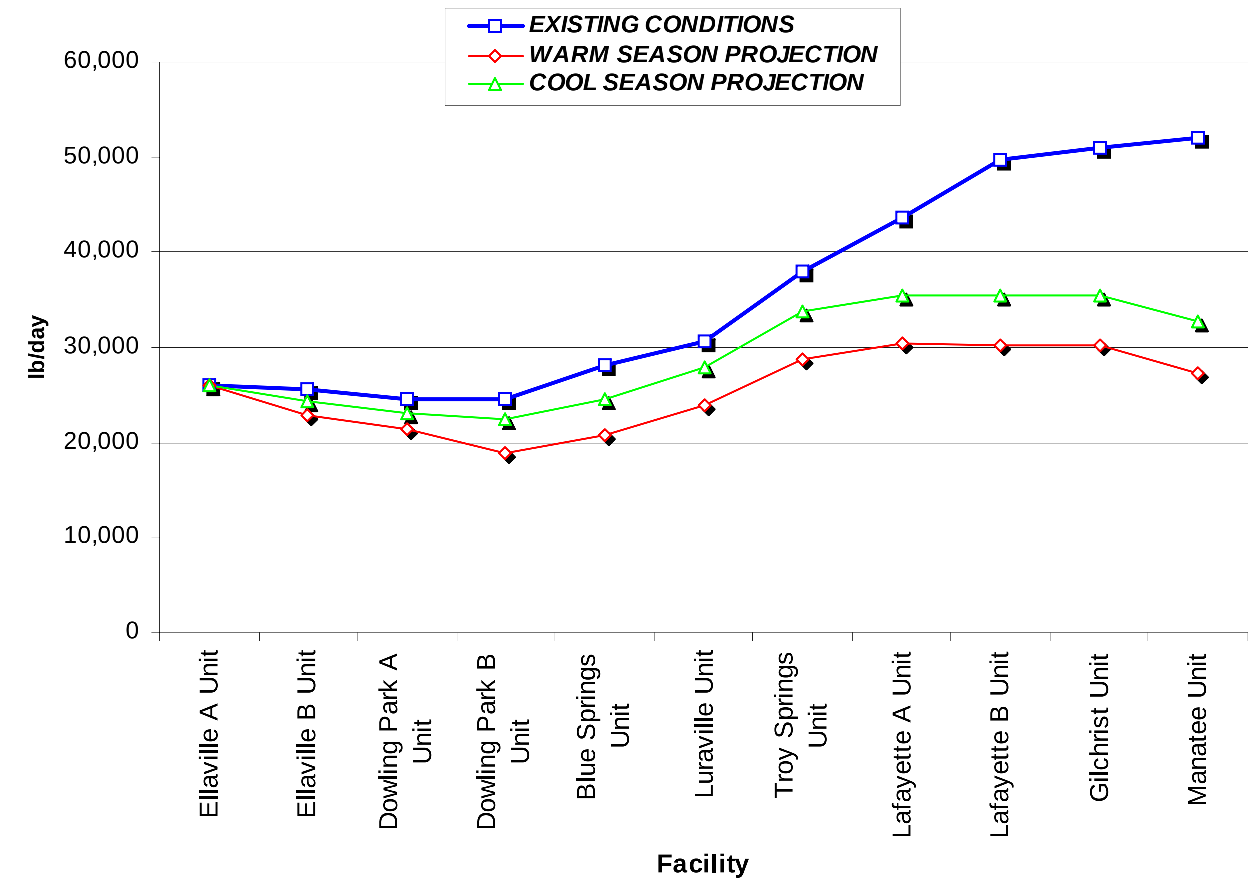

Figure 18. Existing and Projected Total Nitrogen Loads Middle Suwannee River

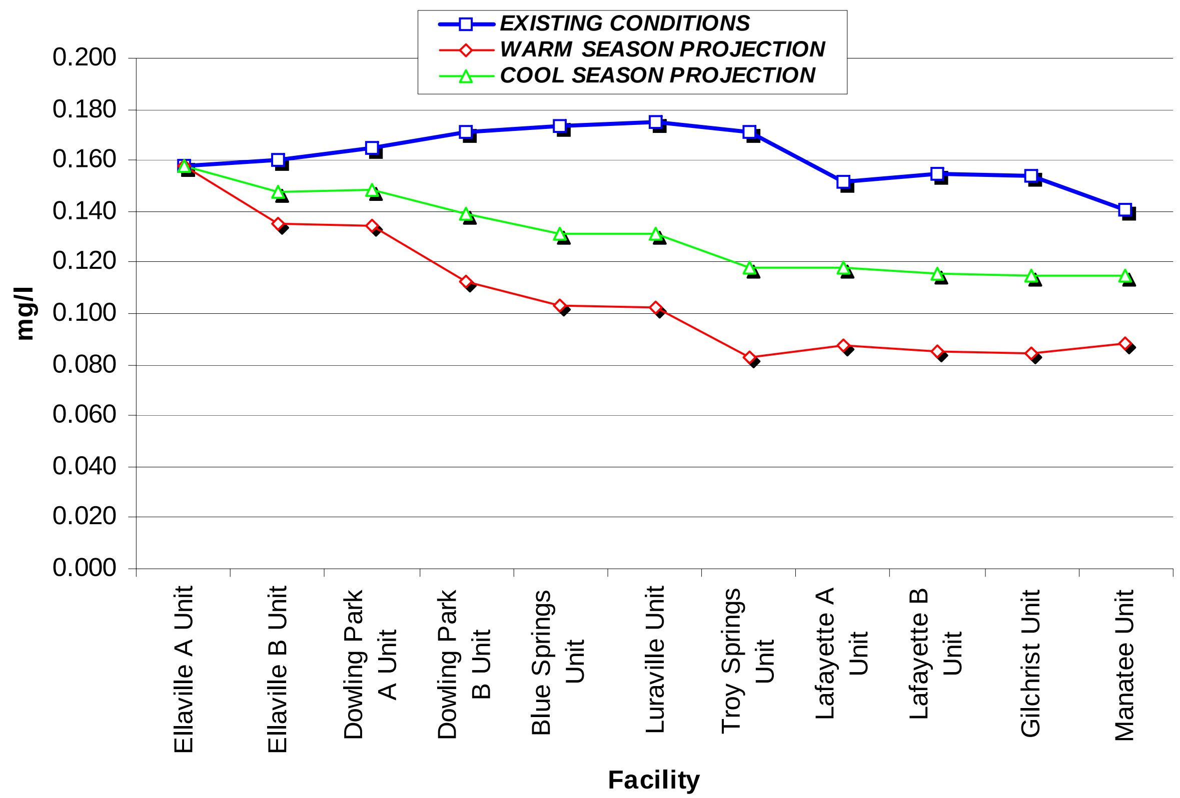

Figure 19. Existing and Projected Total Phosphorus Concentrations Middle Suwannee River

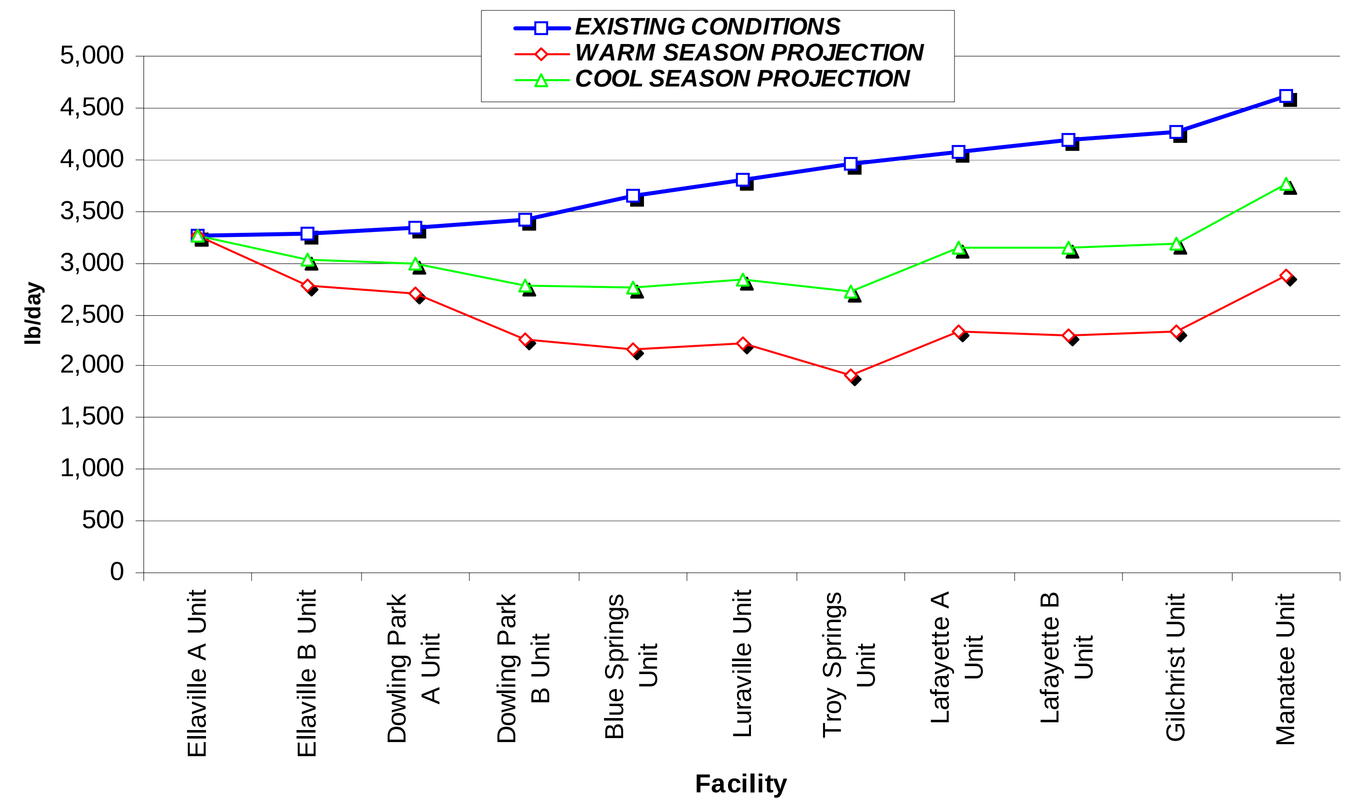

Figure 20. Existing and Projected Total Phosphorus Loads Middle Suwannee River

Preliminary Capital Cost Estimate

Over the past few years construction costs in Florida have fluctuated upward, tracking the market demand created by the extensive amount of construction within the state, as well as responding to substantial increases in material and fuel prices. This makes cost estimating both difficult and precarious in terms of setting long term budgets. Therefore, the costs as developed and presented here should be viewed with respect to these concerns. The capital costs for the specific units may be considered to be the sum of the product of the number of modules and the projected module cost: the land cost, engineering costs, the cost of all peripheral support facilities, including the road network, the lift stations, the influent feeder canal, the discharge manifold and structure, electrical and instrumentation, operational support, and stormwater management facilities. The peripheral support facilities, including electrical, engineering, technology fees, and contingency are assumed for this review to be 50% of the module component. Land costs are estimated from the most recent property appraisers values—the average value being about $3,000/acre. Even though many of the selected sites already belong to the SRWMD, the costs have been included in this analysis to be consistent with federal cost assessment guidelines for water projects. Capital cost projections based upon these assumptions are summarized within Table 10.

Preliminary Operating and Maintenance Cost Estimate

Operating costs include energy associated primarily with pumping and with vehicles: labor costs associated with harvesting and biomass processing, monitoring costs, leasing of harvesting equipment and vehicles, and professional services costs. Estimated operational labor cost per module are $76,000/year, based on the assessed scenario which reflects multiple modules per site. Projected electrical costs for each unit are shown in Table 11. Maintenance, repair and replacement includes grounds keeping costs, equipment and material maintenance and repair, and equipment and material replacement. For purposes of this assessment it is assumed that the pumps will be electrical driven. It likely will prove more cost effective to consider natural gas or diesel driven engines to drive the pumps. These pumps will be axial flow lift pumps (low head, high volume). Equipment life is considered to be 15 years, with vehicle life at 10 years and geomatrix replacement in 20 years. The HDPE geomembrane is assumed to last the full 50 year life cycle. An estimate of annual operating and maintenance (O&M) costs are presented within Table 12.

Table 10. Capital Cost Approximations Proposed Comprehensive Suwannee River ATS™ Based Nutrient Control Program

Unit	Number of Modules	Cost/Module (million $)	Total Module Costs (million $)	Land Costs ($/acre)	Purchased Land Area (acres)1	Total Land Costs (million $)	Peripheral Support Costs (million $)	Total Capital Cost (million $)
Ellaville A	20	$ 3.85	$ 77.05	$ 3,000	1,425	$ 4.28	$ 38.52	$ 119.84
Ellaville B	3	$ 3.85	$ 11.56	$ 3,000	450	$ 1.35	$ 5.78	$ 18.69
Dowling Park A	22	$ 3.85	$ 84.75	$ 3,000	1,715	$ 5.15	$ 42.38	$ 132.27
Dowling Park B	7	$ 3.85	$ 26.97	$ 3,000	274	$ 0.82	$ 13.48	$ 41.27
Blue Springs	5	$ 3.85	$ 19.26	$ 3,000	560	$ 1.68	$ 9.63	$ 30.57
Luraville	24	$ 3.85	$ 92.46	$ 3,000	1,145	$ 3.44	$ 46.23	$ 142.12
Troy Springs	2	$ 3.85	$ 7.70	$ 3,000	104	$ 0.31	$ 3.85	$ 11.87
Lafayette A	5	$ 3.85	$ 19.26	$ 3,000	286	$ 0.86	$ 9.63	$ 29.75
Lafayette B	2	$ 3.85	$ 7.70	$ 3,000	70	$ 0.21	$ 3.85	$ 11.77
Gilchrist	6	$ 3.85	$ 23.11	$ 3,000	264	$ 0.79	$ 11.56	$ 35.46
Manatee	24	$ 3.85	$ 92.46	$ 3,000	1,040	$ 3.12	$ 46.23	$ 141.80
Total Projected Capital Costs (Million $)								$ 715.41

[1] Assumes full parcel purchase ased on surrent parcel boundaries and acreages. This land acquisition assumption results in the purchase of excess land. Effective treatment area for 120 ATS™ units is equal to 1440 acres, plus land required for periphial support facilities.

Table 11. Approximations Annual Pumping Electrical Costs Suwannee River ATS™ Based Nutrient Control Program

Unit	Flow (MGD)	Flow (GPM)	Head (tdh)	Pump (Brake HP)	Pump (kW)	Energy/day (kW-hrs/day)	Energy cost ($/kW-hr)	cost/day ($/day)	cost/year (million $/yr)	Annual cost/mgd ($)
Ellaville A	500	347,222	21	2,302	2,074	49,769	0.100	$ 4,977	$ 1.82	$ 3,633
Ellaville B	75	52,083	21	345	311	7,465	0.100	$ 747	$ 0.27	$ 3,633
Dowling Park A	550	381,944	21	2,532	2,281	54,746	0.100	$ 5,475	$ 2.00	$ 3,633
Dowling Park B	175	121,528	23	882	795	19,078	0.100	$ 1,908	$ 0.70	$ 3,979
Blue Springs	125	86,806	22	603	543	13,035	0.100	$ 1,303	$ 0.48	$ 3,806
Luraville	600	416,667	22	2,894	2,607	62,567	0.100	$ 6,257	$ 2.28	$ 3,806
Troy Springs	50	34,722	22	241	217	5,214	0.100	$ 521	$ 0.19	$ 3,806
Lafayette A	125	86,806	22	603	543	13,035	0.100	$ 1,303	$ 0.48	$ 3,806
Lafayette B	50	34,722	22	241	217	5,214	0.100	$ 521	$ 0.19	$ 3,806
Gilchrist	150	104,167	23	756	681	16,353	0.100	$ 1,635	$ 0.60	$ 3,979
Manatee	600	416,667	22	2,894	2,607	62,567	0.100	$ 6,257	$ 2.28	$ 3,806
Total									$ 11.28	

Table 12. Approximations Operations and Maintenance Costs Suwannee River ATS™ Based Nutrient Control Program

Unit	Number of Modules	Total Labor Cost ($M/year)	Harvest/Process Equipment Lease Cost ($M/year)	Pumping Electrical Costs $M/year)	Pump Maintenance Costs ($M/year)	Equipment Maintenance Costs ($M/year)	Additional Energy Costs ($M/year)	Monitoring and Miscellaneous Costs ($M/year)	Total O&M Costs ($M/year)
Ellaville A	20	$ 1.52	$ 0.80	$ 1.82	0.036	0.154	$ 0.182	$ 0.200	$ 4.71
Ellaville B	3	$ 0.23	$ 0.12	$ 0.27	0.005	0.023	$ 0.027	$ 0.030	$ 0.71
Dowling Park A	22	$ 1.67	$ 0.88	$ 2.00	0.040	0.170	$ 0.200	$ 0.220	$ 5.18
Dowling Park B	7	$ 0.53	$ 0.28	$ 0.70	0.014	0.054	$ 0.070	$ 0.070	$ 1.72
Blue Springs	5	$ 0.38	$ 0.20	$ 0.48	0.010	0.039	$ 0.048	$ 0.050	$ 1.20
Luraville	24	$ 1.82	$ 0.96	$ 2.28	0.046	0.185	$ 0.228	$ 0.240	$ 5.77
Troy Springs	2	$ 0.15	$ 0.08	$ 0.19	0.004	0.015	$ 0.019	$ 0.020	$ 0.48
Lafayette A	5	$ 0.38	$ 0.20	$ 0.48	0.010	0.039	$ 0.048	$ 0.050	$ 1.20
Lafayette B	2	$ 0.15	$ 0.08	$ 0.19	0.004	0.015	$ 0.019	$ 0.020	$ 0.48
Gilchrist	6	$ 0.46	$ 0.24	$ 0.60	0.012	0.046	$ 0.060	$ 0.060	$ 1.47
Manatee	24	$ 1.82	$ 0.96	$ 2.28	0.046	0.185	$ 0.228	$ 0.240	$ 5.77
Total Units	120								
Total Projected O&M Costs ($M)		$ 9.12	$ 4.80	$ 11.28	0.226	0.925	$ 1.128	$ 1.200	$ 28.68

Within Table 12, pump maintenance is estimated as 2% of the electrical costs, and equipment maintenance is estimated at 2% of the estimated remaining equipment costs, which in turn is estimated as 10% of the module construction costs. Additional energy costs include vehicle fuel and other electrical costs (rake, recycle pumps etc.), and is estimated as 10% of the pumping electrical costs. Monitoring and miscellaneous costs are estimated at $10,000/module-year, and equipment lease costs (harvest and processing equipment) at $40,000/module-year. Based on multiple modules per site, the estimated total O&M costs are $240,000 per module.

