Project Report For

Attorney General Agreements Initiative

Draft Final Report

Solid Separation/Constructed Wetland System for Swine Wastewater Treatment

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General Description

The constructed wetland system was installed at a 3,520 head swine finishing facility in Onslow County, North Carolina. The design loading rate of 25 kg/ha/day was based on a 5-year prototype study with loading rates ranging from 3 to 25 kg/ha/day and nitrogen removal rates from 98 to 87% respectively (Rice et al.). The existing anaerobic lagoon was cleaned out and resealed to serve as a storage pond for the wetland effluent. Wastewater from the swine houses flows to lift stations at each barn and is then pumped to a mechanical solids separator (Figure 1). Separator effluent flows through two parallel constructed wetlands with a combined surface area of 8 acres and then to a 2-acre storage pond. Excess liquid from the storage pond and separated solids are applied to cropland used to grow corn, wheat, and soybeans as well as pine trees.

The evaluated constructed wetland system was a low-tech, low-energy alternative to a conventional anaerobic lagoon system. This low-tech system produced effluent with lower nutrient concentrations and less land was required for terminal land application than the lagoon system. Constructed wetland systems can employ higher levels of technology and costs to obtain increased nitrogen and phosphorus removals, which would require even less land for the constructed wetland and terminal land application. For example, prototype studies document that up to 5.4 times the nitrogen removal for the low-tech constructed wetland system can be obtained if the influent is nitrified to facilitate greater nitrogen removal by denitrification (Rice et al.). Increased phosphorus removal can also be obtained by chemical precipitation, as an additional treatment process.

Technology Description

The initial system consisted of five major components: (1) solids separation by mechanical solids separator (2) solids separation by gravity settling basin (3) wetlands (4) storage pond and (5) cropland/trees for terminal management (Figure 2). Initially, wastewater from a pull plug system is emptied from each house and flows to lift stations for pumping to the mechanical solids separator. The mechanical separator produces solids directly. The liquid filtrate then flows to a settling basin that has a 30-minute retention time for additional solids separation. Solids settle by gravity and are periodically pumped back to the mechanical separator for removal. Solids are only removed from the treatment system from the mechanical separator. All separated solids are land applied but can potentially be used in alternative processes for conversion to value-added products for off-farm use. Plans by a second party for using the separated solids at a vermicomposting facility were not realized. The liquid portion of the waste stream flows to two constructed wetland cells, which are shallow, lined channels planted with wetland vegetation. Microbial colonies in the roots of the vegetation facilitate nitrification-denitrification, thus achieving nitrogen reduction with less odor and ammonia emissions. It takes the wastewater approximately twelve days to flow through the wetlands, after which it flows to a storage pond. This storage pond is the original anaerobic lagoon, but had all material removed and then it was renovated to meet current

Natural Resources Conservation Service (NRCS) Standards. Storage pond effluent is either land applied or used for recharging the manure collection pits. Recycling this treated water for pit recharge, has the potential to improve the in-house environment.

ISCO automated water samplers and integral flow meters were installed to collect samples and flow data for system evaluation. Due to high water levels, caused by excessive rainfall during the evaluation period, the flow meters could not be operated. When the Maximizer separator was installed, the design flow rate was reduced to meet the specifications of this unit. This reduced flow rate resulted in the lift station pumps cycling off and on frequently, which is not compatible with the magnetic flow meter that was used. The magnetic flow meter takes several seconds to reach steady state flow; therefore with the frequent fluctuation in flows, the readings were judged to be unreliable. In order to estimate the flow through the system, wetland system water level data from two surveys taken 485 days apart were used to calculate the volume of liquid in the system and adjusted with rainfall, evaporation and irrigation data over the same time period.

