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THREE-YEAR COMPREHENSIVE MONITORING REPORT

NAOMI FRESHWATER DIVERSION
BA-03

State Wetland Restoration Project

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ABSTRACT

Historically, the Mississippi River was the major source of freshwater and sediment for the entire deltaic Louisiana coastal marsh system. Due to a combination of natural processes and anthropogenic factors, most of the freshwater and sediments are no longer available to maintain and create coastal marsh habitats. These reasons have contributed to Louisiana having the highest rate of land loss in the United States. Specifically, the Barataria Basin marshes adjacent to the community of Naomi, Louisiana, have seen large increases in brackish marsh in an area that once was primarily fresh marsh. The objective of the Naomi freshwater diversion project is to introduce freshwater, nutrients, and alluvial sediments from the Mississippi River into the project area, and thereby improve conditions in the area by reducing and stabilizing mean salinity, increasing relative abundance of the fresh-to-intermediate marsh type plant species, and increasing the marsh to open water ratio.

Results indicate that the diversion appears to have made improvements in the project area marsh since its initial opening on February 3, 1993. The goal of reducing ambient salinity has been met even at the most southern reaches of the project area. Furthermore, while the fresh-intermediate marsh zone does not appear to have increased in size, the area has at least been maintained and not significantly decreased in size. Species more adapted to fresh and intermediate marsh have appeared in limited quantities in the southern portion of the project area that is currently classified as brackish marsh. However, deviations in vegetation were not statistically analyzed due to differences in data collection protocols. Project effects on marsh to open water ratio remain to be determined.

INTRODUCTION

The Mississippi River was historically a major source of freshwater and sediment for the entire deltaic Louisiana coastal marsh system. The current coastal area of Louisiana is actually a composite of seven different river deltas that have been formed and then abandoned over the past 7,000 years. It was during this period that the river created approximately 14,000 mi^2 (36,260 km^2) of wetlands (Rude 1990). This system represents 96 % of the deltaic wetlands on the Gulf of Mexico coast. Unfortunately, due to a combination of natural processes such as subsidence, sea-level rise, and anthropogenic factors including canal dredging and sediment diversion, the river now funnels sediments over the continental shelf making them unavailable for coastal marshes (Bowman et al. 1995). In addition, dam construction across Bayou Lafourche along with systematic levee building on the Mississippi River have reduced freshwater inputs over 70% between 1901 and 1930 (Reed and Nyman 1995). These reasons have contributed to Louisiana having the highest rate of land loss in the United States (Wells and Coleman 1987; Dunbar et al. 1992).

Freshwater introductions in the form of man made diversions were designed to utilize the Mississippi River as early as the late 1800's to draw river water into the nearby rice fields. The first controlled freshwater diversion for fish and wildlife purposes was constructed at Bayou Lamoque in 1956. The freshwater from this project was diverted into lower California Bay in the Breton Sound Basin to enhance oyster production (Bowman et al. 1995).

The essential goals of modern freshwater diversions are to manage the productivity of wildlife and fishery resources by controlling salinity and to maintain marsh elevation by introducing additional freshwater and sediment to the marsh (Roberts et al. 1992). Fishery resources depend upon the movement of larval, post-larval, and juvenile organisms in the saline, brackish, and fresh/intermediate marsh nursery grounds and therefore depend on the sustained salinity gradient from fresh to saline wetlands. Several studies to determine the feasibility of large-scale controlled freshwater diversions from the Mississippi River to the adjacent estuarine areas were conducted in the past by the U. S. Army Corps of Engineers (USACE 1982). These studies indicated that controlled diversion to these areas is technically feasible and would result in substantial overall net benefits to estuarine organisms. Other studies point to salinity as being the single most important factor in determining the distribution and abundance of many estuarine organisms (Gunter et al. 1974; Chatry and Chew 1985). Marsh maintenance is achieved when freshwater and sediments help to balance the accretion deficit as a result of subsidence. However, marsh vertical accretion in the Gulf Coast and New England occurs through vegetative growth rather than mineral sedimentation. In such systems, mineral sediments are believed to contribute to accretion indirectly by contributing bound nutrients (McCaffrey and Thomson 1980, Hatton etal. 1983, Bricker-Urso 1991, Nyman et al 1993, Callaway et al. 1995). This decrease in net subsidence aids in reducing tidal water exchange and accompanying salinity, subsequently protecting the freshwater and low-salinity wetland vegetation from salt-related stress (Roberts et al.1992).