Preliminary Fifty (50) Year Present Worth Analysis

A present worth analysis based upon a fifty year operational period and the Federal Discount Rate for water projects of 5.125%, including the replacement and land salvage costs is summarized within Table 13. When this present worth cost estimate of $1.25 billion is divided by the fifty year nutrient removal estimates, a unit removal cost of $9.76/lb-nitrate-nitrogen; $6.57/lb-total nitrogen; and $35.16/lb-total phosphorus is calculated. These costs do not include reductions in costs from any potential revenues with either sales of the soil amendment, or from sales of nutrient removal credits—nitrogen, phosphorus and carbon. The product management assumption is that the final soil amendment (compost) product, will be given to local agricultural interests for free pick-up.

Table 13. Approximations Fifty Year Present Worth Costs Suwannee River ATS™ Based Nutrient Control Program

Unit	Capital Costs ($M)	Annual O&M ($M)	Present Worth Replacement & Salvage ($M)	Total 50 year Present Worth Costs ($M)
Ellaville A	$ 119.84	$ 4.71	$ 3.70	$ 207.87
Ellaville B	$ 18.69	$ 0.71	$ 0.55	$ 31.89
Dowling Park A	$ 132.27	$ 5.18	$ 4.07	$ 229.10
Dowling Park B	$ 41.27	$ 1.72	$ 1.29	$ 73.29
Blue Springs	$ 30.57	$ 1.20	$ 0.92	$ 53.01
Luraville	$ 142.12	$ 5.77	$ 4.44	$ 249.83
Troy Springs	$ 11.87	$ 0.48	$ 0.37	$ 20.84
Lafayette A	$ 29.75	$ 1.20	$ 0.92	$ 52.19
Lafayette B	$ 11.77	$ 0.48	$ 0.37	$ 20.74
Gilchrist	$ 35.46	$ 1.47	$ 1.11	$ 62.91
Manatee	$ 141.80	$ 5.77	$ 4.44	$ 249.51
Total Projected O&M Costs ($M)				$ 1,251.20

	50 years (Pounds Removed)	50 year Present Worth ($/Pound Removed)
Nitrate N	128,214,410	$ 9.76
Total Nitrogen	190,567,290	$ 6.57
Total Phosphorus	35,586,755	$ 35.16

BENEFITS AND RECOMMENDATIONS

The proposed Algal Turf Scrubber® Based Nutrient Control Program is offered as a supplementary program to the District’s current efforts to reduce nutrient loads in the Suwannee River Watershed.

As part of its overall strategic plan, the SRWMD has identified a number of management strategies to reduce nutrient loads in the Suwannee River Watershed. These include (i) assisting farmers in implementing BMPs through the Suwannee River Partnership, (ii) partnering with local governments for improved springs protection and management, and (iii) partnering with the Florida Springs Initiative for improved springs protection.

It is projected that these programs will result in tangible reductions in nutrient loads to the Suwannee River. However, additional treatment measures will be required to restore the Suwannee River and reduce nutrient loads discharged to the Gulf of Mexico.

The proposed Algal Turf Scrubber® Based Nutrient Control Program offers a number of advantages when considering available approaches for nutrient load reduction in the watershed. These benefits include relatively low land requirements and the capacity to cost effectively recover nutrient pollutants from high flow, relatively low concentration impaired surface waters.

The proposed nutrient control program is ideally suited for phased implementation. It is recommended that a site such as the Troy Site, be selected for Phase 1 implementation. The selected site should be in an area that is readily accessible, yet adequately removed from residential or critical environmental features. As noted in the Preliminary Technical Analysis, to enhance treatment performance, the intake at this unit could easily be located to allow for a blend between spring water and river water.

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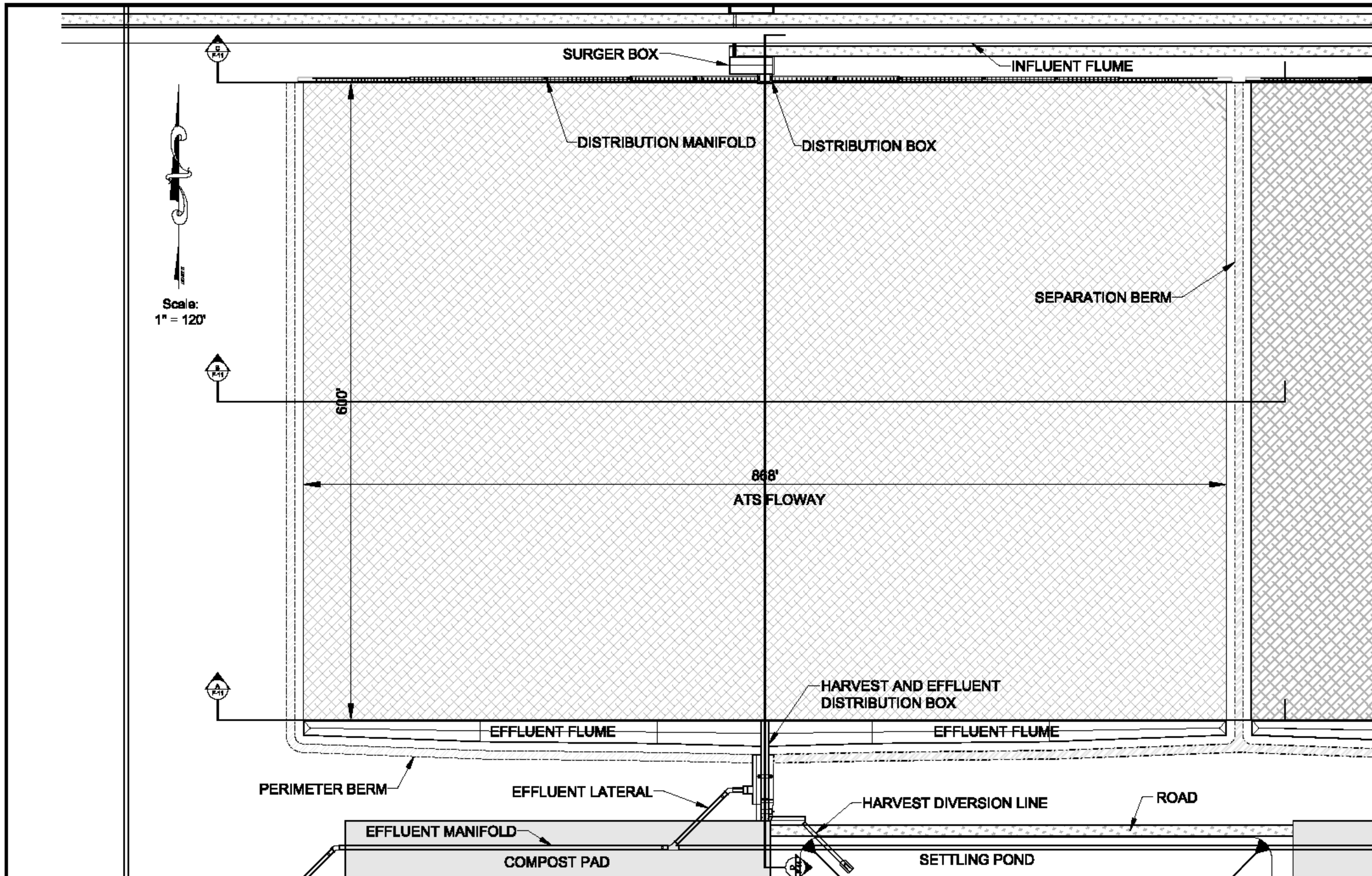
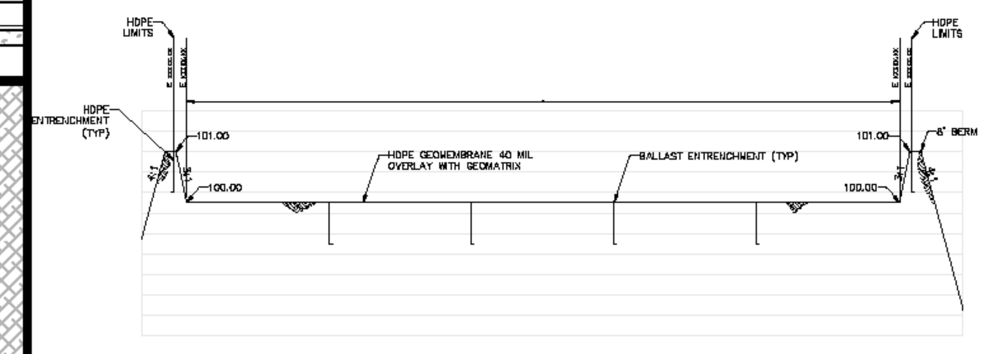
APPENDIX A

STANDARD 25 MGD ATS™ MODULE



LEGEND

ATS Floway	Crushed Shell Roadway
Asphalt Pad	8' Maintenance Berm



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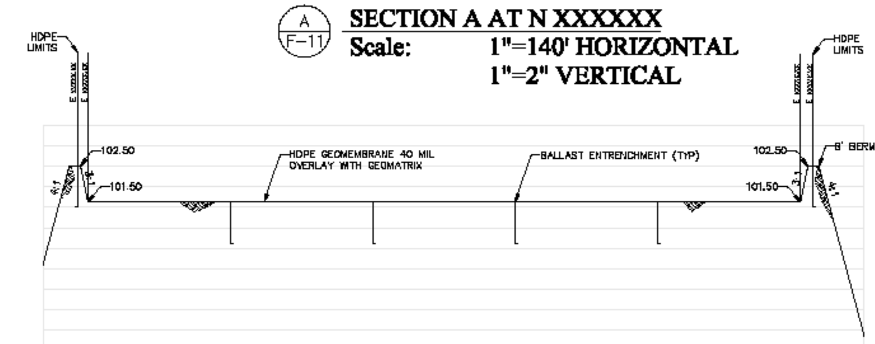

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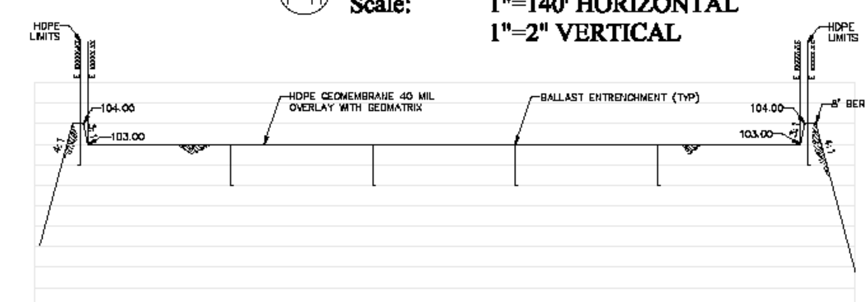

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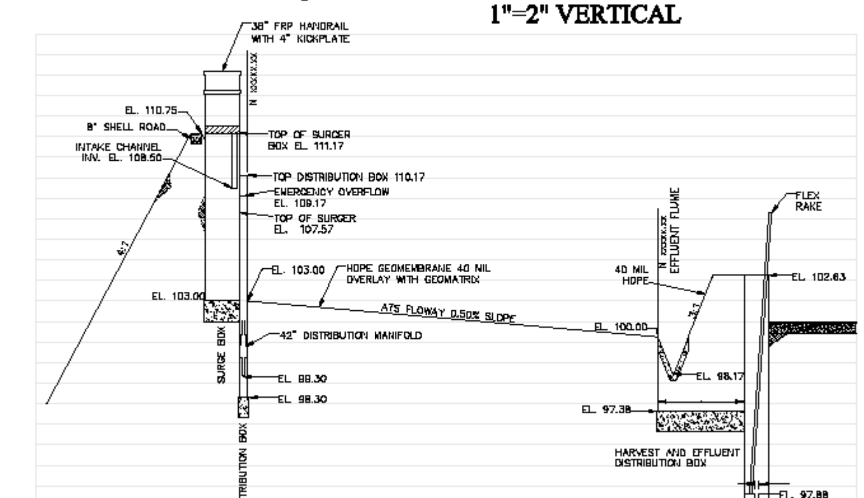

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NO.	REVISION	APPROVED	DATE

DSG. SCP
DWN. SCP
CHK. -
APPV. -

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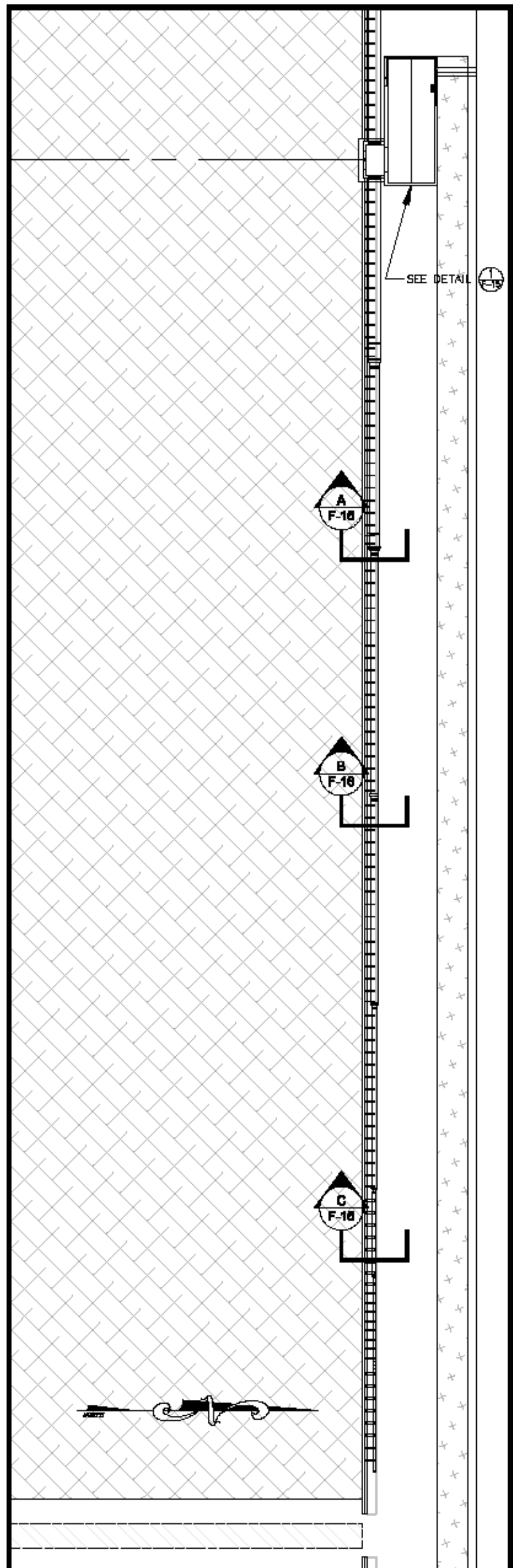
Preliminary Engineering Assessment Comprehensive Algal Turf Scrubber® ATS™ Based Nutrient Control Program for the Suwannee River in Florida

ATS™ Plan and Sections 25 MGD Module (typ)

E. ALLEN STEWART III P.E. NO. 23677
DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
SHEET 1



ATS™ Headworks Plan

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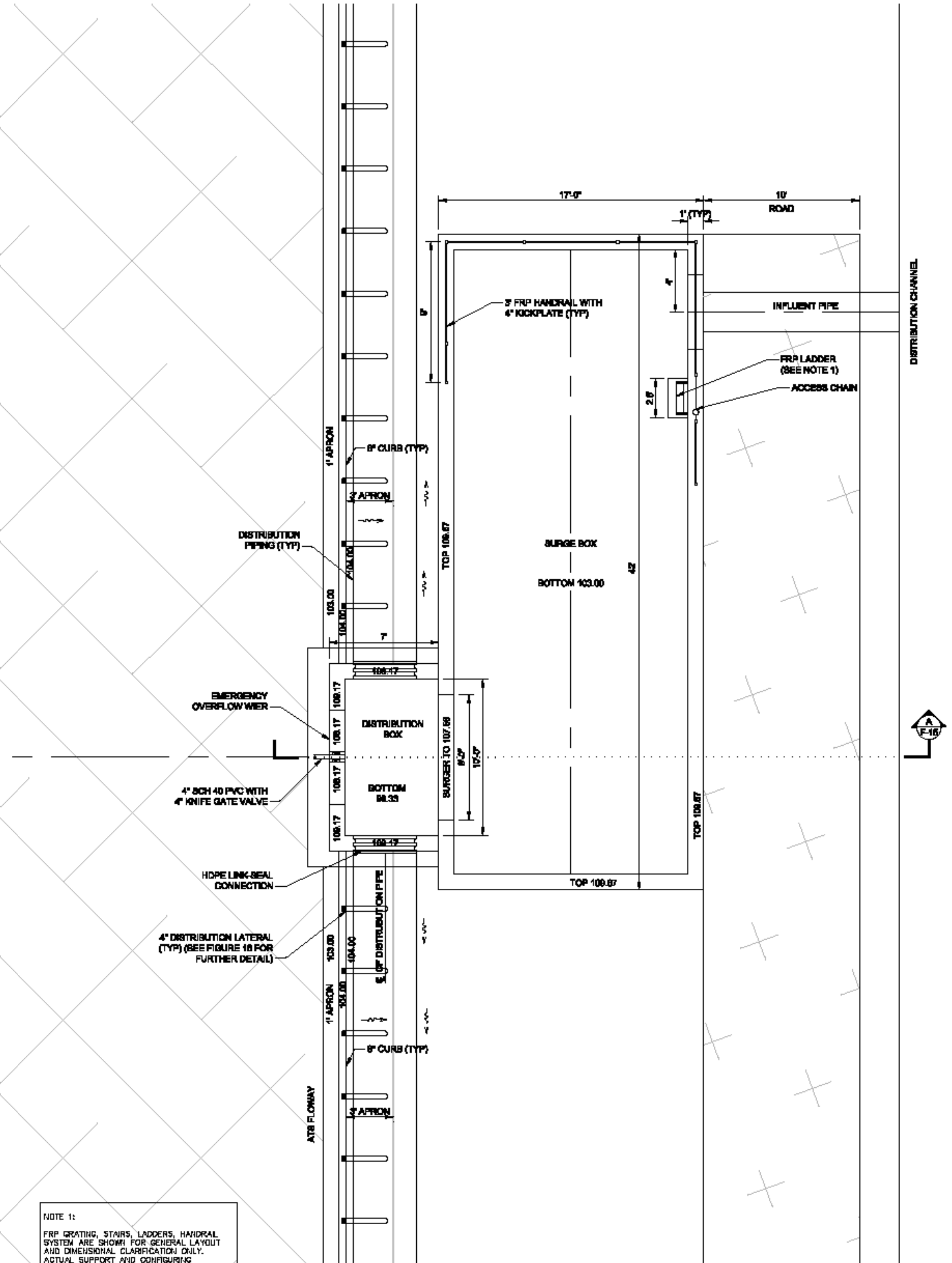