Figure 1. Flow Diagram of Wetland System

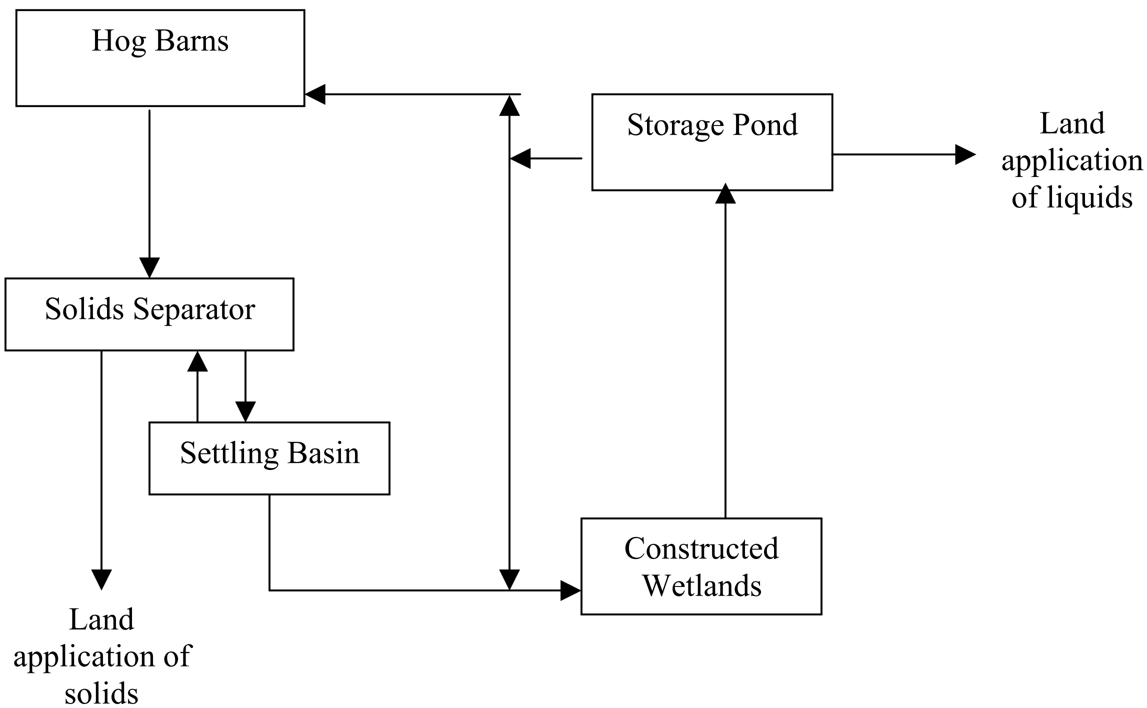
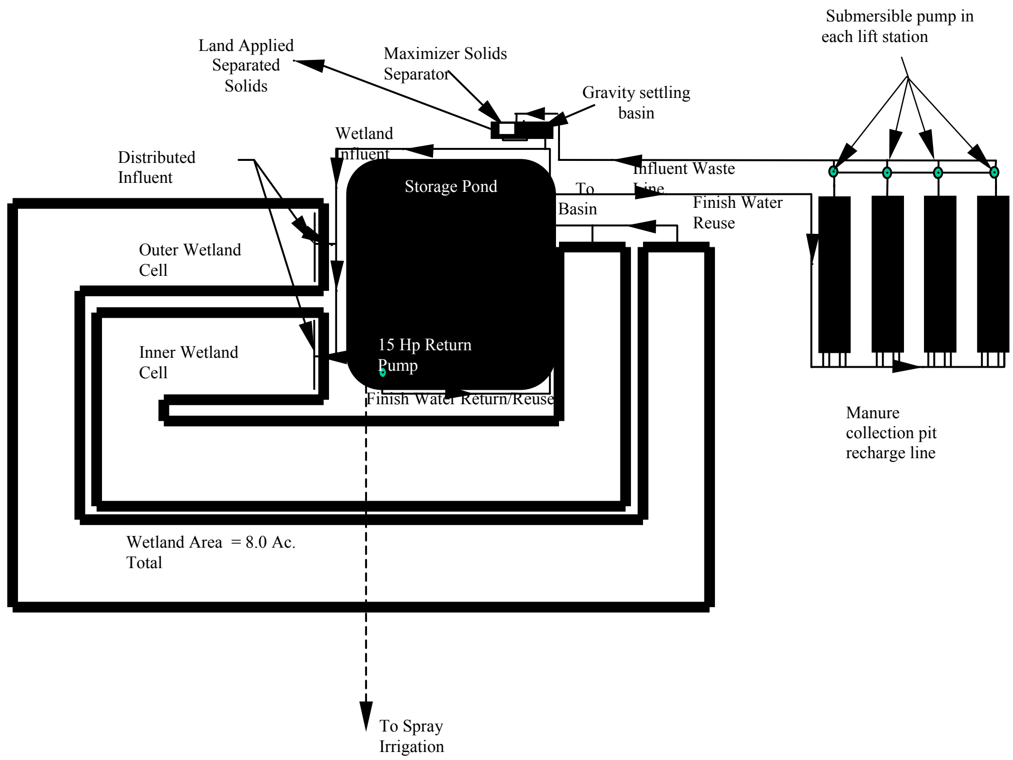


Figure 2. Constructed Wetland System Diagram



Solid Separation Component

Evaluation

The original system design was based on a solids separation efficiency of at least 40% for suspended solids. During the course of the evaluation, three different solids/liquid separators were investigated in an attempt to reach the design solids removal.

Initially, an Andritz-Ruthner, Inc., Hydrasieve static screen with 0.025-inch screen openings was selected due to its successful use for municipal wastewater treatment. The suspended solids removal efficiency of the Andritz screen was less than 15% and produced solids that were too wet to manage with available on-farm equipment.