Several freshwater diversions currently exist along the Mississippi River; one of which occurs on the west bank of the Mississippi River at Naomi, Louisiana. The Naomi project area contains approximately 13,000 acres (5,261 ha) of intermediate and brackish marsh and is located within Plaquemines and Jefferson parishes (figure 1). The Naomi freshwater diversion structure, located at river mile 64 Above Head of Passes (AHP) at Naomi, Louisiana, consists of eight 6-ft (1.8 m) diameter siphon tubes with a combined maximum discharge of 2,144 cfs (60 cms). The siphons empty into a revetted discharge pond with one 30-ft (9.2 m) wide by 3,300-ft (1005 m) long outfall channel (Brown & Root, Inc. 1992). All siphon operations are performed by Plaquemines Parish Government (PPG) in accordance with an operations scheme developed in 1992 by Brown and Root, Inc., and revised in 1993 by PPG and the Louisiana Department of Natural Resources, Coastal Restoration Division (LDNR/CRD). The revised operations scheme calls for the structure to be operated at full capacity for all months except March and April when it is to be operated at 25% capacity.

Wetlands have deteriorated in the project area for the past 35 years. The average rate of change from marsh to non-marsh (including loss to both open water and commercial development) has been relatively consistent since the 1930's. Marsh loss rates for the Barataria quadrangle were 1.08 mi^2/yr (2.80 km^2/yr) between 1939 and 1956, 1.20 mi^2/yr (3.11 km^2/yr) between 1956 and 1974, 0.70 mi^2/yr (1.81 km^2/yr) between 1974 and 1983, and 1.06 mi^2/yr (2.75 km^2/yr) between 1983 and 1990 (Dunbar et al. 1992).

In 1956, the area was classified as fresh marsh with 600 acres (243 ha) of open water. Approximately 2,500 acres (1,012 ha) of marsh converted to open water from 1956 to 1978 and an additional 4,000 acres (1,619 ha) converted to open water from 1978 to 1984 (U.S. Soil Conservation Service 1991). In 1978, Chabreck and Linscombe classified the vegetation in the area as 62% intermediate and 38% brackish. A decade later Chabreck and Linscombe (1988) noted a continued increase in brackish marsh with 61% of the area being classified as brackish marsh and the remainder classified as intermediate. Observations in 1991 by the Soil Conservation Service (currently Natural Resources Conservation Service) indicated that the northeast portion of the project area was dominated by (70%-80%) *Sagittaria lancifolia* (bulltongue), *Typha spp.* (cattail), *Scirpus californicus* (California bullrush), *Phragmites australis* (common reed), and *Zizaniopsis miliaceae* (southern wildrice). Western and southern portions of the project area were dominated by *Spartina patens* (saltmeadow cordgrass). The brackish marsh in the vicinity of the Cheniere Traverse Bayou contains extensive open water areas interspersed with islands of *S. patens*, *Cyperus odoratus* (fragrant flatsedge), and *Vigna luteola* (deerpea).

The soils of the area consist of the Barbary, Allemands, Kenner, and Lafitte muck types (Soil Conservation Service 1983). The Barbary series is found mainly along the Mississippi River in a narrow band and is characterized as level, very poorly drained, semi-fluid mineral soil formed in clayey alluvium from the Mississippi River deposited in water. The Allemands series is found in the immediate outfall area adjacent to the siphon discharge pond. It is characterized as level, poorly drained organic soil formed in moderately thick accumulations of decomposed herbaceous materials. The Kenner series is found in a narrow band that follows a northwest to southeast path through the project area. It is also characterized as level, very poorly drained, semifluid organic soil formed in herbaceous plant material in freshwater marshes. The Lafitte series is found throughout the

Figure 1. Location of the Naomi Freshwater Diversion (BA-03) project area.

remaining southern portion of the project area and is characterized by a thick surface layer of semifluid saline muck with underlying semifluid, saline clay and silty clay loam. The surface layers of all the soils within the project area are organic and very susceptible to erosion especially when not protected by vegetation. The soils are also prone to compaction when allowed to dry (U.S. Soil Conservation Service 1991).

The main objective of the Naomi diversion was to protect the project area from continued saltwater intrusion and reduce wetland loss by restoring riverine inputs of freshwater and sediments to the marsh. The diverted river water will contribute freshwater, nutrients, and alluvial sediments into the project area, improving growing conditions for fresh-to-intermediate marsh plant species. Specific measurable goals established to evaluate project effectiveness include: (1) reduce and stabilize mean salinity, (2) increase relative abundance of fresh-to-intermediate plant species, and (3) increase marsh to open water ratio (LDNR 1996).

METHODS

All hydrologic monitoring of the Naomi project was performed by LDNR/CRD. Salinity (ppt), specific conductance (μ siemens/cm), water temperature (°C) (all measured at the surface and bottom of the water column), and station depth (ft) have been measured monthly at 16 stations throughout the project area since November 17, 1992 (figure 2). Water level was measured at seven staff gauge stations (1,3,6,10,11,14, and16) surveyed to the National Geodetic Vertical Datum (NGVD) until October 1997 when these stations were re-surveyed to the North American Vertical Datum (NAVD) (figure 2). All water level data recorded in NGVD were converted to NAVD for analysis.