NOTE 1:

FRP GRATING, STAIRS, LADDERS, HANDRAIL SYSTEM ARE SHOWN FOR GENERAL LAYOUT AND DIMENSIONAL CLARIFICATION ONLY. ACTUAL SUPPORT AND CONFIGURING LAYOUT SHALL BE FINALIZED BY FRP SYSTEM SUPPLIER, WHO SHALL ALSO PROVIDE REQUIRED CONCRETE EMBEDS AND COORDINATE WITH CONTRACTOR REGARDING SHOP DRAWINGS FOR CONCRETE WORK. THE FRP WALKWAY SYSTEM IS INTENDED TO ACCOMMODATE A 250 LB/SF UNIFORM LOAD, 440 LB/FT CONCENTRATED LOAD. SIZING AND SPACING OF SUPPORT BEAMS AND OTHER EMBEDS SHALL BE ADJUSTED AS APPROPRIATE BY FRP SYSTEM SUPPLIER. SUPPLIERS SHALL BE McNICHOLS CO. OF TAMPA, FLORIDA OR CREATIVE PULTRUSIONS, INC. OF ALUM BANK, PENNSYLVANIA OR APPROVED EQUAL.

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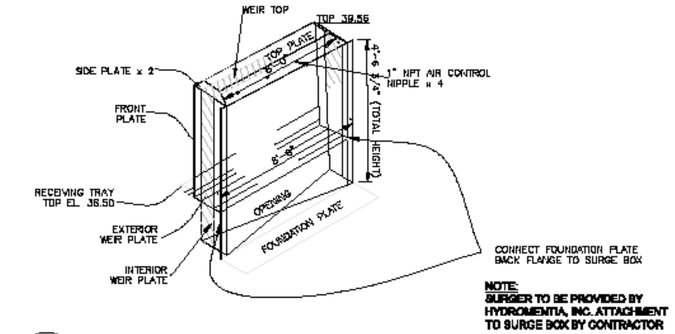

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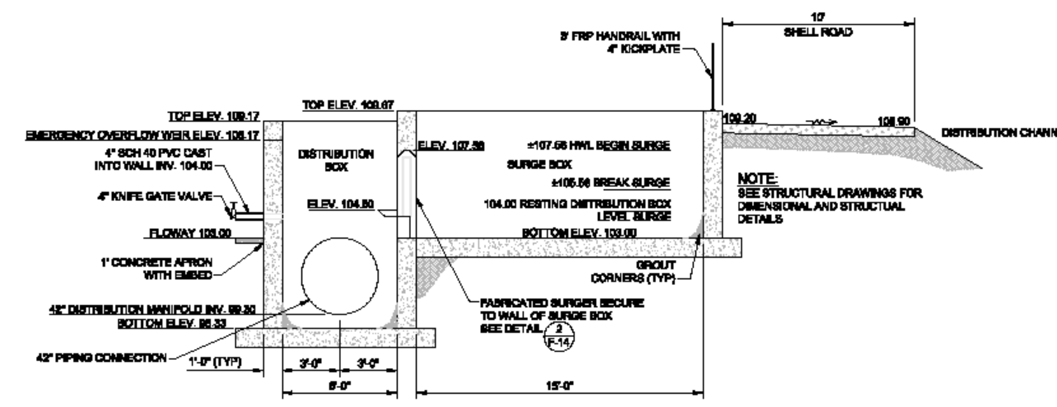

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NO.	REVISION	APPROVED	DATE	
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ATS™ Headworks Plan, Details and Sections 25 MGD Module (typ)

E. ALLEN STEWART III P.E. NO. 23577

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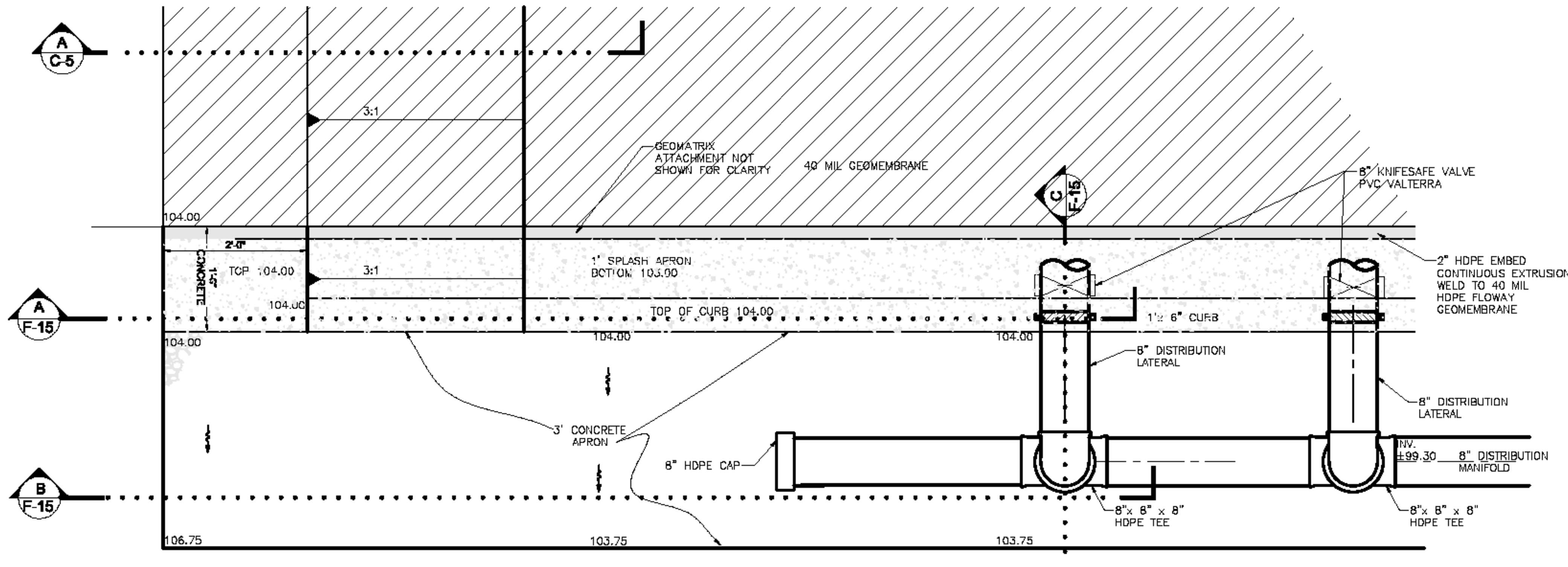
PROJECT:	SR-ATS
DATE:	JULY 2006
SHEET 2	



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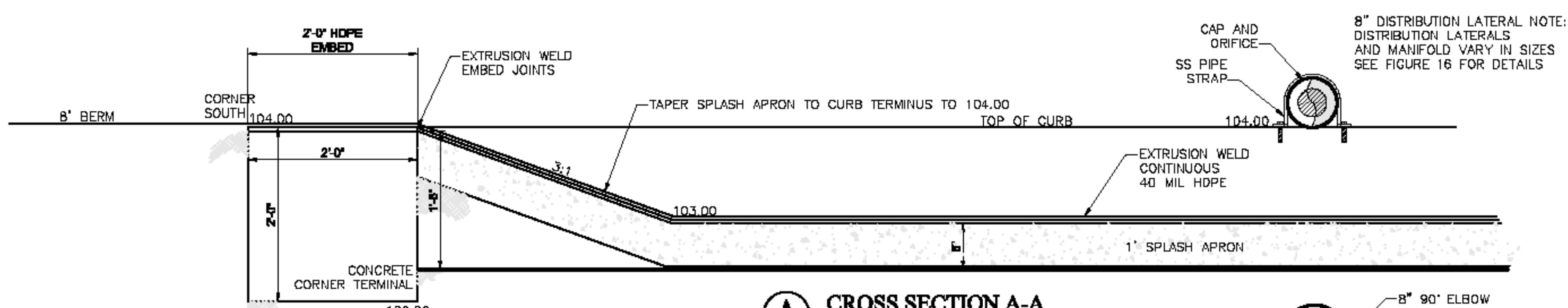

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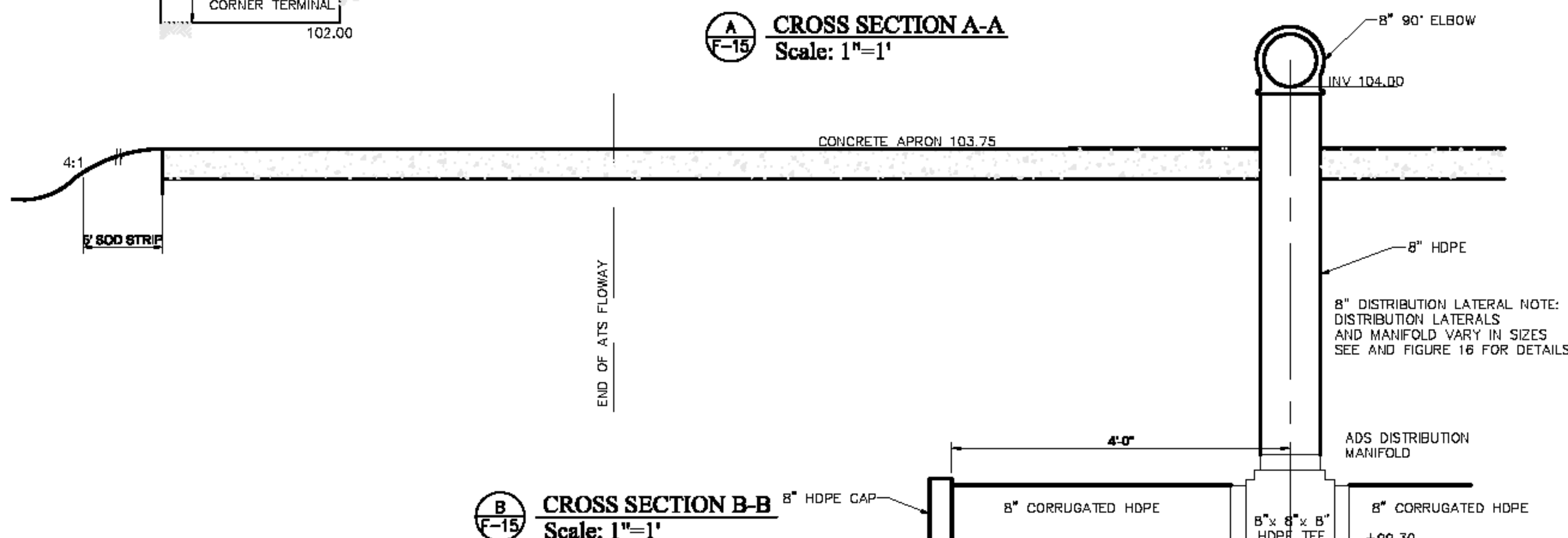

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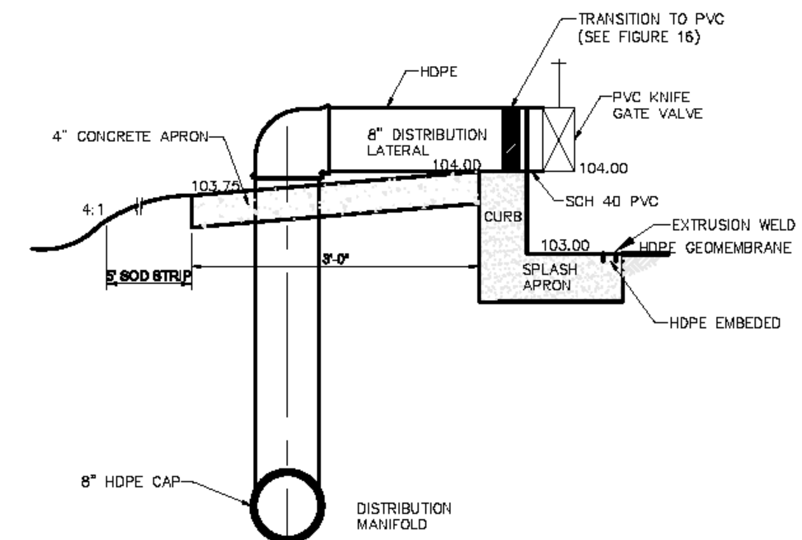

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				DWN.	SCP
				CHK.	-
				APPV.	-

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PROJECT:	SR-ATS
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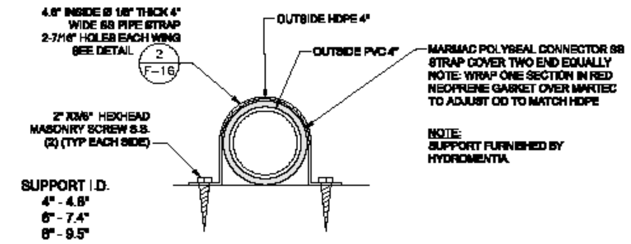
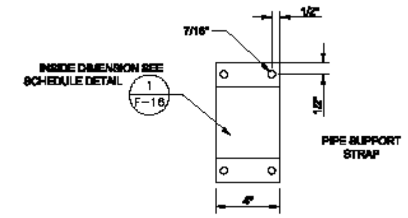
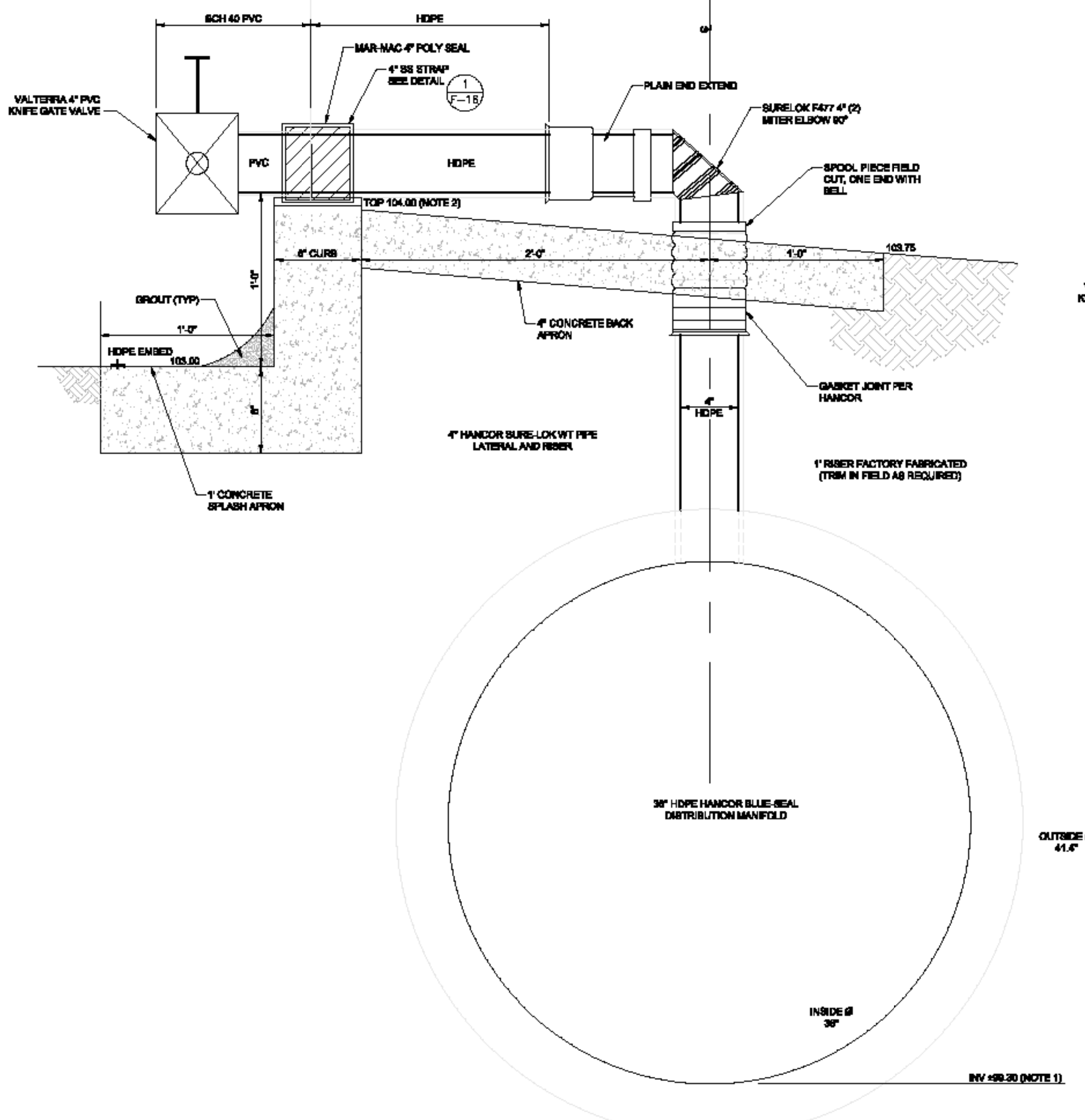
SHEET 3	