A dissolved air flotation (DAF) unit was added to the system in an attempt to further enhance the removal of fine suspended solids. A prototype system designed and built by VanAire, Inc. was installed to accept flow from the Andritz screen prior to the liquid being introduced to the constructed wetland cells. The solids from the DAF unit were conveyed into the solids collection basin to be land applied with the solids from the screen. The fine bubbles generated by the DAF unit coagulated the fine suspended solids and lifted them to the top of the unit where they were skimmed off. While the DAF unit had a suspended solids removal rate of greater than 50%, the foamy nature of the air-entrained solids created a large volume of material that was difficult to contain and manage. In addition, maintenance issues kept the unit from being operational on a continuous basis.

The third separator investigated was a Brome Agri, Maximizer Unit with 0.0625 screen openings. When initial testing failed to produce satisfactory results, the screen opening size was reduced to 0.035 inch. With this modification, a suspended solids removal efficiency between 15-30% was achieved. The average removal of suspended solids during the evaluation period was 18%. The highest removal rates were achieved when the influent solids concentration was greater than 0.6 percent. The average removal efficiency observed during the on-farm evaluation was less than the 28% removal rate reported for the Environmental Technology Verification (ETV) testing of a Maximizer unit with the same screen size but shorter conveyor section (ETV Report, 2003).

In order to improve suspended solids removal prior to the liquid flowing into the wetland cells, the solids drying bed was modified with baffles to create a solids settling basin with a liquid residence time of approximately thirty minutes. The combination of Maximizer and settling basin provided approximately a 32% removal for suspended solids.

Future Plans

A new settling tank has been installed to enhance solid/liquid separation but is not yet in service. The tank will be used in a batch mode. The effluent from the barns will fill the tank and the contents allowed to settle. Once settling has occurred, the supernatant will be pumped directly to the wetland cells and the remaining material will be mixed and pumped to the mechanical solids separator. The higher concentration of solids and more homogeneous material should improve the effectiveness of the mechanical solids separator. It is planned to collect some initial data from the new tank once revised permit is approved.

Table 1. Summary of Solids/Liquid Separator Evaluation

Separator	Screen opening size	Suspended Solids Removal Efficiency (%)	Maintenance	Moisture Content of Solids %	Liquid Detention Time
Andrix	0.02 (in.)	<15	Med.	>85%	N/A
DAF	N/A	>50	High	>90	N/A
Maximizer	0.035 (in.)	15-30 (Avg. 18)	Med.	77-87	N/A
Settling Basin	N/A	17	Low	N/A	30 min.

Maintenance/management

Due to the farm layout at this site with the barns at a lower elevation than the treatment system, extra precautions had to be incorporated into the system to safeguard against possible spills in the event of pump or power failure. These extra controls required additional periodic adjustments and cleaning to maintain safe operation.

Andriz-Ruthner, Hydrasieve Screen
Since there are no moving parts maintenance is limited to periodic inspection and cleaning. The screen tended to become clogged with swine hair and produced extremely wet solids.

DAF
This was a prototype unit. Swine hair, in the barn effluent, clogged both the filter screen and the pump, thereby requiring frequent dismantling and cleaning. The designer of the system recognized the problems associated with swine wastewater and concluded that the system was not practical for such an application

Maximizer
As a mechanical system with two electric motors and gearboxes, a chain conveyor and float switches to control the system, periodic inspection, servicing and repairs were required. During the course of the evaluation, one electric motor had to be replaced, a loose setscrew caused one set of sprockets to wear prematurely and require replacement, and the screen had to be cleaned with acid to remove salt build-up (struvite) that was plugging the screen openings.

Wetland Component

Evaluation
The flows into and out of the wetland cells were to be measured with pressure transducer based flow meters but were rendered useless because of high water levels in the cells due to excessive rainfall during 2003. Many parts of the region experienced record rainfall during this period. Morehead City, for example, set a record of 91.52 inches for 2003, nearly 20 inches above the previous record of 72.49 inches.

To estimate the system flow the liquid level from two surveys, conducted on April 9, 2002 and on August 22, 2003 were used to measure the change in liquid volume by taking into account rainfall and evaporation over that same timeframe (Table 2). The change in liquid volume was then divided by the number of days (485) to yield an average daily flow of 8,000 gallons.

Grab samples were collected periodically and taken to the Environmental Analysis Laboratory in Biological and Agricultural Engineering Department at North Carolina State University. The results of these analyses along with the estimated flow were used to calculate total Kjeldahl nitrogen (TKN), total phosphorus (TP), copper (Cu) and zinc

(Zn) mass balances. The mass balances were then used to determine removal efficiencies for the constituents. These results are presented in Table 3.