Daily siphon discharge in cubic feet per second (cfs) was estimated from the head differential between the daily river and immediate outfall staff gauges and the number of pipes in operation. Any missing values for daily gauge readings were interpolated from known values, and linear shifts in discharge were applied to unknown ranges in an attempt to estimate the daily amount of discharge entering the project area through the siphons. In addition, monthly flow means were calculated and grouped into one of three categories: noflow (0 cfs [0 cms]/month), minor discharge (0 - 1,072 cfs [30 cms]/month) or major discharge (>1,072 cfs [30 cms]/month). Operational strategies (Brown and Root 1992), indicated an attempt would be made to operate siphons at maximum discharge except during mid March through April. Ambient water elevation is at its highest levels during this time period and any additional inundation may be detrimental to the vegetation community.

Bottom salinity and water level data from the 16 monthly monitoring stations were analyzed during different categories of siphon operation. Bottom salinity was used in the statistical analysis because more data points were collected for bottom salinity. A Kruskal-Wallis test was performed between bottom and surface salinity to ascertain if any significant difference existed between the two (SAS, 1989). Data that had been collected on a weekly or bi-weekly basis were averaged to obtain monthly means for each station. Finally, data from all stations were averaged by month to obtain a value indicative of the overall project area. Monthly means were used in the statistical model. Salinity data were square root transformed to improve normality and analyzed as a split plot repeated measures ANOVA that tested mean salinities of the three levels of siphon operation (noflow, minor discharge, and major discharge). Water level did not require transformation and was analyzed using the same model. Additionally, a simple linear regression was performed on water level by station. Post-ANOVA Tukey pairwise comparisons were used to investigate mean differences when models were found to be significant (SAS, 1989).

Vegetation species composition and abundance were measured in the project area at 6 stations in 1992 using an ocular estimate method (Ensminger 1992). Whereas in October 1997, 40 stations were measured (2 m^2 plots) using the Braun-Blanquet sampling protocol (Mueller-Dombois and Ellenberg 1974) (figures 3 and 4). Because different stations and methods were used for the two vegetation surveys, these data were only qualitatively compared in an attempt to determine changes in plant community structure. Preconstruction aerial photography (1:12,000) of the project area was obtained in November 1993. Changes in marsh to open water ratios will be evaluated after acquisition of additional photography scheduled to be taken in the Fall of 1999.