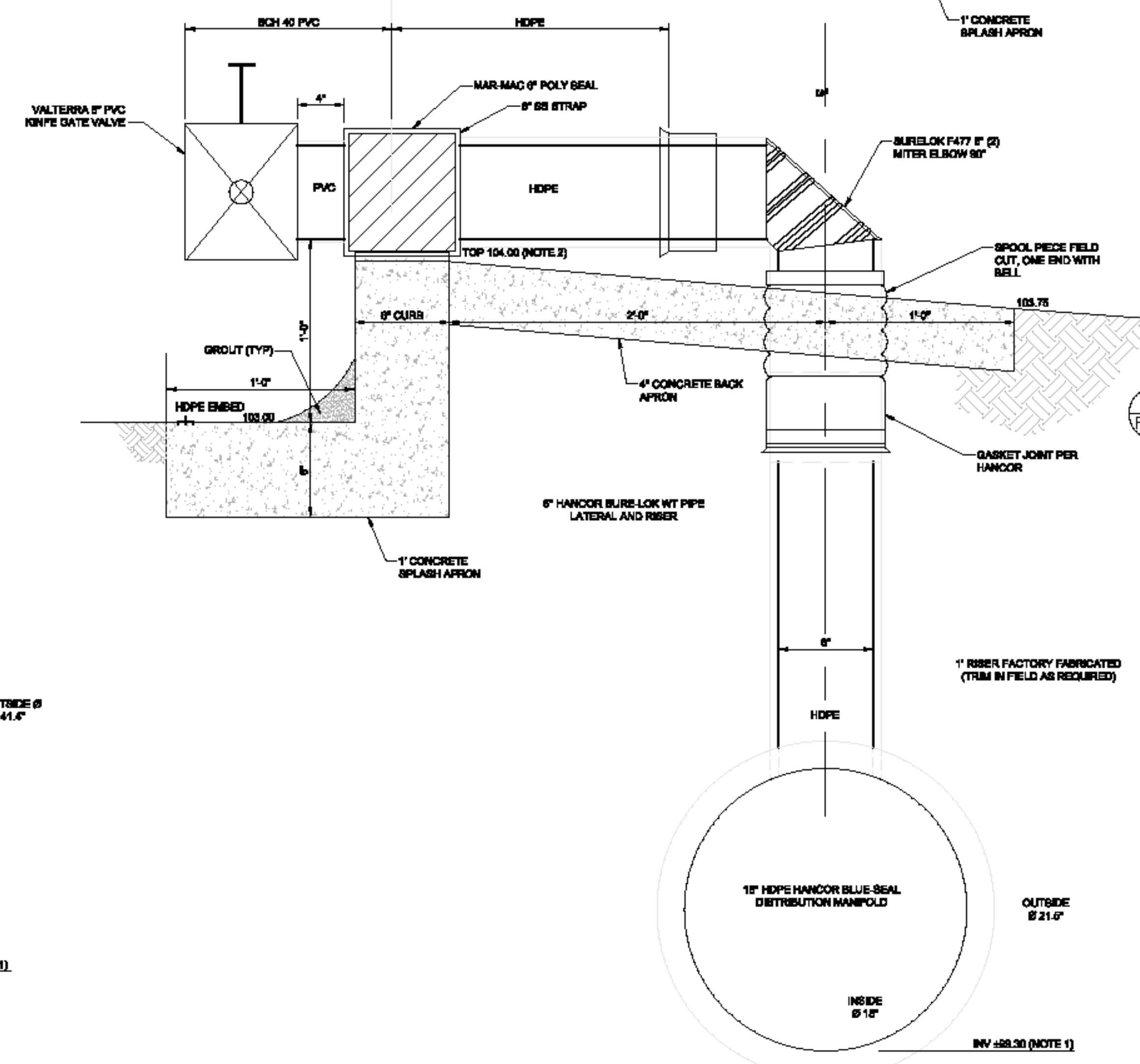
1 / F-15 **PIPE SUPPORT STRAP DETAIL**
Scale: NTS



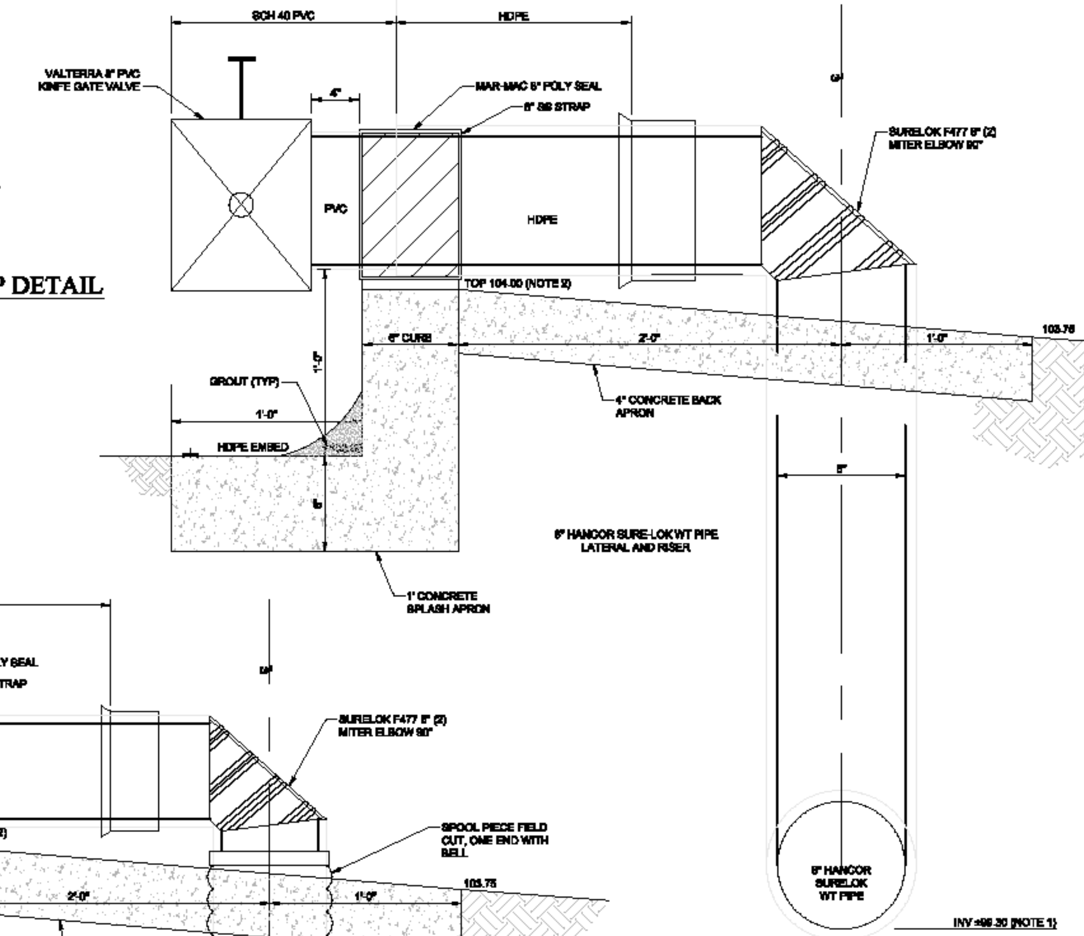
2 / F-15 **PIPE SUPPORT STRAP DETAIL**
Scale: NTS



A / F-14 **TYPICAL 4" DISTRIBUTION LATERAL**
Scale: 2"=1'



B / F-14 **TYPICAL 6" DISTRIBUTION LATERAL**
Scale: 2"=1'



C / F-14 **TYPICAL 8" DISTRIBUTION LATERAL**
Scale: 2"=1'

NOTES:
1. THE INVERT OF THE MANIFOLD FOR 6"-30" SECTIONS MAY BE SLIGHTLY HIGHER THAN ELE. 31.30 BECAUSE OF INVERT ADJUSTMENTS ASSOCIATED WITH THE REDUCERS.
2. IT IS CRITICAL TO SYSTEM PERFORMANCE THAT THE INVERT FOR EACH LATERAL BE LEVEL AT ELEV. 36.00 (±0.05 FT)
3. LATERALS FURNISHED BY HYDROMENITA TO INCLUDE RISERS, FITTING, MARMAC CONNECTIONS, KNIFE GATE VALVES, PVC AND HDPE PIPE, AND SUPPORTS. ASSEMBLY, INSTALLATION, SCREWS AND GASKET MATERIAL TO BE PROVIDED BY CONTRACTOR.

NO.	REVISION	APPROVED	DATE		
				DSG.	SCP
				DWN.	SCP
				CHK.	-
				APPV.	-

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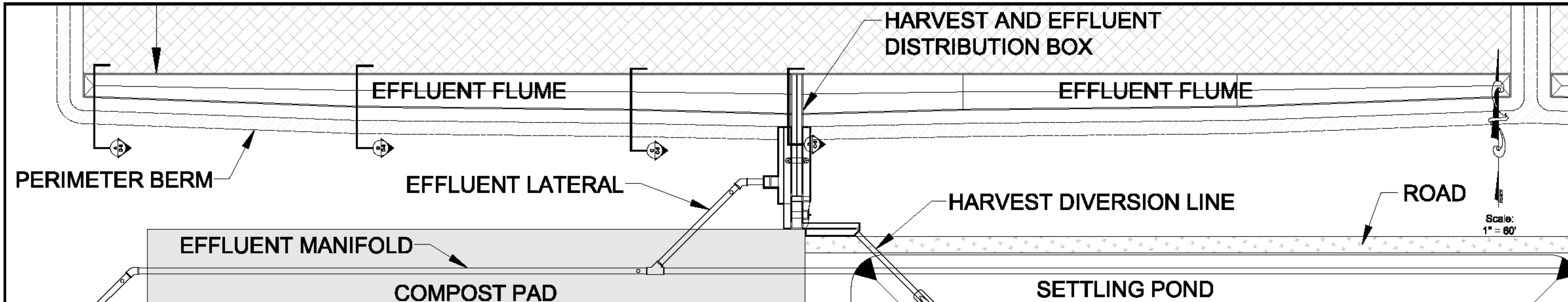
Preliminary Engineering Assessment Comprehensive Algal Turf Scrubber® ATS™ Based Nutrient Control Program for the Suwannee River in Florida

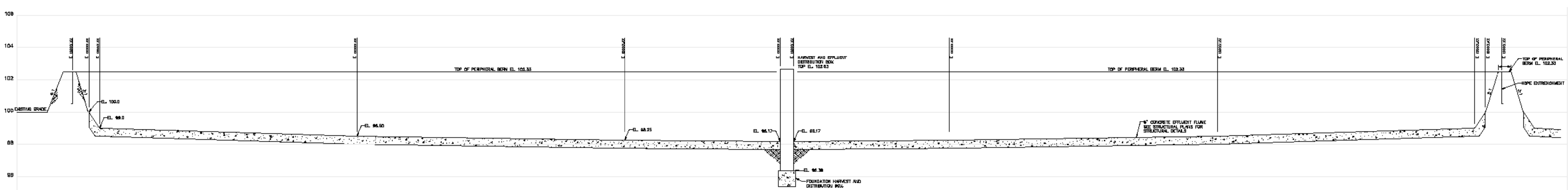
ATS™ Distribution Laterals 25 MGD Module (typ)

E. ALLEN STEWART III P.E. NO. 23577
DATE

SCALE:	AS SHOWN
PROJECT:	SR-ATS
DATE:	JULY 2006
SHEET 4	



Effluent Flume Plan
Scale:
1" = 60'



Effluent Flume Profile
Scale:
Horizontal 1" = 60'
Vertical 1" = 6'

LEGEND

- ATS Floway
- Asphalt Pad
- Crushed Shell Roadway
- 8' Maintenance Berm
- Concrete Effluent Flume

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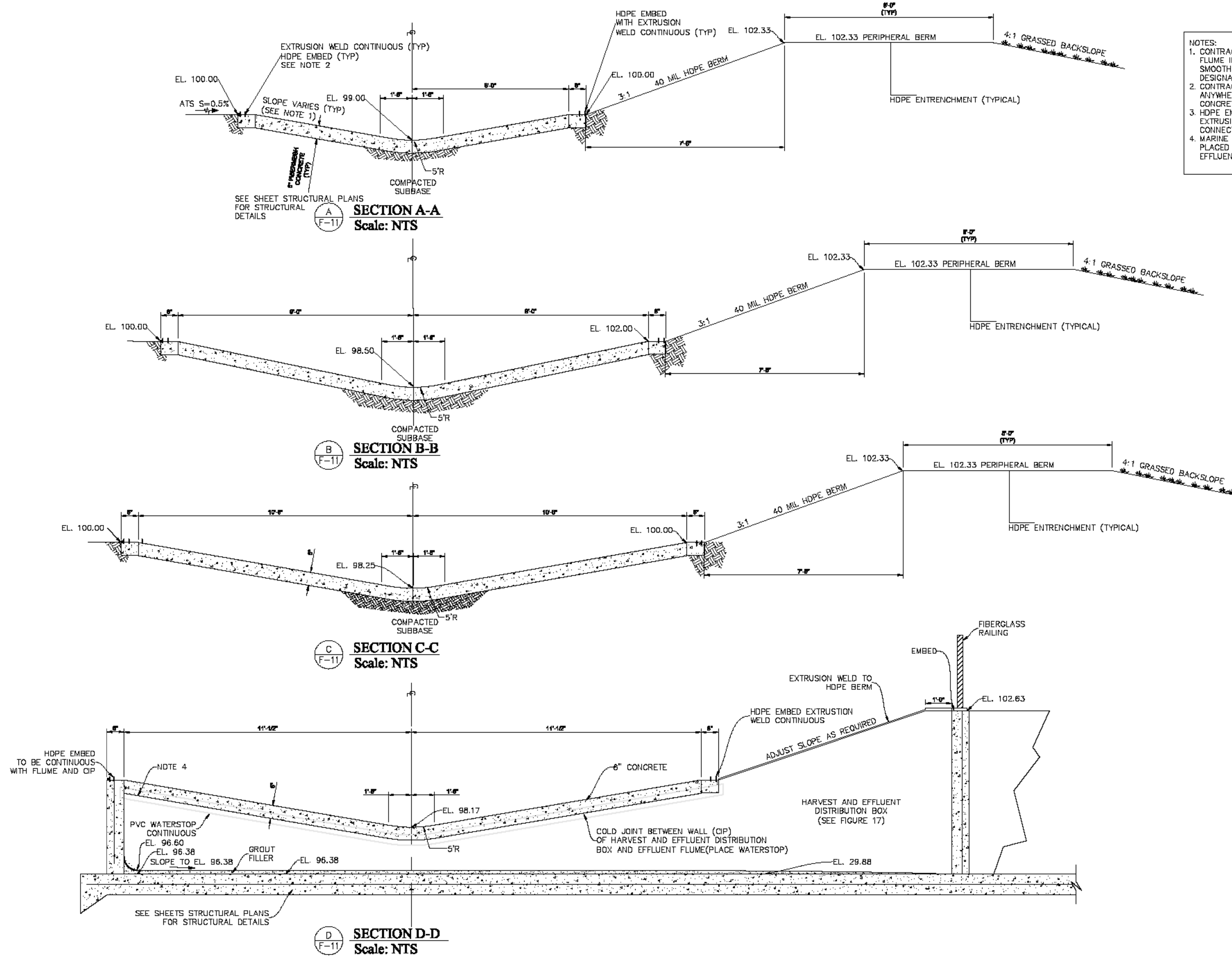
Preliminary Engineering Assessment Comprehensive Algal Turf Scrubber® ATS™ Based Nutrient Control Program for the Suwannee River in Florida

ATS™ Effluent Flume Plan and Profile 25 MGD Module (typ)

E. ALLEN STEWART III P.E. NO. 23577
DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
SHEET 5



NOTES:
1. CONTRACTOR MAY VARY SLOPE AND RADIUS OF FLUME INVERT AS APPROPRIATE TO PROVIDE A SMOOTH CONTINUOUS SLOPED SURFACE AT DESIGNATED INVERTS.
2. CONTRACTOR TO PLACE UNDERLYING RUB SHEET ANYWHERE 40 MIL HDPE INTERFACES WITH CONCRETE.
3. HDPE EMBED STRIPS TO BE CONNECTED VIA EXTRUSION WELDS AT ALL JUNCTIONS AND CONNECTED LENGTHS.
4. MARINE JOINT COMPOUND 5200 SHALL BE PLACED AT ALL JOINTS OR CRACKS WITHIN EFFLUENT FLUME.