When calculations are made using the average flow and concentration data, the annual total Kjeldahl nitrogen (TKN) loading to the system of about 170 lbs/day was similar to values reported by Team OPEN (Third Year Progress Report, 2003). The wetland/pond system removed approximately 57% of the TKN loading from the liquid stream prior to land application. Measurements at the Duplin County prototype wetland showed that less than 10% of the applied nitrogen was volatilized as ammonia (Poach et al.).

Constructed Wetland Vegetation

When the constructed wetlands cells went into operation in Dec. 2000, they were planted with local rushes and cattails. Excellent cattail growth occurred in the spring of 2001; however, cattail caterpillars infested the wetlands in early August. The infestation started at the northern end and progressed around the wetland cells. The caterpillars reduced the amount of biomass buildup and encouraged new shoot growth but the plants were severely stressed. A few redwinged blackbirds appeared and reduced the caterpillar population.

Excellent cattail growth occurred again in the spring of 2002 with the exception of a few areas that did not re-vegetate after predation. During the summer, the cattail caterpillars re-appeared in July. More redwinged blackbirds appeared, so there was somewhat less wetland plant damage due to caterpillars. The blackbirds over-wintered at the wetlands that year resulting in a resident population.

Spring 2003 was one of the wettest on record. Onslow County received 80 inches of rain for the year while the normal is 55 inches. Because of the resulting high water levels, monitoring of the wetland system was terminated in August 2003. Thereafter, the goal was to reduce water levels to the design depth of 3-6 inches and facilitate wetland plant regeneration. Damage from the cattail caterpillars did not appear until September 2003. It is not known if the late appearance was due to the wet weather, the redwinged blackbirds, or a combination of events.

Spring 2004 was not as wet as 2003. Additional plant types were added to the outer wetland cell: pickerelweed, arum, lizard's tail, and water hyacinth. Two pickup truck loads of water hyacinth were added to the influent end of the outer cell in April. By June, the cell was nearly 25% covered with hyacinth. By September, the outer cell had 95% cover: 75% water hyacinth, 20% cattails, and 5% other plants (pennywort, pickerelweed, duckweed, etc.). There was no noticeable damage of vegetation by cattail caterpillars in either wetland cell. The caterpillars did arrive, but few healthy caterpillars were observed because some were parasitized, some appeared to have a fungus, and the rest were likely eaten by the rather large resident redwinged blackbird population.

The water hyacinths died back in the fall of 2004; however, the dead vegetation remained floating on the water's surface. The cattails were roughly 9-18" tall April 2005. The pickerelweed has broken dormancy and is also beginning to grow. The pennywort and rushes are doing well. No new hyacinths have been observed by April 20, which is still early for germination.

Table 2. Wetland System Liquid Volumes (thousand gallons)

Date	Outer Cell	Inner Cell	Storage Pond
4/09/2002	495	754	4,076
8/22/2003	2,346	1,545	5,343

Table 3. Mass Removal Efficiencies by the Wetland Cells/Pond System

Constituent	TKN	Phosphorus	Copper	Zinc
Removal from Liquid	57%	87%	41%	39%

Maintenance/management

Record rainfalls during the evaluation period resulted in the need for additional land application of effluent, but the application was limited by the soil hydraulic application rate rather than a nitrogen application rate due to the low concentration of nitrogen. At no time was there a system overflow from system due to heavy rains.

The large land area required for a constructed wetland system and the desire for a gravity flow system make a constructed wetland system inappropriate for all farms. Wetland vegetation should be monitored for signs of insect infestation and appropriate actions taken to ensure the long-term sustainability of the system. A periodic check of the berms of the wetland cells should be made to detect the presence of burrowing rodents that could jeopardize the structural integrity of the cells.

It is estimated that about one hour per week would be required to inspect the constructed wetland cells and maintain the system. To facilitate the inspection of the berms the banks should be kept mowed which will require additional time during warm weather.

Summary

The low-tech, low energy wetland system required less total land than the replaced lagoon/land application system. The amount of land required can be reduced further if unit processes such as nitrification of wetland influent and chemical participation of phosphorus are added. Land requirements could be further reduced if solids are processed to value added by-products for off-farm use. Further treatment of the storage pond water such that it could be used as drinking water for the animals would reduce the number of irrigation events required and may make the system appropriate for more locations.

The TKN removal rate for the full-scale system was significantly less than that observed for the prototype system (57% verses 85%, at the 25 kg/ha/day loading rate). The prototype system was only operated during times when freezing temperatures were least likely and averaged 270 days each year, while the full-scale system operated continuously. Another significant difference was the water level in the cells. Shallow water depths enable higher nitrogen removal rates by nitrification and denitrification (Hunt et al.). The wetland systems were designed for water depths of 4-6 inches in the cells but record rains during the evaluation period caused the water levels to exceed the design depth by a foot or more for extended periods of time. This resulted in reduced nitrogen removals and submergence of the installed flow measurement and automated sampling equipment. The alternative grab sampling and flow surveys employed resulted in data similar Team OPEN and prototype wetland system results. In spite of the record rainfalls there was no system overflow and design water depths and vegetative conditions are being restored.