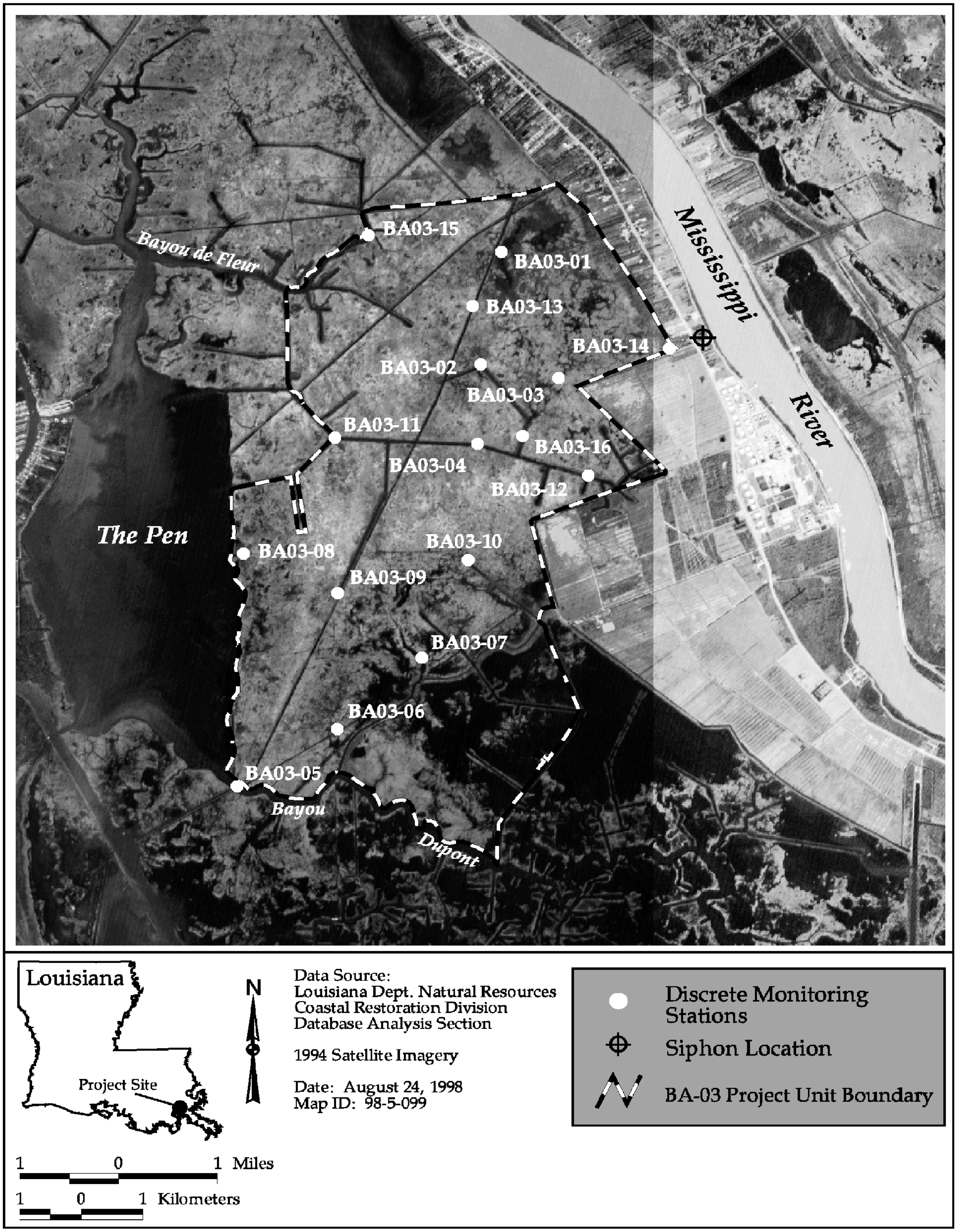

Figure 2. Locations of discrete monitoring stations at the Naomi Freshwater Diversion Project.

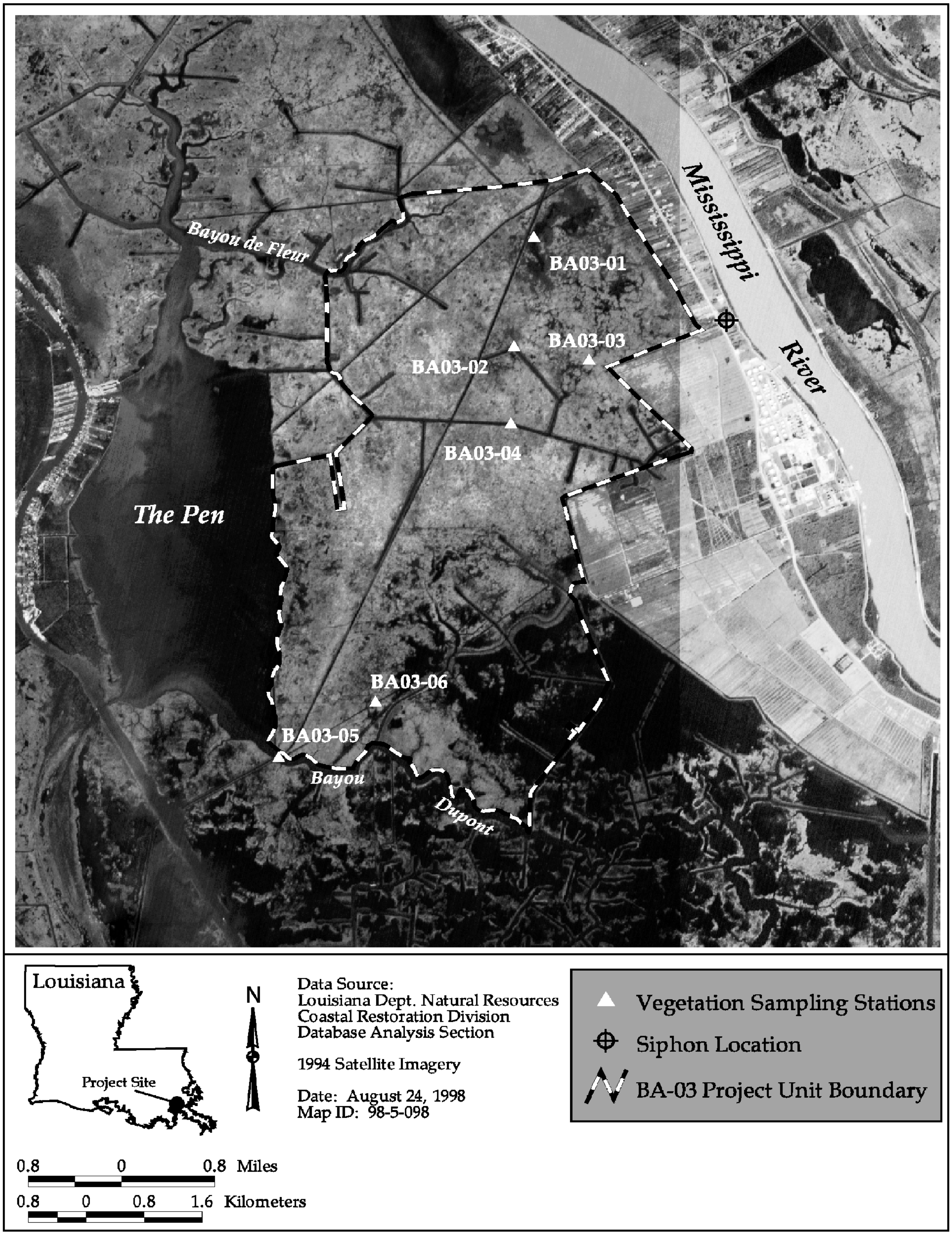

Figure 3. Preconstruction (1992) vegetation sampling stations at the Naomi Freshwater Diversion Project.