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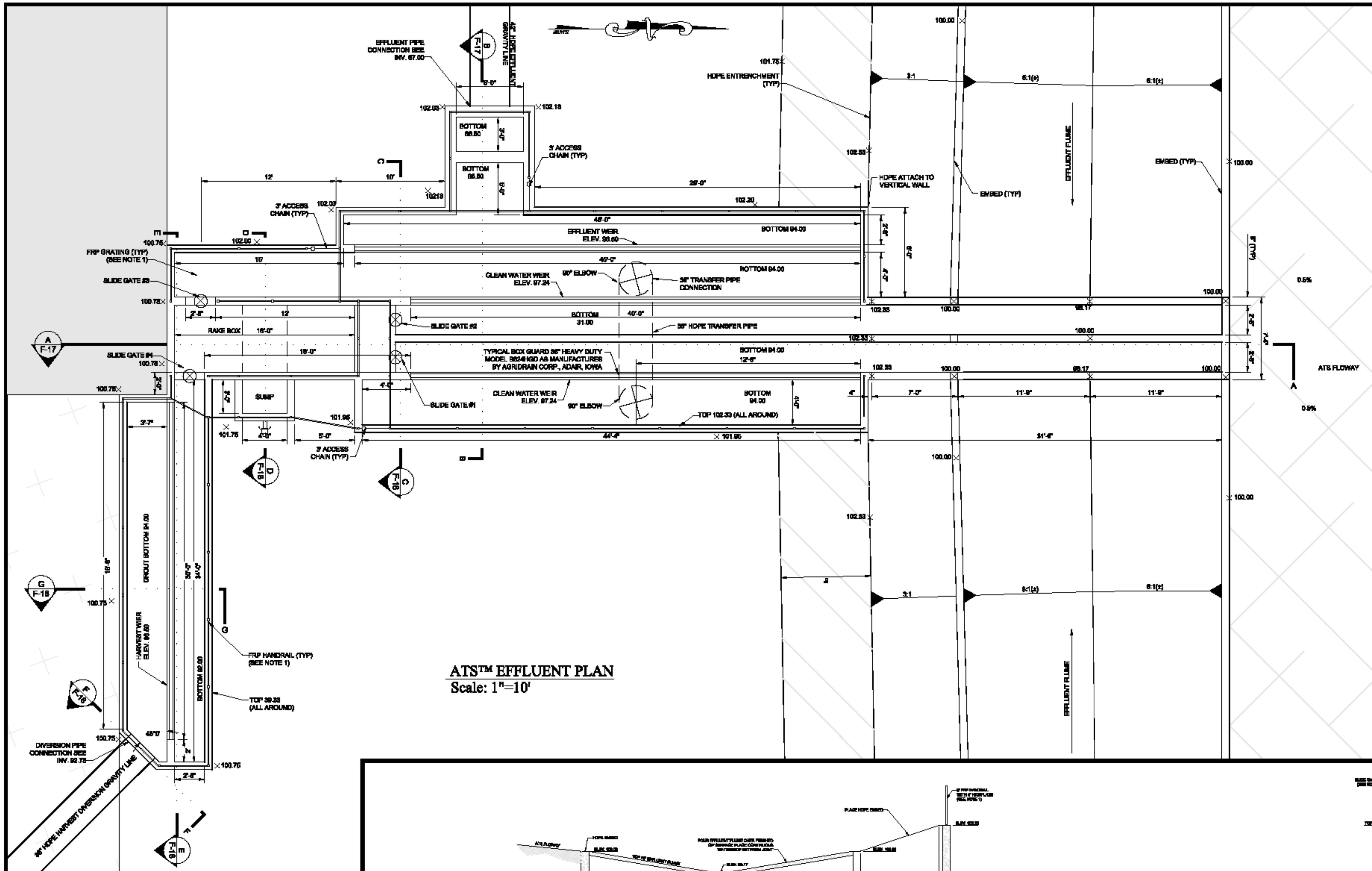
Preliminary Engineering Assessment Comprehensive Algal Turf Scrubber® ATS™ Based Nutrient Control Program for the Suwannee River in Florida

ATS™ Effluent Flume Sections
25 MGD Module (typ)

E. ALLEN STEWART III P.E. NO. 23677

DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
SHEET 6



ATS™ EFFLUENT PLAN
Scale: 1"=10'

LEGEND

- ATS Floway
- Asphalt Pad
- Crushed Shell Roadway
- 8' Maintenance Berm

NOTES:

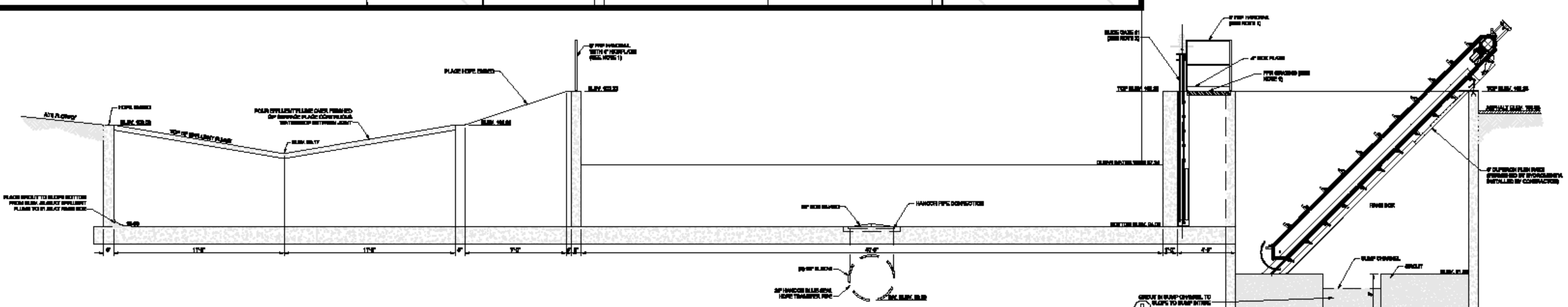
1. FRP GRATING, STAIRS, LADDERS, HANDRAIL SYSTEM ARE SHOWN FOR GENERAL LAYOUT AND DIMENSIONAL CLARIFICATION ONLY. ACTUAL SUPPORT AND CONFIGURING LAYOUT SHALL BE FINALIZED BY FRP SYSTEM SUPPLIER, WHO SHALL ALSO PROVIDE REQUIRED CONCRETE EMBEDS AND COORDINATE WITH CONTRACTOR REGARDING SHOP DRAWINGS FOR CONCRETE WORK. THE FRP WALKWAY SYSTEM IS INTENDED TO ACCOMMODATE A 250 LB/SF UNIFORM LOAD, 440 LB/FT CONCENTRATED LOAD. SIZING AND SPACING OF SUPPORT BEAMS AND OTHER EMBEDS SHALL BE ADJUSTED AS APPROPRIATE BY FRP SYSTEM SUPPLIER.

2. SLIDE GATE SCHEDULE (GATES FURNISHED BY HYDROMENTIA INSTALLED BY CONTRACTOR)

NUMBER	HEIGHT	WIDTH	GUIDE CONNECTION
1	2'-6"	2'-8"	EMBED
2	2'-6"	2'-8"	EMBED
3	4'-0"	2'-8"	SURFACE ATTACHMENT
4	2'-6"	2'-8"	EMBED

3. DIMENSIONING DETAILS SHOWN IN STRUCTURAL DRAWINGS TAKE PRECEDENCE RELATED TO STRUCTURE SIZING.

4. GROUT IN CORNERS OF BOXES TO PREVENT SOLIDS ACCUMULATION.



CROSS SECTION A-A
Scale: 1"=10'

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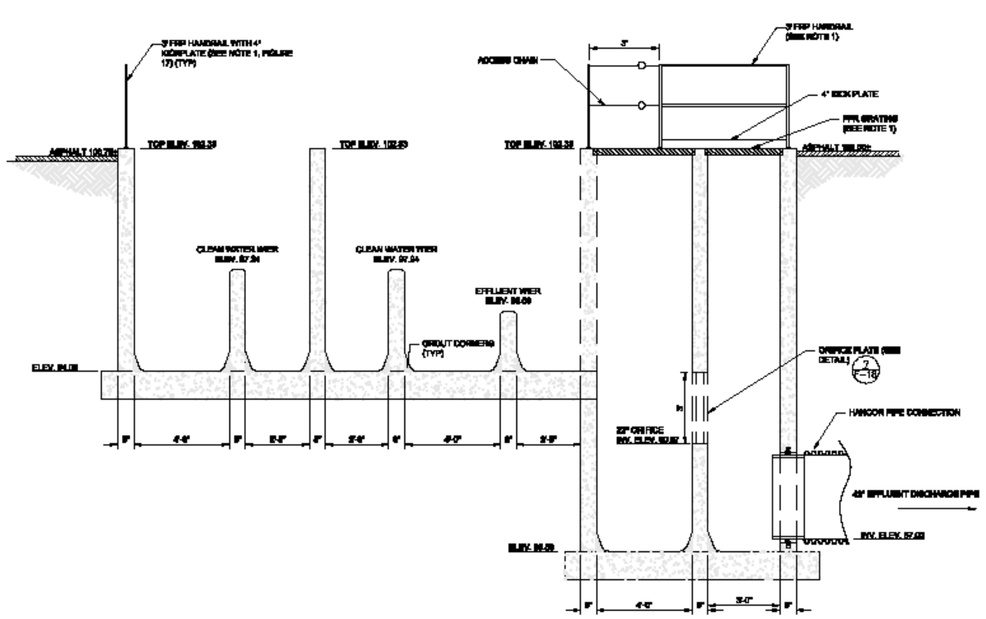
Preliminary Engineering Assessment Comprehensive Algal Turf Scrubber® ATS™ Based Nutrient Control Program for the Suwannee River in Florida

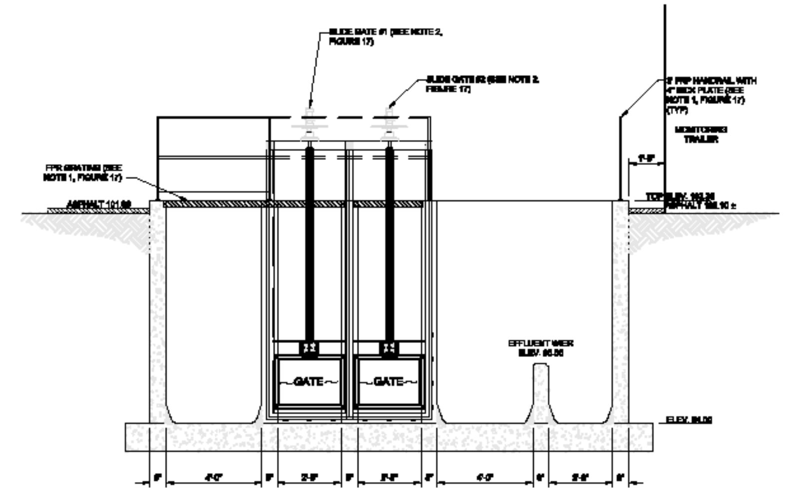
ATS™ Effluent Works Plan, Details and Sections

E. ALLEN STEWART III P.E. NO. 23077
DATE

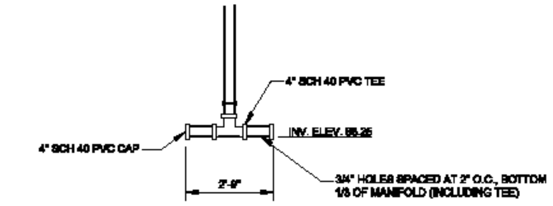
SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
SHEET 7



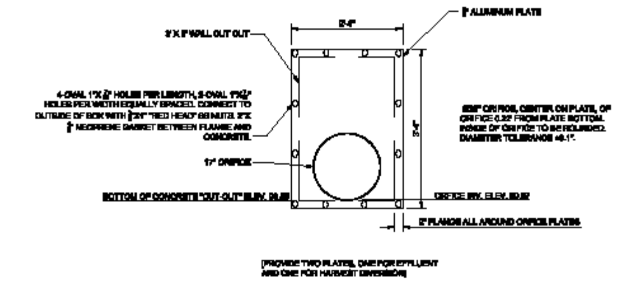
CROSS SECTION B-B
Scale: 1"=8'



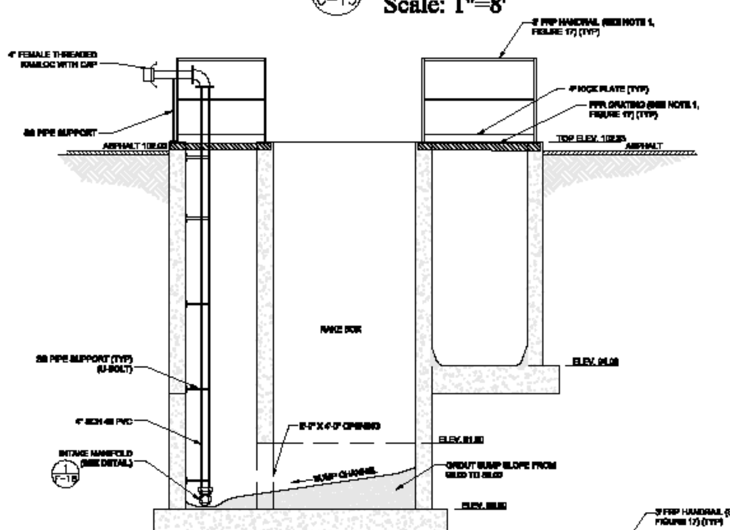
CROSS SECTION C-C
Scale: 1"=8'



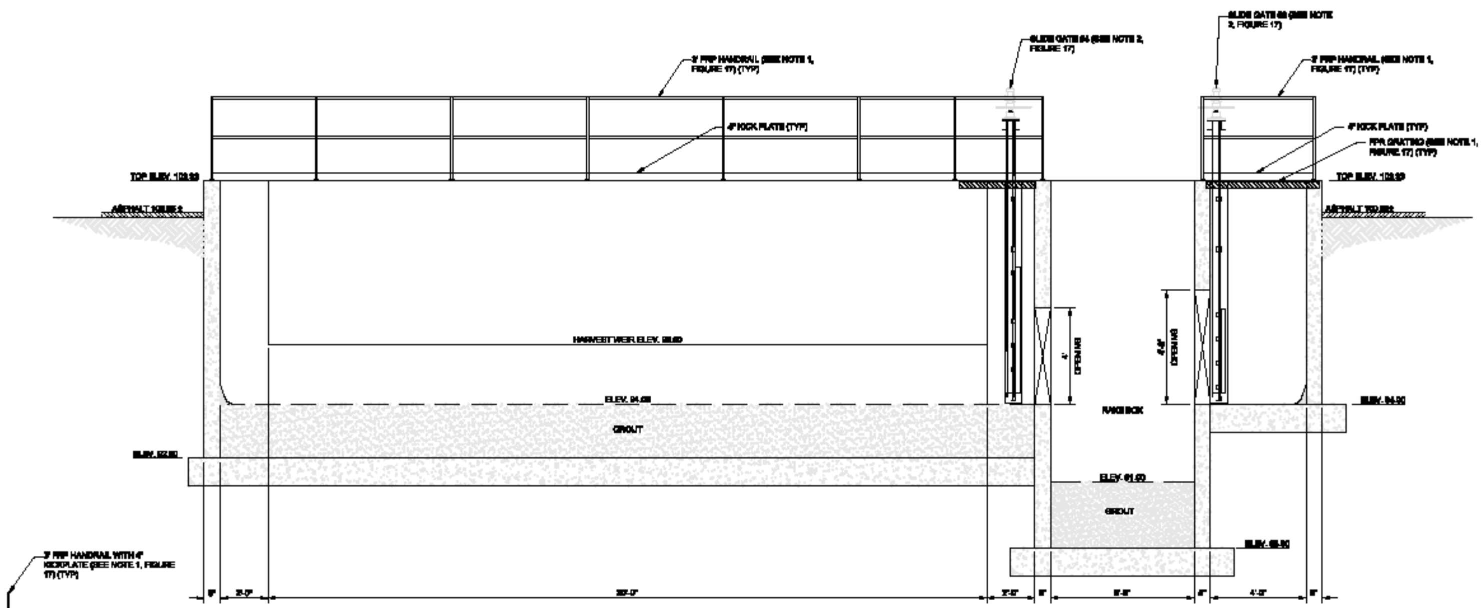
INTAKE MANIFOLD
Scale: 1"=6'



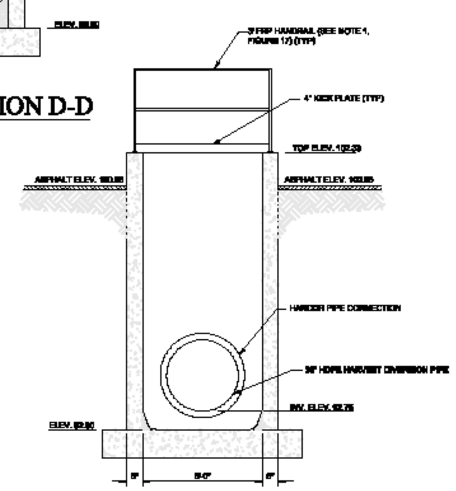
ORIFICE PLATE DETAIL
Scale: NTS



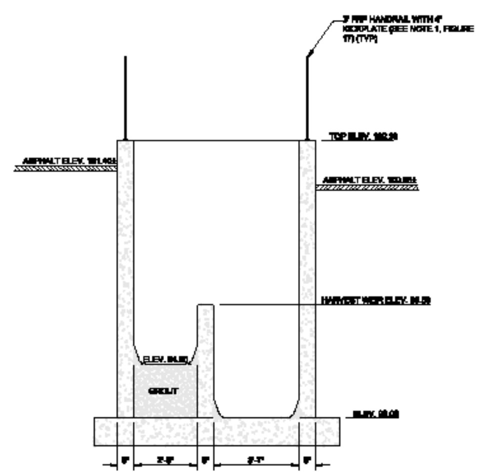
CROSS SECTION D-D
Scale: 1"=3'



CROSS SECTION E-E
Scale: 1"=8'



CROSS SECTION F-F
Scale: 1"=3'



CROSS SECTION G-G
Scale: 1"=3'