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Appendix A

Water Sample Analysis Data

Inflow to Separator

CODE	MO	DAY	YR	TKN	NH3N	NO3N	TP	%TS	%VS	FSS	CL	CU	ZN
TRS1	11	9	01	.	.	.	.	8.13		.			
TRS1	2	4	02	3180	2462	0	410	1.55		17400			
TRS1	2	26	02	.	.	.	.	2.88		.			
TRS1	6	6	02	2492	1649	0	.	0.83	34.94		515	0.54	34.9
TRS1	6	11	02	2580	1646	0	.	1.51	68.21	.	444	5.4	31.4
TRS1	9	24	02	4577	1038	0	1784	4.61	75.05	.	557	13.3	108
TRS1	10	15	02	1510	1469	0	335	0.95	61.05	.	295	2.28	14.8
TRS1	11	13	02	1637	1405	0.05	115	0.46	45.65	1467	351	.	.
TRS1	12	3	02	2077	2022	0	228	0.59	49.15	4433	534	.	.
TRS1	1	14	03	2339	1805	0	373	1.06	61.32	6933	554	2	15.4
TRS1	3	3	03	3659	2479	0	769	2.36	71.19	.	587	0	0.2
TRS1	3	24	03	2821	2092	0.09	612	1.79	66.48	16700	533	.	.
TRS1	4	8	03	2489	2269	0	337	0.93	60.22	8067	601	.	.
TRS1	4	22	03	2383	1853	.	243	1.14	62.28	13767	615	.	.
TRS1	5	13	03	2068	1347	.	650	2.05	73.17	.	360	8	51
TRS1	5	26	03	2779	2388	.	221	0.86	48.7	.	614	.	.
TRS1	6	16	03	1862	1567	.	540	0.65	55.38	3300	271	.	.

Average	**2563.53**	**1832.73**	**0.01**	**509.00**	**1.90**	**59.49**	**9008.38**	**487.93**	**4.50**	**36.53**
Median	2489.00	1805.00	0.00	373.00	1.14	61.19	7500.00	533.50	2.28	31.40
Max	4577	2479	0.09	1784	8.13	75.05	17400	615	13.3	108
Min	1510	1038	0	115	0.46	34.94	1467	271	0	0.2

Inflow to Settling Basin

CODE	MO	DAY	YR	TKN	NH3N	NO3N	TP	%TS	%VS	FSS	CL	CU	ZN
TRS2	11	9	01	.	.	.	.	1.41		13500	.	.	.
TRS2	2	4	02	3228	2450	0	409	1.23		12533	.	.	.
TRS2	2	26	02	.	.	.	.	1.94		.	.	.	.
TRS2	2	26	02	.	.	.	.	1.7		.	.	.	.
TRS2	2	26	02	.	.	.	.	1.6		.	.	.	.
TRS2	2	26	02	.	.	.	.	1.03		.	.	.	.
TRS2	6	6	02	2418	1626	0	.	1.73	69.94		494	5.7	35.4
TRS2	6	11	02	2362	1608	0	.	1.65	72.73	.	439	5.4	30.4
TRS2	9	24	02	3379	1012	0	1388	3.63	84.57	.	511	12.2	99.4
TRS2	10	15	02	1409	1489	0	273	0.82	59.76	.	291	2.08	14.4
TRS2	11	13	02	1652	1404	0.02	124	0.46	47.83	1693	357	.	.
TRS2	12	3	02	2075	1976	0	204	0.7	51.43	3720	530	.	.
TRS2	1	14	03	2202	1754	0	336	0.97	59.79	6533	551	1.76	14.7
TRS2	3	3	03	4359	2757	0	1142	2.69	69.89	.	672	4.4	35.6
TRS2	3	24	03	3103	2539	0.09	554	1.32	62.88	10433	535	.	.
TRS2	4	8	03	2479	2279	0	385	1.08	62.96	7800	583	.	.
TRS2	4	22	03	2448	2072	.	233	0.97	57.73	6583	644	.	.
TRS2	5	13	03	2215	1415	.	691	1.79	70.39	.	341	9	51
TRS2	5	26	03	2893	2339	.	232	0.85	48.8	.	605	.	.
TRS2	6	16	03	2079	1871	.	603	0.61	54.1	3450	270	.	.