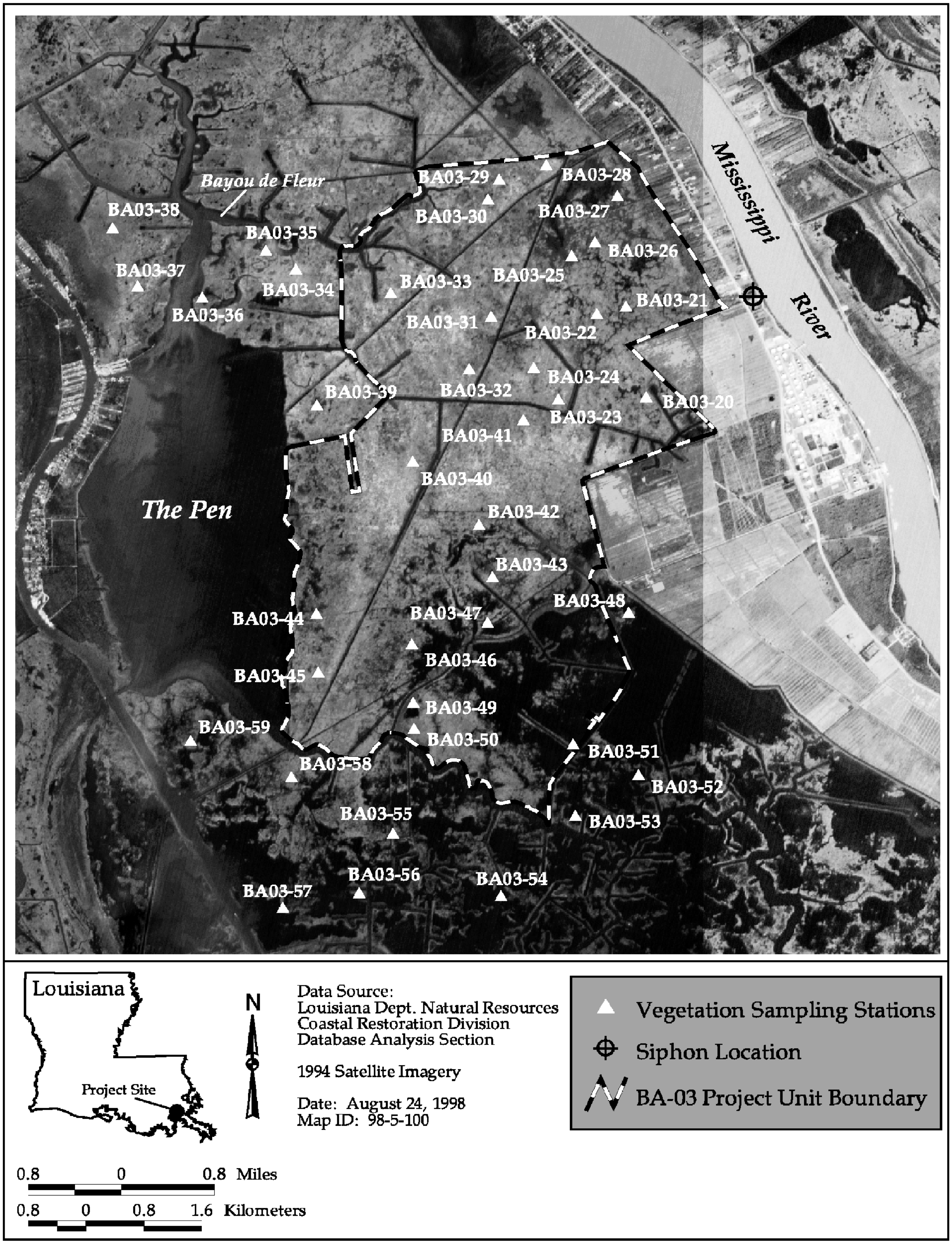

Figure 4. Postconstruction (1997) vegetation sampling stations at the Naomi Freshwater Diversion Project.

RESULTS

Approximately 6 years of hydrologic monitoring data were collected since monitoring was initiated in November 1992. Specifically, 22, 25, and 22 months of data were collected during periods when the structure was functioning as noflow, minor discharge, and major discharge, respectively (Appendix 1).