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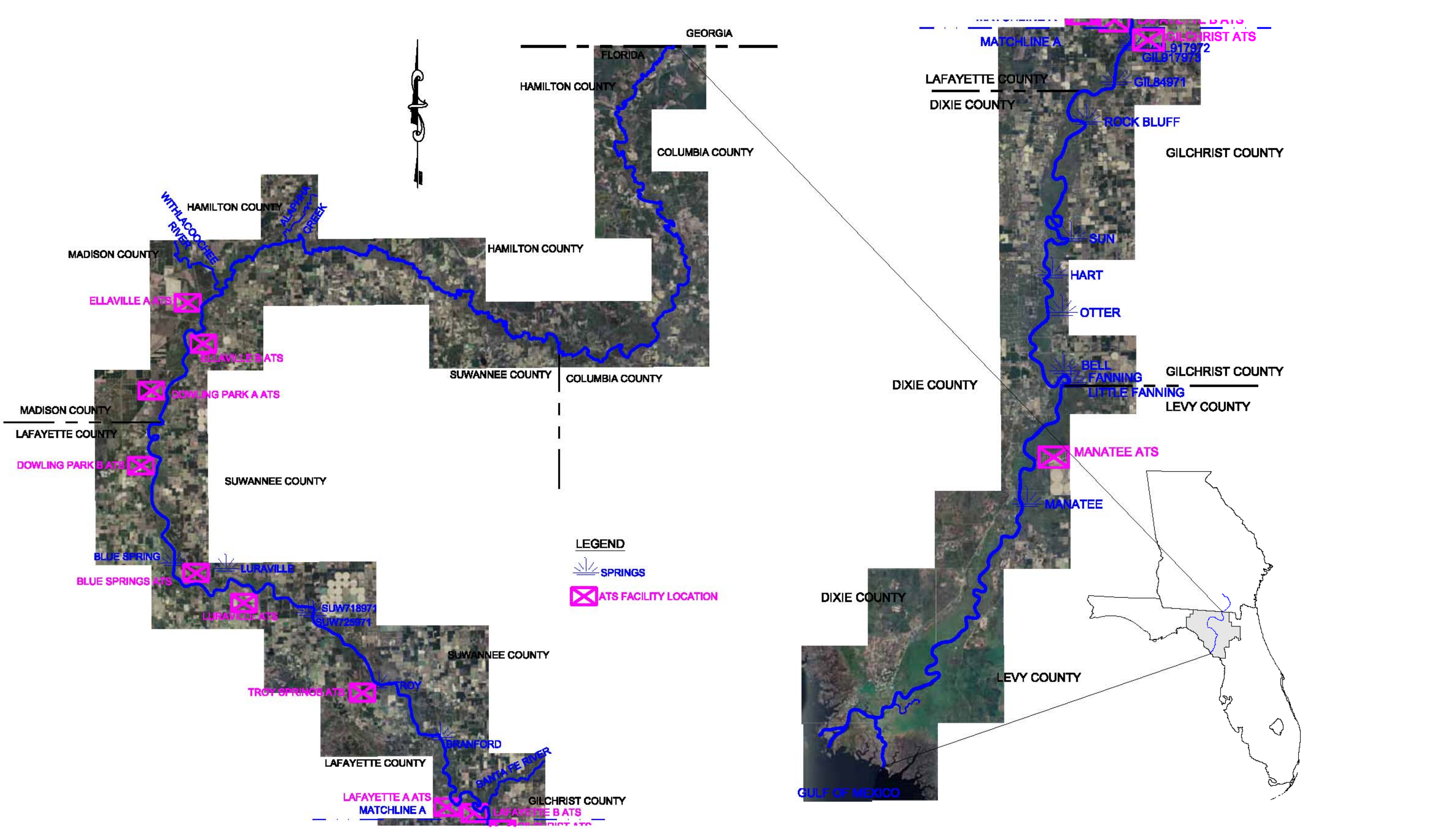
Preliminary Engineering Assessment Comprehensive Algal Turf Scrubber® ATS™ Based Nutrient Control Program for the Suwannee River in Florida

ATS™ Effluent Works Details and Sections

E. ALLEN STEWART III P.E. NO. 23577
DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
SHEET 8

APPENDIX B
REGIONAL TREATMENT
SITE LOCATION MAPS



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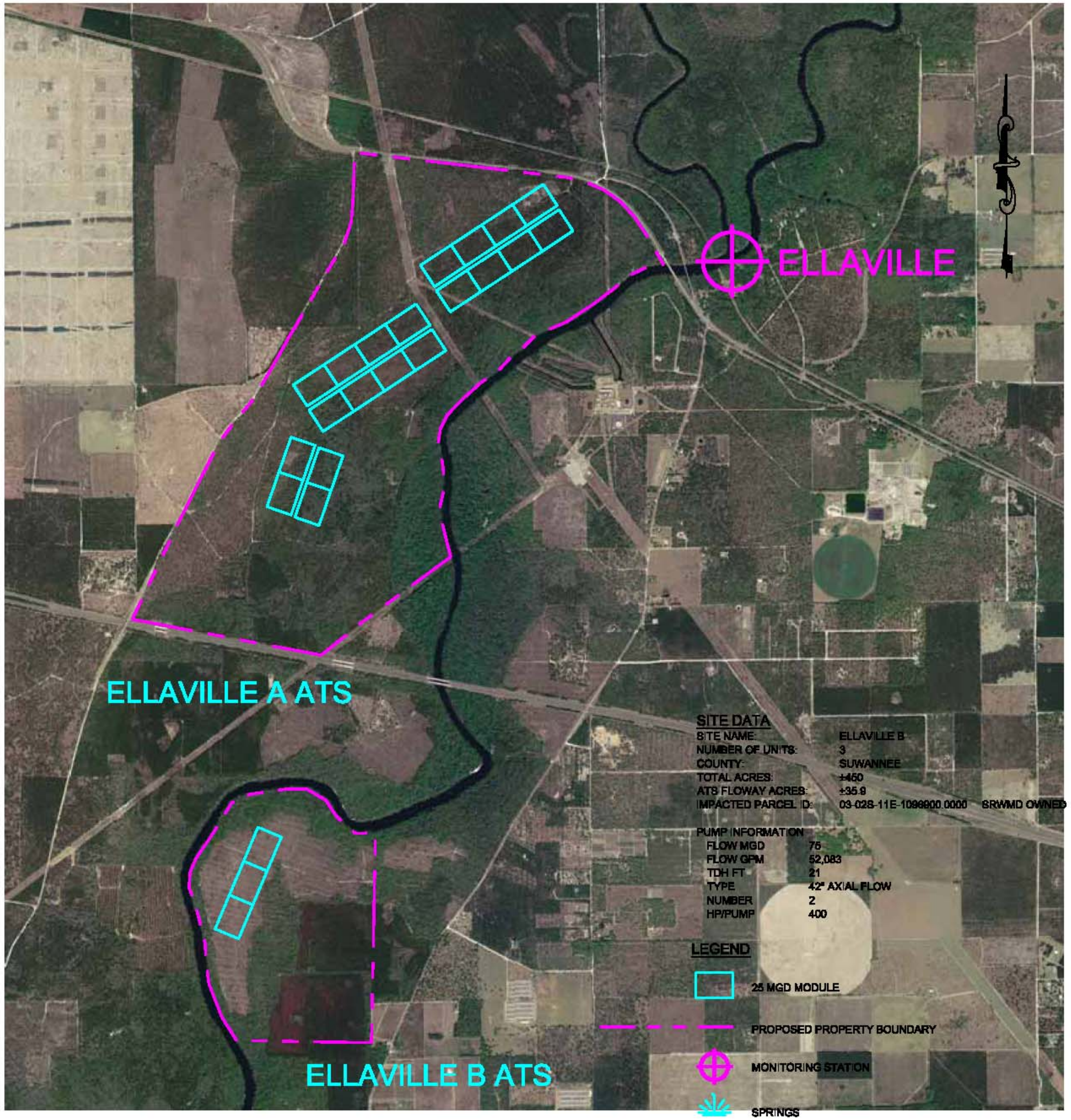
FLORIDA SECTION OF SUWANNEE RIVER

E. ALLEN STEWART III P.E. NO. 23577
DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006

FIGURE 18



SITE DATA

SITE NAME: ELLAVILLE A
NUMBER OF UNITS: 20
COUNTY: MADISON
TOTAL ACRES: ±1,425
ATS FLOWAY ACRES: ±239.1
IMPACTED PARCEL IDS:
23-1S-11-1553-000-000 SRWMD OWNED
26-1S-11-1561-000-000 SRWMD OWNED
24-1S-11-1559-000-000 SRWMD OWNED
27-1S-11-1562-001-000 SRWMD OWNED
34-1S-11-1586-000-000 SRWMD OWNED
22-1S-11-1552-001-000 SRWMD OWNED
22-1S-11-1551-000-000 SRWMD OWNED

PUMP INFORMATION
FLOW MGD 500
FLOW GPM 347,222
TDH FT 21
TYPE 120" AXIAL FLOW
NUMBER 2
HP/PUMP 2,500

Ellaville A Unit 25 MGD Module Cool Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.7	0.9	194	25	11.97	1.25	0.95	0.158	0.100
Number of Modules	20	20	20	20	20				
Site Total	93.4	18.3	3,882	500	239				
Daily Removals lb/day	1,245	244							

Ellaville A Unit 25 MGD Module Warm season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	14.1	2.7	593	25	11.97	1.25	0.62	0.158	0.037
Number of Modules	20	20	20	20	20				
Site Total	281.3	54.1	11,857	500	239				
Daily Removals lb/day	2,617	504							

Ellaville B Unit 25 MGD Module Cool season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.8	0.9	199	25	11.97	1.19	0.88	0.148	0.089
Number of Modules	3	3	3	3	3				
Site Total	14.3	2.8	598	75	36				
Daily Removals lb/day	191	37							

Ellaville B Unit 25 MGD Module Warm season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	13.2	2.5	563	25	11.97	1.12	0.53	0.135	0.025
Number of Modules	3	3	3	3	3				
Site Total	39.7	7.4	1,689	75	36				
Daily Removals lb/day	369	69							

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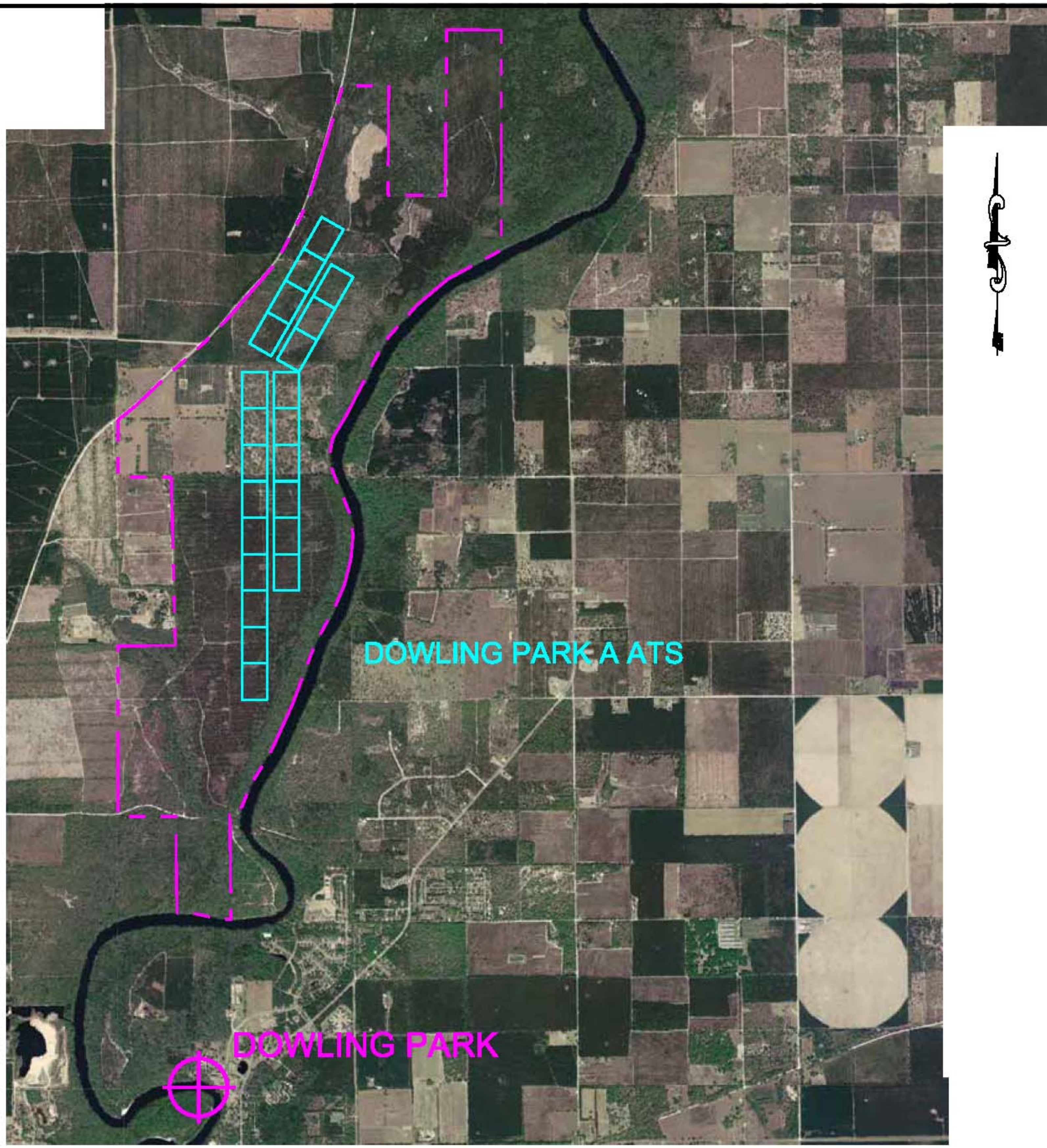
ELLAVILLE SITES

E. ALLEN STEWART III P.E. NO. 23677

DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006

FIGURE 30



SITE DATA

SITE NAME:	DOWLING PARK A	
NUMBER OF UNITS:	22	
COUNTY:	MADISON	
TOTAL ACRES:	±1,715	
ATS FLOWAY ACRES:	±263.0	
IMPACTED PARCEL IDS:	16-2S-11-1606-000-000	SRWMD OWNED
	21-2S-11-1616-000-000	SRWMD OWNED
	20-2S-11-1611-001-000	SRWMD OWNED
	20-2S-11-1614-000-000	PRIVATELY OWNED
	29-2S-11-1617-000-000	SRWMD OWNED
	32-2S-11-1630-000-000	SRWMD OWNED
	17-2S-11-1607-001-000	SRWMD OWNED

PUMP INFORMATION

FLOW MGD	550
FLOW GPM	381,944
TDH FT	21
TYPE	120" AXIAL FLOW
NUMBER	2
HP/PUMP	3,000

Dowling Park A Unit 25 MGD Module Cool Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.7	0.9	199	25	11.97	1.14	0.84	0.149	0.089
Number of Modules	22	22	22	22	22				
Site Total	104.1	20.4	4,373	550	263				
Daily Removals lb/day	1,389	272							

Dowling Park A Unit 25 MGD Module Warm Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	12.6	2.5	558	25	11.97	1.06	0.50	0.135	0.023
Number of Modules	22	22	22	22	22				
Site Total	276.5	55.1	12,282	550	263				
Daily Removals lb/day	2,572	513							

LEGEND

- 25 MGD MODULE
- PROPOSED PROPERTY BOUNDARY
- MONITORING STATION
- SPRINGS

NO.	REVISION	APPROVED	DATE

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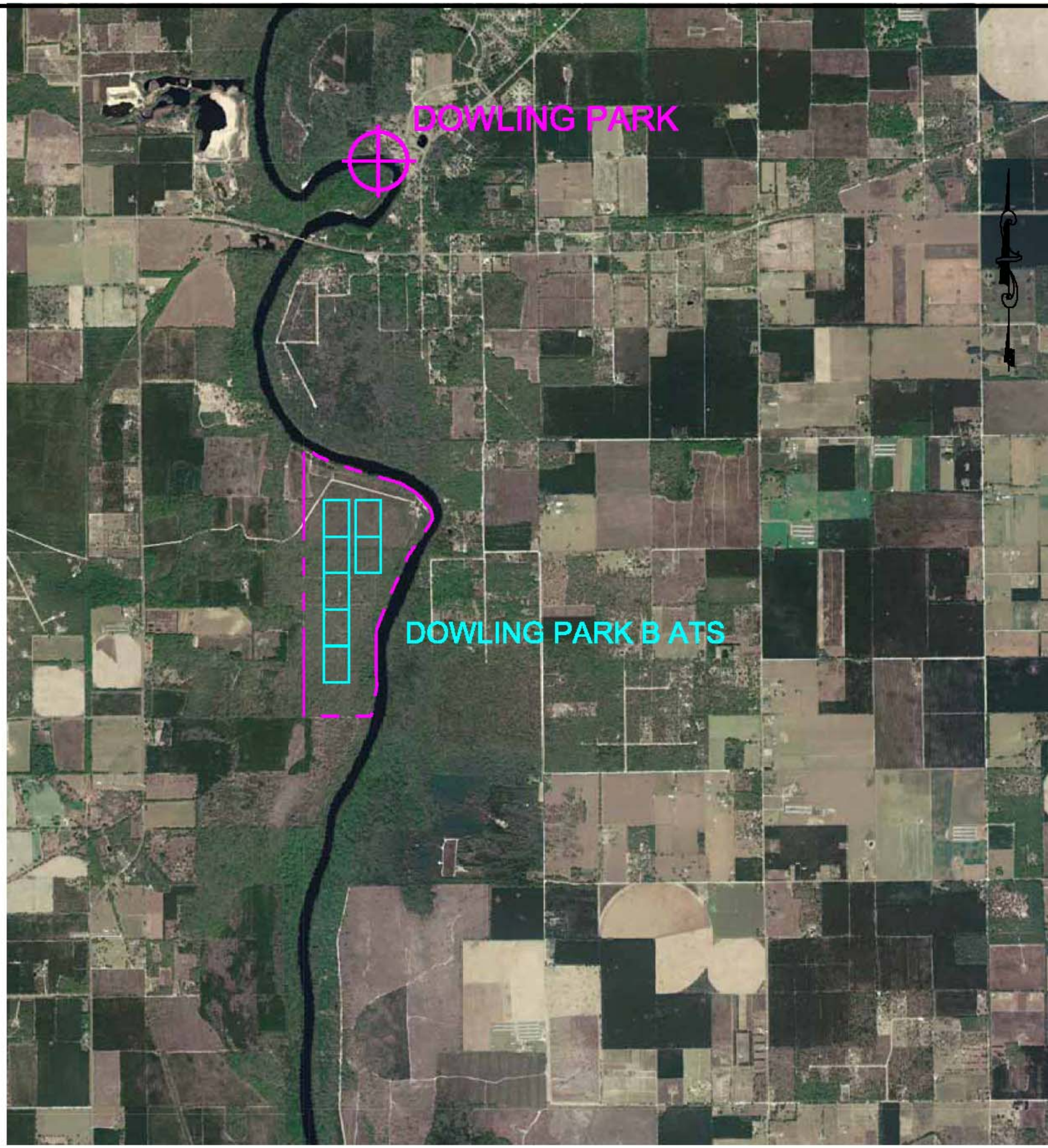
DOWLING PARK A SITE