	TKN	NH3N	NO3N	TP	%TS	%VS	FSS	CL	CU	ZN
Average	**2553.40**	**1906.07**	**0.01**	**505.69**	**1.41**	**62.34**	**7360.56**	**487.36**	**5.79**	**40.13**
Median	2433.00	1865.00	0.00	360.50	1.28	61.34	6583.00	530.00	5.40	35.40
Max	4359	2757	0.09	1388	3.63	84.57	13500	672	12.2	99.4
Min	1409	1012	0	124	0.46	47.83	1693	291	1.76	14.4

<u>Outflow from Settling Basin</u>

CODE	MO	DAY	YR	TKN	NH3N	NO3N	TP	%TS	%VS	FSS	CL	CU	ZN
SBO	**11**	**9**	**01**	**.**	**.**	**.**	**.**	**0.48**	**.**	**2567**	**.**	**.**	**.**
SBO	**2**	**26**	**02**	**.**	**.**	**.**	**.**	**0.93**	**.**	**.**	**.**	**.**	**.**
SBO	**6**	**6**	**02**	**1902**	**1498**	**0**	**.**	**0.74**	**78.38**		**451**	**1.84**	**9.44**
SBO	**6**	**11**	**02**	**2336**	**1694**	**.**	**.**	**0.74**	**55.4**	**.**	**467**	**1.6**	**8.72**
SBO	**9**	**24**	**02**	**2893**	**855**	**0**	**926**	**2.12**	**67.45**	**.**	**472**	**7.7**	**59.7**
SBO	**10**	**15**	**02**	**1433**	**1653**	**0**	**128**	**0.43**	**46.51**	**.**	**309**	**0.52**	**3.44**
SBO	**11**	**13**	**02**	**1583**	**1358**	**0.03**	**142**	**0.48**	**47.92**	**1893**	**360**	**.**	**.**
SBO	**12**	**3**	**02**	**1955**	**1862**	**0**	**267**	**0.68**	**51.47**	**3573**	**519**	**.**	**.**
SBO	**1**	**14**	**03**	**1994**	**1676**	**0**	**197**	**0.71**	**54.93**	**3167**	**559**	**0.56**	**6.44**
SBO	**3**	**3**	**03**	**4304**	**2583**	**0**	**1237**	**2.8**	**69.64**	**.**	**622**	**6**	**44.9**
SBO	**3**	**24**	**03**	**2847**	**2386**	**0.06**	**352**	**0.94**	**57.45**	**5067**	**536**	**.**	**.**
SBO	**4**	**8**	**03**	**3013**	**2225**	**0**	**877**	**1.75**	**68**	**18100**	**546**	**.**	**.**
SBO	**4**	**22**	**03**	**2508**	**2093**	**.**	**221**	**0.99**	**58.59**	**6767**	**622**	**.**	**.**
SBO	**5**	**13**	**03**	**2083**	**1382**	**.**	**535**	**1.27**	**66.93**	**12233**	**330**	**3.8**	**23.6**
SBO	**5**	**26**	**03**	**2867**	**2276**	**.**	**360**	**0.98**	**55.3**	**5500**	**520**	**.**	**.**
SBO	**6**	**16**	**03**	**1236**	**1115**	**.**	**183**	**0.4**	**47.5**	**1883**	**213**	**.**	**.**

Average	**2353.86**	**1761.14**	**0.01**	**452.05**	**1.03**	**58.96**	**6075.00**	**466.14**	**3.15**	**22.32**
Median	2209.50	1685.00	0.00	309.50	0.84	56.43	4320.00	495.50	1.84	9.44
Max	4304	2583	0.06	1237	2.8	78.38	18100	622	7.7	59.7
Min	1236	855	0	128	0.4	46.51	1883	213	0.52	3.44

Inflow to Inner Wetland Cell

CODE	MO	DAY	YR	TKN	NH3N	NO3N	TP	%TS	%VS	FSS	CL	CU	ZN
CW1-I	2	4	02	3042	2194	0	473	1.47	.	.			
CW1-I	6	6	02	272	120	0	.	0.34	41.18	.	319	0.68	5.6
CW1-I	6	11	02	313	198	0	.	0.33	42.42	.	334	0.38	2.74
CW1-I	9	24	02	2250	778	0	214	0.7	47.14	.	442	0.72	6.36
CW1-I	10	15	02	1273	1190	9.2	93	0.42	42.86	.	307	0.46	3.36
CW1-I	11	13	02	1707	1533	0.04	90.3	0.46	43.48	1300	365	.	.
CW1-I	12	3	02	1954	1793	0	152	0.55	47.27	2027	467	.	.
CW1-I	1	14	03	1633	1391	0.02	131	0.52	46.15	1700	544	0	3.48
CW1-I	3	3	03	2255	1558	0	608	1.53	67.97	.	433	5.9	45.7
CW1-I	3	24	03	3417	2564	0.07	583	1.41	65.96	11000	545	.	.
CW1-I	4	8	03	2434	2015	0.09	688	1.65	67.88	15367	465	.	.
CW1-I	4	22	03	2083	1802	0	184	0.88	57.95	5567	593	.	.
CW1-I	5	13	03	7055	1180	0	732	0.54	57.41	3200	324	7	32
CW1-I	5	26	03	2416	1612	0	458	1.21	63.5	8433	380	.	.
CW1-I	6	16	03	206	179	0	122	0.23	43.48	524	190	.	.