A Kruskal-Wallis test indicated no statistical difference between bottom salinity and surface salinity ($X^2 = 0.01546$, df = 1, P = 0.9010) over the course of this study. This result, along with the fact that more bottom salinity than surface salinity data were collected, reinforce the decision to only use bottom salinity in the analysis. Mean transformed salinity in the project area was significantly (F = 15.03, df = 2, P < 0.0001) affected by siphon operation. Mean non-transformed project area salinity during major discharge, minor discharge, or noflow periods was 0.44 ppt ± 0.02 s.e., 0.66 ppt ± 0.06 s.e., and 1.23 ppt ± 0.05 s.e., respectively. Post-ANOVA Tukey's comparisons indicated no significant difference between mean transformed salinity during periods when the structure was in minor or major discharge operation. However, transformed mean salinity during both periods was significantly different than that from periods of noflow. Stations 5, 6, 7, 8, and 10 are located farthest from the structure and exhibit the greatest mean salinity in each phase of siphon operation (figure 5). With the exception of station 10, these stations also exhibit the greatest reduction in mean salinity as a result of siphon operation.

Mean water levels in the project area were also significantly (F = 7.37, df = 2, P = 0.0013) affected by siphon operation. Moreover, post-ANOVA Tukey's comparisons indicated that mean water level for each level of siphon operation was significantly different from each other. Mean water level during periods of major discharge, minor discharge, and noflow was 1.41 ft NAVD ± 0.04 s.e., 1.24 ft NAVD ± 0.04 s.e., and 1.06 ft NAVD ± 0.05 s.e., respectively. The strongest relationship between siphon operation and water level existed at station 14, located in the immediate outfall channel (via simple linear regression, $R^2 = 0.47$, P < 0.0001). With station 14 removed from the analysis, water level was not significantly (F = 1.97, df = 2, P = 0.1489) affected by siphon operation. Mean water levels (calculated without station 14) during periods of major discharge, minor discharge, and noflow were 1.28 ft NAVD ± 0.03 s.e., 1.13 ft NAVD ± 0.04 s.e., and 1.12 ft NAVD ± 0.06 s.e., respectively. It appears that stations 6, 10, and 11 show little or no relationship between siphon status and water level while stations 1, 3, and 16 exhibit only slight (and non-significant) water level reductions with decreases in siphon flow (figure 6).

The preconstruction vegetation survey performed in June 1992 revealed a total of 24 species at 6 sites (table 1a), with a mean species richness at each site of 8.00 ± 1.21 s.e. The 1997 survey indicated a total of 38 species tabulated at 40 sites (table 1b). Mean species richness at each individual station was 7.25 ± 0.37 s.e. Based on a qualitative comparison of the species composition data, there were no marked changes in general community type within the project area. Ensminger (1992) indicated that fresh/intermediate marsh comprised the northeast portion of the project area while brackish marsh dominated the remainder. In 1992, the entire area as a whole was dominated by *S. lancifolia*, *Scirpus americanus* (three-square bulrush), and *S. patens*. Specifically, *S. patens*