E. ALLEN STEWART III P.E. NO. 23677
DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
FIGURE 31



SITE DATA

SITE NAME:	DOWLING PARK B	
NUMBER OF UNITS:	7	
COUNTY:	LAFAYETTE	
TOTAL ACRES:	±274	
ATS FLOWAY ACRES:	±63.7	
IMPACTED PARCEL IDS:	17-03-11-0000-0000-00101	TRUST
	17-03-11-0000-0000-00100	LAFAYETTE COUNTY OWNED
	17-03-11-0000-0000-00200	PRIVATELY OWNED
	17-03-11-0000-0000-00300	PRIVATELY OWNED
	17-03-11-0000-0000-00400	PRIVATELY OWNED
	17-03-11-0000-0000-00401	PRIVATELY OWNED
	20-03-11-0000-0000-00100	PRIVATELY OWNED

PUMP INFORMATION

FLOW MGD	175
FLOW GPM	121,528
TDH FT	23
TYPE	80" AXIAL FLOW
NUMBER	2
HP/PUMP	1,000

Dowling Park B Unit 25 MGD Module Cool Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.5	0.9	187	25	11.97	1.12	0.84	0.139	0.084
Number of Modules	7	7	7	7	7				
Site Total	31.2	6.1	1,312	175	84				
Daily Removals lb/day	416	81							

Dowling Park B Unit 25 MGD Module Warm Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	10.0	2.2	492	25	11.97	0.94	0.50	0.113	0.015
Number of Modules	7	7	7	7	7				
Site Total	69.8	15.3	3,444	175	84				
Daily Removals lb/day	649	142							

LEGEND

25 MGD MODULE

PROPOSED PROPERTY BOUNDARY

MONITORING STATION

SPRINGS

NO.	REVISION	APPROVED	DATE

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DWN. SCP
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APPV. -

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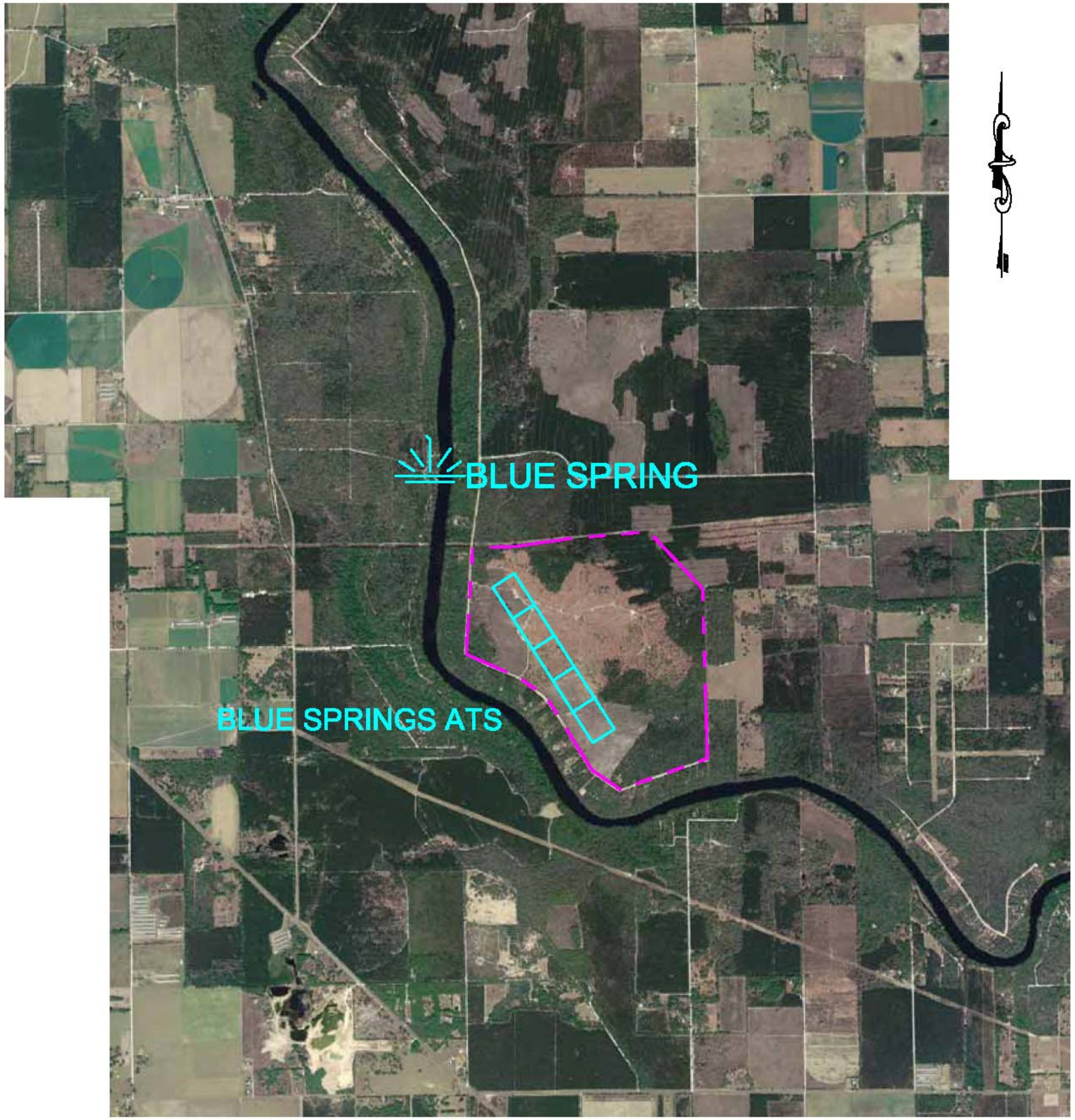
DOWLING PARK B SITE

E. ALLEN STEWART III P.E. NO. 23677

DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006

FIGURE 32



SITE DATA

SITE NAME:	BLUE SPRINGS	
NUMBER OF UNITS:	5	
COUNTY:	SUWANNEE	
TOTAL ACRES:	±560	
ATS FLOWAY ACRES:	±59.8	
IMPACTED PARCEL IDS:	21-04S-11E-1199900.0000	PRIVATELY OWNED
	22-04S-11E-1200000.0000	PRIVATELY OWNED
	26-04S-11E-1207600.0000	COMPANY OWNED
	27-04S-11E-1207400.0000	PRIVATELY OWNED

PUMP INFORMATION

FLOW MGD	125
FLOW GPM	86,806
TDH FT	22
TYPE	54" AXIAL FLOW
NUMBER	2
HP/PUMP	700

Blue Spring Unit 25 MGD Module Cool Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.9	0.9	204	25	11.97	1.17	0.85	0.131	0.071
Number of Modules	5	5	5	5	5				
Site Total	24.3	4.7	1,020	125	60				
Daily Removals lb/day	325	62							

Blue Spring Unit 25 MGD Module Warm Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	10.4	2.0	446	25	11.97	0.98	0.52	0.104	0.016
Number of Modules	5	5	5	5	5				
Site Total	52.2	9.8	2,229	125	60				
Daily Removals lb/day	486	92							

LEGEND

- 25 MGD MODULE
- PROPOSED PROPERTY BOUNDARY
- MONITORING STATION
- SPRINGS

NO.	REVISION	APPROVED	DATE

DSG. SCP
DWN. SCP
CHK. -
APPV. -

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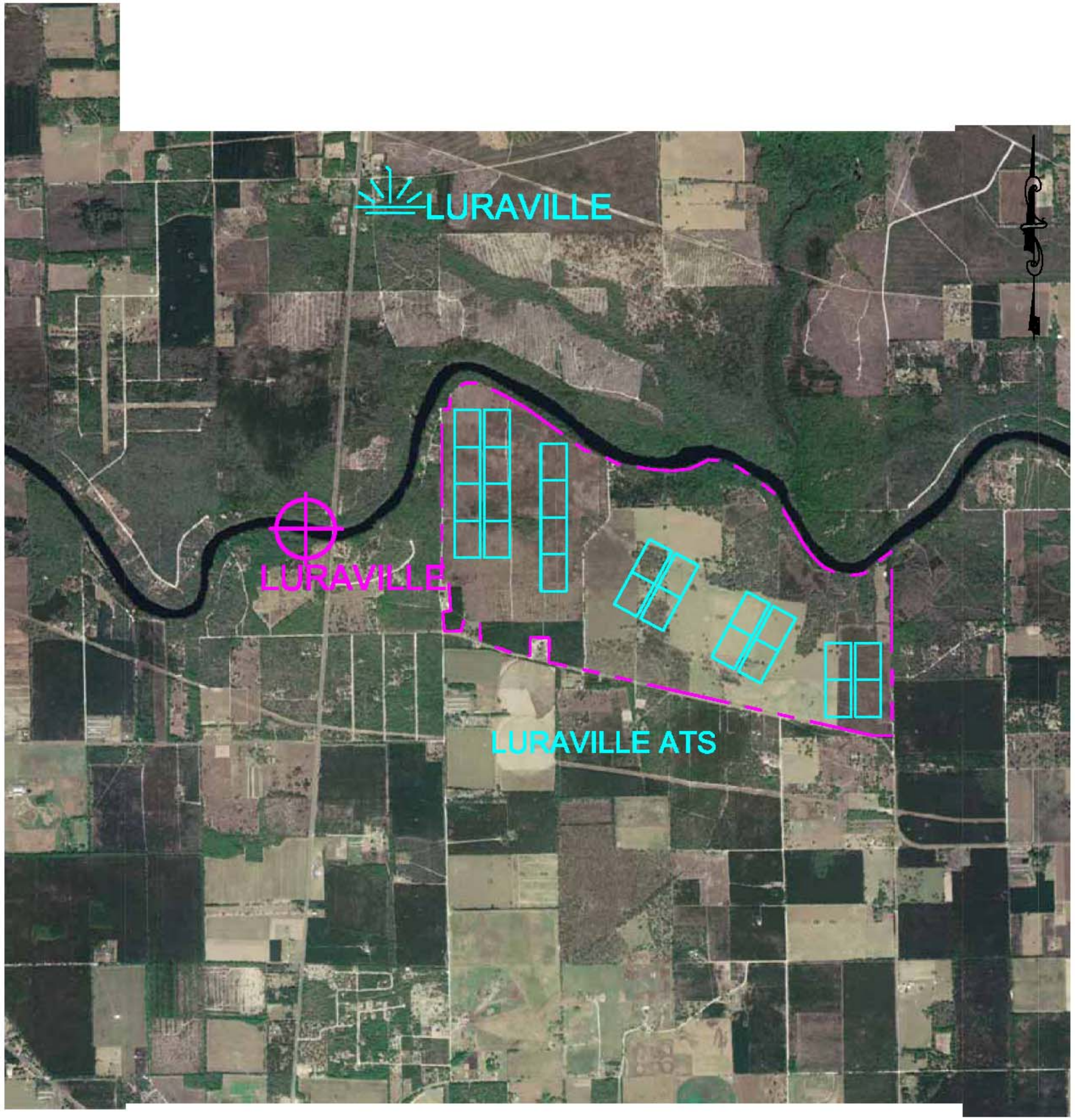
BLUE SPRINGS SITE

E. ALLEN STEWART III P.E. NO. 23677
DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
FIGURE 33



SITE DATA

SITE NAME: LURAVILLE
NUMBER OF UNITS: 24
COUNTY: LAFAYETTE
TOTAL ACRES: ±1,145
ATS FLOWAY ACRES: ±266.9

IMPACTED PARCEL IDS:

32-04-12-0000-0000-00200	COMPANY OWNED
31-04-12-0000-0000-00100	COMPANY OWNED
30-04-12-0000-0000-00600	PRIVATELY OWNED
30-04-12-0000-0000-00500	PRIVATELY OWNED
30-04-12-0000-0000-00400	PRIVATELY OWNED
30-04-12-0000-0000-00300	PRIVATELY OWNED
31-04-12-0000-0000-00402	PRIVATELY OWNED
31-04-12-0000-0000-00403	PRIVATELY OWNED
31-04-12-0000-0000-00300	PRIVATELY OWNED
31-04-12-0000-0000-00301	PRIVATELY OWNED

PUMP INFORMATION

FLOW MGD	600
FLOW GPM	416,667
TDH FT	22
TYPE	120" AXIAL FLOW
NUMBER	2
HP/PUMP	3,400

Luraville Unit 25 MGD Module Cool Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.6	0.9	189	25	11.97	1.28	0.99	0.131	0.076
Number of Modules	24	24	24	24	24				
Site Total	109.5	20.8	4,529	600	287				

Daily Removals lb/day	1,459	277

Luraville Unit 25 MGD Module Warm Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	11.1	2.1	468	25	11.97	1.10	0.61	0.102	0.010
Number of Modules	24	24	24	24	24				
Site Total	266.8	49.6	11,238	600	287				

Daily Removals lb/day	2,482	461

LEGEND

25 MGD MODULE
PROPOSED PROPERTY BOUNDARY
MONITORING STATION
SPRINGS

NO.	REVISION	APPROVED	DATE

DSG. SCP
DWN. SCP
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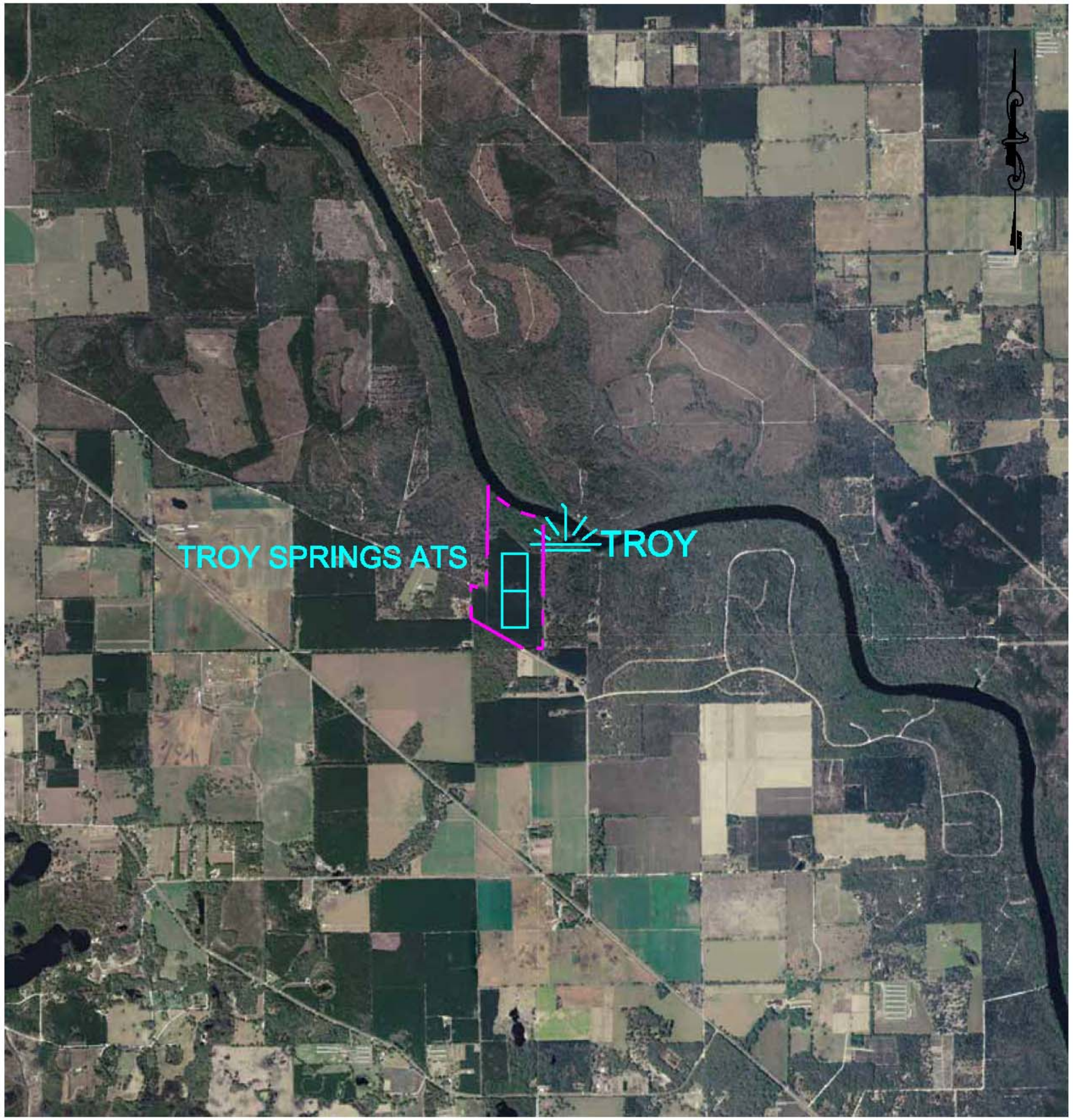
LURAVILLE SITE

E. ALLEN STEWART III P.E. NO. 23677
DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
FIGURE 34



SITE DATA

SITE NAME: TROY SPRINGS
NUMBER OF UNITS: 2
COUNTY: LAFAYETTE
TOTAL ACRES: ±104
ATS FLOWAY ACRES: ±23.9
IMPACTED PARCEL ID: 34-05-13-0000-0000-00400 PRIVATELY OWNED

PUMP INFORMATION
FLOW MGD 50
FLOW GPM 34,722
TDH FT 22
TYPE 36" AXIAL FLOW
NUMBER 2
HP/PUMP 300

Troy Springs Unit 25 MGD Module Cool Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.4	0.8	180	25	11.97	1.47	1.18	0.118	0.066
Number of Modules	2	2	2	2	2				
Site Total	8.9	1.6	361	50	24				
Daily Removals lb/day	118	22							