	TKN	NH3N	NO3N	TP	%TS	%VS	FSS	CL	CU	ZN
Average	**2154.00**	**1340.47**	**0.63**	**348.33**	**0.82**	**52.48**	**5457.56**	**407.71**	**2.16**	**14.18**
Median	2083.00	1533.00	0.00	214.00	0.55	47.21	3200.00	406.50	0.68	5.60
Max	7055	2564	9.2	732	1.65	67.97	15367	593	7	45.7
Min	206	120	0	90.3	0.23	41.18	524	190	0	2.74

Inflow to Outter Wetland Cell

CODE	MO	DAY	YR	TKN	NH3N	NO3N	TP	%TS	%VS	FSS	CL	CU	ZN
CW1-O	6	6	02	204	97.1	0	.	0.28	35.17	.	314	1.6	2.72
CW1-O	6	11	02	278	182	0	.	0.29	37.93	.	333	0.32	1.96
CW1-O	9	24	02	1610	381	0	681	1.83	67.21	.	455	6.32	47
CW1-O	10	15	02	1295	1242	2.75	107	0.44	45.45	.	302	0.54	4.42
CW1-O	11	13	02	1871	1620	0.04	126	0.48	45.83	1553	364	.	.
CW1-O	12	3	02	1649	1549	0.26	152	0.57	49.12	2427	467	.	.
CW1-O	1	14	03	1787	1558	0.4	124	0.55	45.45	1475	531	0	3.12
CW1-O	3	3	03	3043	2032	0	754	2.05	69.27	.	541	3.2	29
CW1-O	3	24	03	3267	2532	0.05	546	1.32	62.12	10867	527	.	.
CW1-O	4	8	03	140	122	0.04	59.9	0.2	40	317	231	.	.
CW1-O	4	22	03	2297	1857	0	192	0.9	57.78	5667	606	.	.
CW1-O	5	13	03	1755	1221	0	347	0.13	67.26	11667	331	6	36
CW1-O	5	26	03	2224	1737	0	359	1.13	61.2	6967	426	.	.
CW1-O	6	16	03	75.9	68.7	0.03	98	.	NOT ENOUGH	.	188	.	.

Average	**1535.42**	**1157.06**	**0.26**	**295.49**	**0.78**	**52.60**	**5117.50**	**401.14**	**2.57**	**17.75**
Median	1702.00	1395.50	0.02	172.00	0.55	49.12	4047.00	395.00	1.60	4.42
Max	3267	2532	2.75	754	2.05	69.27	11667	606	6.32	47
Min	75.9	68.7	0	59.9	0.13	35.17	317	188	0	1.96

Outflow from Inner Wetland Cell

CODE	MO	DAY	YR	TKN	NH3N	NO3N	TP	%TS	%VS	FSS	CL	CU	ZN
CW2-I	2	4	02	236	175	0.13	47	0.2	.	.	.	.	.
CW2-I	6	6	02	230	133	0	.	0.3	33.33	.	379	0.02	0.16
CW2-I	6	11	02	104	24.8	0.07	.	0.24	25	.	333	0	0.08
CW2-I	9	24	02	82.03	37.22	0.12	670	0.21	14.29	.	333	0	0.12
CW2-I	10	15	02	16.74	10.07	0.06	54	0.19	15.79	.	335	0	0.12
CW2-I	11	13	02	124	100.5	0.1	31.6	0.18	36.67	93	262	.	.
CW2-I	12	3	02	207	199	0.28	33.1	0.21	23.81	68	316	.	.
CW2-I	1	14	03	117	98.2	0.55	36.5	0.18	27.28	371	290	0	0.14
CW2-I	3	3	03	137	112	0.39	16.9	0.18	33.33	160	239	4.5	38.7
CW2-I	3	24	03	183	110	0.23	41.6	0.19	36.84	290	221	.	.
CW2-I	4	8	03	103	101	0.04	59.5	0.21	38.1	520	235	.	.
CW2-I	4	22	03	67.5	57.9	0.52	42.6	0.16	31.25	97	209	.	.
CW2-I	5	13	03	186	66.7	3.03	99.3	0.22	36.36	492	247	0.16	0.68
CW2-I	5	26	03	90.4	60.6	3.62	76.7	0.14	20.7	43	187	.	.
CW2-I	6	16	03	62	48.8	0.27	87.6	0.15	33.33	833	172	.	.