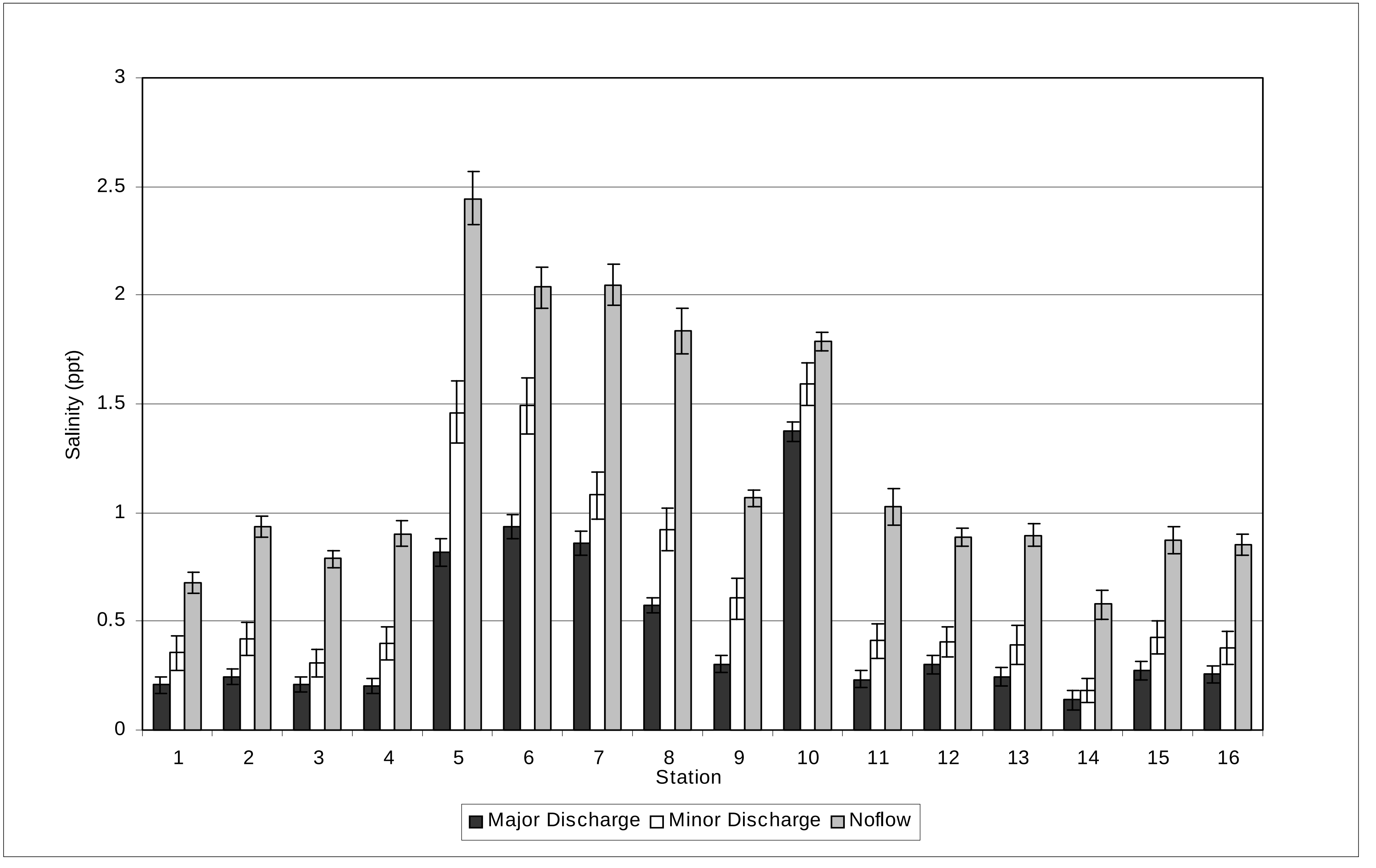

Figure 5. Mean salinity (±SE) for three operational categories at the 16 discrete monthly hydrologic stations (Major discharge, > 1,072 cfs [30 cms]/month; Minor discharge, 0 - 1,072 cfs [30cms]/month; Noflow, 0 cfs [0cms]/month).