Troy Springs Unit 25 MGD Module Warm Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	9.4	1.6	385	25	11.97	1.25	0.83	0.083	0.010
Number of Modules	2	2	2	2	2				
Site Total	18.8	3.3	770	50	24				
Daily Removals lb/day	175	30							

LEGEND

- 25 MGD MODULE
- PROPOSED PROPERTY BOUNDARY
- MONITORING STATION
- SPRINGS

NO.	REVISION	APPROVED	DATE

DSG. SCP
DWN. SCP
CHK. -
APPV. -

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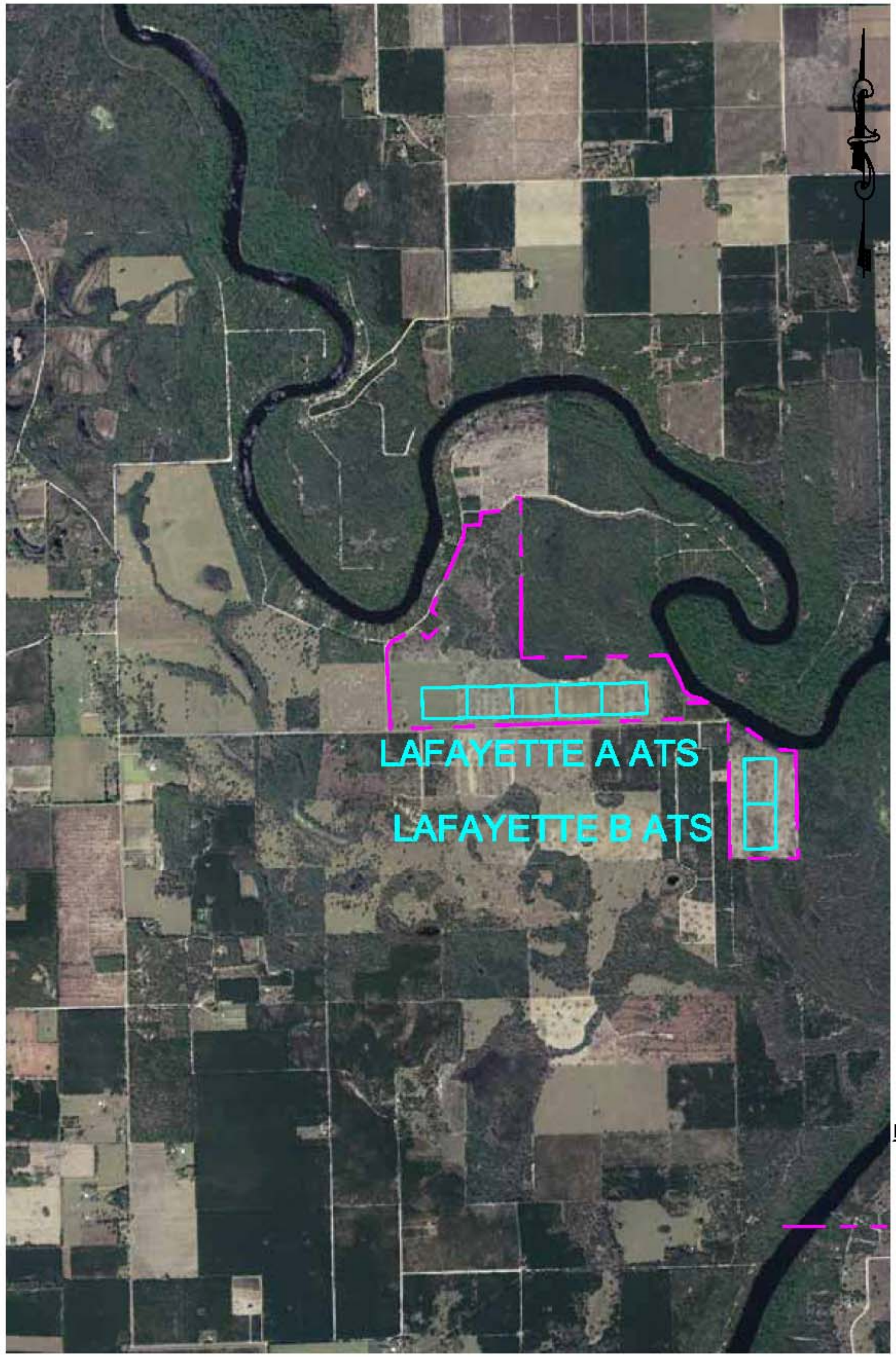
Preliminary Engineering Assessment Comprehensive Algal Turf Scrubber® ATS™ Based Nutrient Control Program for the Suwannee River in Florida

TROY SPRINGS SITE

E. ALLEN STEWART III P.E. NO. 23677
DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
FIGURE 35



SITE DATA

SITE NAME:	LAFAYETTE A	
NUMBER OF UNITS:	5	
COUNTY:	LAFAYETTE	
TOTAL ACRES:	±286	
ATS FLOWAY ACRES:	±59.8	
IMPACTED PARCEL IDS:	10-07-14-0000-0000-00102	PRIVATELY OWNED
	10-07-14-0000-0000-00103	PRIVATELY OWNED
	11-07-14-0000-0000-00200	PRIVATELY OWNED

PUMP INFORMATION

FLOW MGD	125
FLOW GPM	86,806
TDH FT	22
TYPE	54" AXIAL FLOW
NUMBER	2
HP/PUMP	700

Lafayette A 25 MGD Unit Cool Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.4	0.8	180	25	11.97	1.32	1.04	0.118	0.066
Number of Modules	5	5	5	5	5				
Site Total	21.8	4.1	900	125	60				
Daily Removals lb/day	291	54							

Lafayette A 25 MGD Unit Warm Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	9.9	1.7	412	25	11.97	1.13	0.69	0.087	0.010
Number of Modules	5	5	5	5	5				
Site Total	49.7	8.7	2,060	125	60				
Daily Removals lb/day	462	81							

SITE DATA

SITE NAME:	LAFAYETTE B	
NUMBER OF UNITS:	2	
COUNTY:	LAFAYETTE	
TOTAL ACRES:	±70	
ATS FLOWAY ACRES:	±23.9	
IMPACTED PARCEL ID:	14-07-14-0000-0000-00300	PRIVATELY OWNED

PUMP INFORMATION

FLOW MGD	50
FLOW GPM	34,722
TDH FT	22
TYPE	36" AXIAL FLOW
NUMBER	2
HP/PUMP	300

Lafayette B 25 MGD Unit Cool Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.3	0.8	176	25	11.97	1.30	1.03	0.116	0.065
Number of Modules	2	2	2	2	2				
Site Total	8.6	1.6	353	50	24				
Daily Removals lb/day	114	21							

Lafayette B 25 MGD Unit Warm season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	9.5	1.7	396	25	11.97	1.11	0.69	0.085	0.010
Number of Modules	2	2	2	2	2				
Site Total	19.1	3.4	792	50	24				
Daily Removals lb/day	177	31							

LEGEND

- 25 MGD MODULE
- PROPOSED PROPERTY BOUNDARY
- MONITORING STATION
- SPRINGS

NO.	REVISION	APPROVED	DATE

DSG. SCP
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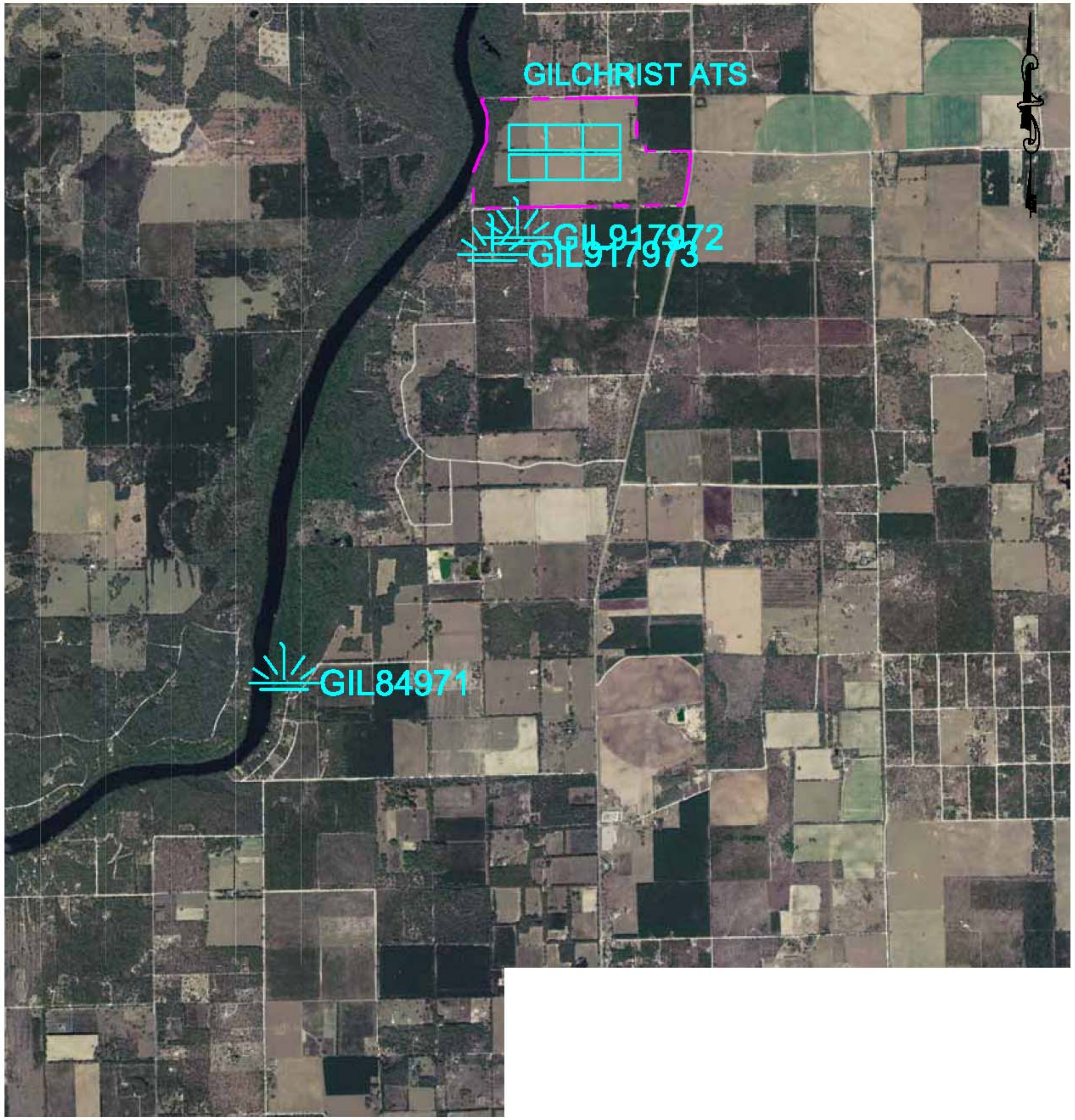
LAFAYETTE SITES

E. ALLEN STEWART III P.E. NO. 28677

DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
FIGURE 36



SITE DATA

SITE NAME: GILCHRIST
NUMBER OF UNITS: 6
COUNTY: GILCHRIST
TOTAL ACRES: ±264
ATS FLOWAY ACRES: ±71.7
IMPACTED PARCEL IDS: 24-07-14-0000-0001-0000 COMPANY OWNED
24-07-14-0000-0003-0000 COMPANY OWNED

PUMP INFORMATION
FLOW MGD 150
FLOW GPM 104,167
TDH FT 23
TYPE 54" AXIAL FLOW
NUMBER 2
HP/PUMP 800

Gilchrist 25 MGD Module Cool Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.3	0.3	176	25	11.97	1.28	1.00	0.116	0.065
Number of Modules	6	6	6	6	6				
Site Total	25.5	2.0	1,056	150	72				
Daily Removals lb/day	340	26							

Gilchrist 25 MGD Module Warm Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	9.5	1.0	394	25	11.97	1.09	0.66	0.084	0.010
Number of Modules	6	6	6	6	6				
Site Total	56.8	5.9	2,366	150	72				
Daily Removals lb/day	528	55							

LEGEND

25 MGD MODULE
PROPOSED PROPERTY BOUNDARY
MONITORING STATION
SPRINGS

NO.	REVISION	APPROVED	DATE

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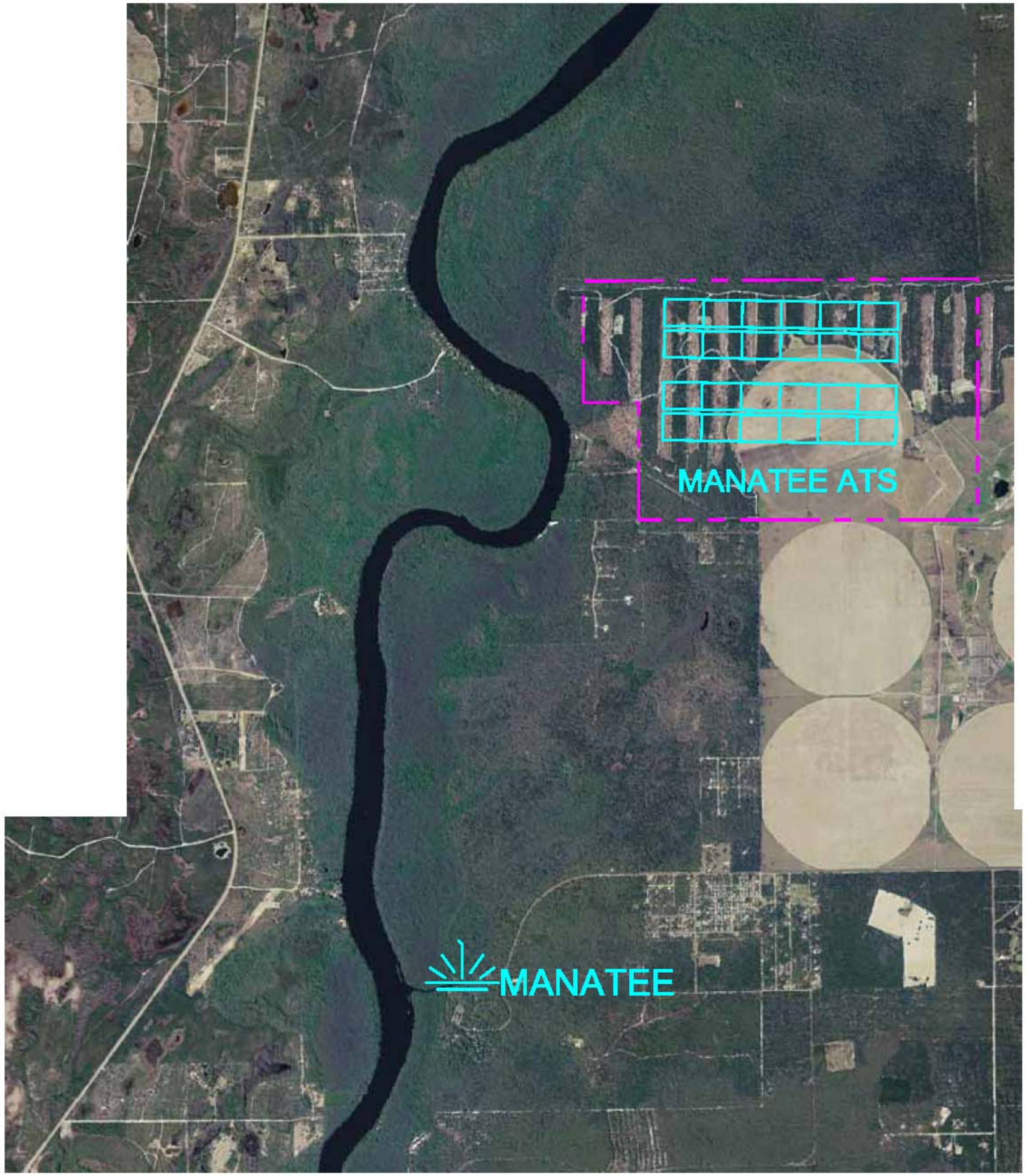
GILCHRIST SITE

E. ALLEN STEWART III P.E. NO. 23677
DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006

FIGURE 37



SITE DATA

SITE NAME:	MANATEE	
NUMBER OF UNITS:	24	
COUNTY:	LEVY	
TOTAL ACRES:	±1040	
ATS FLOWAY ACRES:	±288.9	
IMPACTED PARCEL IDS:	18-11-14-00643-000-00	COMPANY OWNED
	13-11-13-00081-000-00	COMPANY OWNED

PUMP INFORMATION

FLOW MGD	600
FLOW GPM	416,667
TDH FT	22
TYPE	120" AXIAL FLOW
NUMBER	2
HP/PUMP	3,400

Manatee 25 MGD Module Cool Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	4.1	0.8	175	25	11.97	1.00	0.74	0.115	0.064
Number of Modules	24	24	24	24	24				
Site Total	99.1	19.0	4,204	600	287				
Daily Removals lb/day	1,321	254							

Manatee 25 MGD Module Warm Season

	Nitrogen Removed ton/period	Phosphorus Removed ton/period	Compost Produced ton/period	FLOW MGD	Process Area acres	TN Influent mg/l	TN Effluent mg/l	TP Influent mg/l	TP Effluent mg/l
Per Module	9.8	1.8	416	25	11.97	0.84	0.40	0.088	0.010
Number of Modules	24	24	24	24	24				
Site Total	234.3	42.0	9,991	600	287				
Daily Removals lb/day	2,179	391							

LEGEND

- 25 MGD MODULE
- PROPOSED PROPERTY BOUNDARY
- MONITORING STATION
- SPRINGS

NO.	REVISION	APPROVED	DATE

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MANATEE SITE

E. ALLEN STEWART III P.E. NO. 23677
DATE

SCALE: AS SHOWN
PROJECT: SR-ATS
DATE: JULY 2006
FIGURE 38