Average	**129.71**	**88.99**	**0.63**	**99.72**	**0.20**	**29.01**	**296.70**	**268.43**	**0.67**	**5.71**
Median	117.00	98.20	0.23	47.00	0.19	32.29	225.00	254.50	0.00	0.14
Max	236	199	3.62	670	0.3	38.1	833	379	4.5	38.7
Min	16.74	10.07	0	16.9	0.14	14.29	43	172	0	0.08

Outflow from Outer Wetland Cell

CODE	MO	DAY	YR	TKN	NH3N	NO3N	TP	%TS	%VS	FSS	CL	CU	ZN
CW2-O	6	6	02	79.6	37	0	.	0.28	21.43	.	364	0	0.08
CW2-O	6	11	02	164	41.9	0.06	.	0.47	31.91	.	373	0.08	0.72
CW2-O	9	24	02	45.82	28.08	0.04	73.2	0.2	5	.	324	0	0.01
CW2-O	10	15	02	22.66	8.8	0.07	53	0.2	20	.	341	0	0.12
CW2-O	11	13	02	101	72.02	0.52	32.1	0.17	17.65	80	257	.	.
CW2-O	12	3	02	130	129	1.26	34.5	0.19	21.05	37	298	.	.
CW2-O	1	14	03	148	125	0	37.4	0.2	30	50	296	0	0.14
CW2-O	3	3	03	57.6	34.9	3.41	11.3	0.12	33.33	43	175	0	0.14
CW2-O	3	24	03	36.6	5.43	17.4	16.5	0.12	41.67	45	14	.	.
	4	8	03										
CW2-O	4	22	03	132	36.1	1.02	34.9	0.14	28.57	16	188	.	.
CW2-O	5	13	03	140	103	0.39	34.4	0.22	31.82	342	263	0.08	0.22
CW2-O	5	26	03	65.6	41.8	3.12	29.1	0.13	24.8	32	176	.	.
CW2-O	6	16	03	47.6	30.6	0.48	50.8	0.13	23.08	145	157	.	.

Average	**90.04**	**53.36**	**2.14**	**37.02**	**0.20**	**25.41**	**87.78**	**248.15**	**0.02**	**0.20**
Median	79.60	37.00	0.48	34.50	0.19	24.80	45.00	263.00	0.00	0.14
Max	164	129	17.4	73.2	0.47	41.67	342	373	0.08	0.72
Min	22.66	5.43	0	11.3	0.12	5	16	14	0	0.01

Holding Pond

CODE	MO	DAY	YR	TKN	NH3N	NO3N	TP	%TS	%VS	FSS	CL	CU	ZN
HP	11	9	01	47.8	21.2	2.24	59	0.14	.	.	.	.	.
HP	2	4	02	48.2	31	1.01	43.8	0.14	.	.	.	.	.
HP	6	6	02	47.4	9.4	0.03	.	0.2	30	.	300	0	0.12
HP	6	11	02	102	28.7	0	.	0.23	26.09	.	318	0	0.04
HP	9	24	02	29	18.39	0.06	60	0.19	10.53	.	314	0	0.04
HP	10	15	02	31.75	12.5	0.26	65	0.19	26.32	.	309	0.02	0.1
HP	11	13	02	67.63	39.61	0.8	46.68	0.19	15.79	72	307	.	.
HP	12	3	02	82.8	68.5	1.08	34.7	0.18	22.22	45	291	.	.
HP	1	14	03	108	91	0.89	31.6	0.19	26.32	38	286	0	0.12
HP	3	3	03	114	92.4	0.79	31.2	0.18	27.78	140	263	0	0.5
HP	3	24	03	90.1	78.8	1.35	41.9	0.17	29.41	169	222	.	.
HP	4	8	03	106	96.3	0.21	42.9	0.18	33.33	220	226	.	.
HP	4	22	03	80.3	62.5	0.07	33.7	0.16	25	126	224	.	.
HP	5	13	03	85.7	65.5	0.12	44.5	0.17	23.53	168	221	0.02	0.28
HP	5	26	03	83.7	38.6	0.41	36.2	0.17	26.5	230	214	.	.
HP	6	16	03	44.2	25.8	0.11	74.1	0.16	37.5	215	181	.	.

Average	**73.04**	**48.76**	**0.59**	**46.09**	**0.18**	**25.74**	**142.30**	**262.57**	**0.01**	**0.17**
Median	81.55	39.11	0.34	43.35	0.18	26.32	154.00	274.50	0.00	0.12
Max	114	96.3	2.24	74.1	0.23	37.5	230	318	0.02	0.5
Min	29	9.4	0	31.2	0.14	10.53	38	181	0	0.04