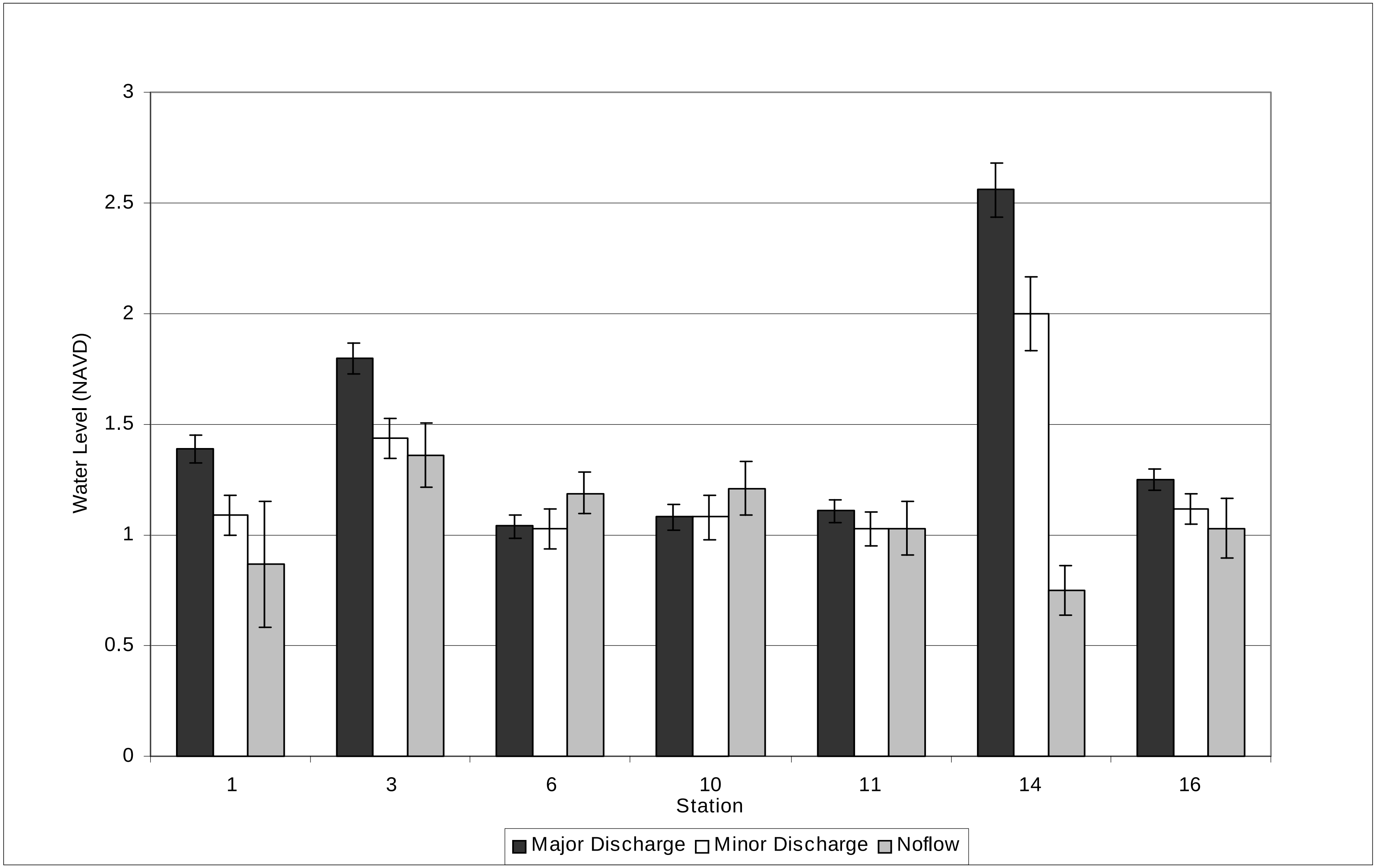

Figure 6. Mean water level (±SE) comparisons of the 3 operational categories at the 7 staff gauges within the project area (Major discharge, >1,072 cfs [30 cms]/month; Minor discharge, 0 - 1,072 cfs [30cms]/month; Noflow, 0 cfs [0cms]/month).

Table 1a. Plant species and related frequencies for vegetation survey, 1992.

Species	**Frequency**
Sagittaria lancifolia	5/6
Scirpus americanus	4/6
Spartina patens	4/6
Echinochloa walteri	3/6
Eleocharis parvula	3/6
Vigna luteola	3/6
Acnida cuspidata	3/6
Pluchea camphorata	2/6
Typha spp.	2/6
Myriophyllum spicatum	2/6
Ceratophyllum demersum	2/6
Carex spp.	2/6
Spartina alterniflora	2/6
Myrica cerifera	1/6
Lemna minor	1/6
Hydrocotyle umbellata	1/6
Ipomoea sagittata	1/6
Pluchea foetida	1/6
Eichornia crassipes	1/6
Scirpus californicus	1/6
Polygomum spp.	1/6
Bacopa monnieri	1/6
Najas quadalupensis	1/6
Alternanthera philoxeroides	1/6

Table 1b. Plant species and related frequencies for vegetation survey, 1997.

Species	Frequency	Species	Frequency
Eleocharis cellulosa	27/40	*Alternanthera philoxeroides*	4/40
Spartina patens	26/40	*Bacopa monnieri*	4/40
Polygonum pensylvanicum	24/40	*Thelypteris palustris*	4/40
Vigna luteola	19/40	*Mikania scandens*	3/40
Phyla nodiflora	18/40	*Sporobolus*	3/40
Sagittaria lancifolia	18/40	*Sacciolepis striata*	1/40
Aster tenuifolius	16/40	*Juncus effusus*	2/40
Hydrocotyle	14/40	*Sagittaria platyphylla*	2/40
Scirpus americanus	14/40	*Amaranthus australis*	1/40
Ipomea sagittata	12/40	*Ammania latifolia*	1/40
Cyperus odratus	10/40	*Echinochloa crusgalli*	1/40
Aster subulatus	9/40	*Eichhornia crassipes*	1/40
Pluchea camphorata	8/40	*Eleocharis parvula*	1/40
Setaria	8/40	*Iva frutescens*	1/40
Solidago sempervirens	8/40	*Juncus romarianus*	1/40
Baccharis halimifolia	7/40	*Ludwigia macrocarpa*	1/40
Ludwigia alternifolia	7/40	*Pluchea odorata*	1/40
Hibiscus lasiocarpus	6/40	*Salvina minima*	1/40
Andropogon geradii	5/40	*Sphenoclea zeylandica*	1/40

dominated the most southern portion (stations 5 and 6) of the project area while the upper northeast portion of the project, stations 1, 2, 3, and 4, were dominated by *S. lancifolia*. Likewise, during the 1997 survey, *S. lancifolia* dominated (Braun-Blaunquet cover value estimate) stations 20, 23, 24, 25, 26, 27, also located in the upper northeast portion of the project area while it was less abundant in other areas of the project (in particular stations 28, 29, 30, 32, 33, 40, and 41). Similarly, stations 29, 30, 33, 42, 43, 44, 45, 46, 47, 49, 50, and 51, located in the southern and western region of the project during the 1997 survey, were dominated by *S. patens.* In addition to the *S. patens*, the appearance of several species more indicative of intermediate or low-salinity brackish marsh occurred at stations 33, 43, 44, 46, 48, 49, and 50. Specifically, these species were as follows: *Aster subulatus* (annual aster), *Bacopa monnieri* (coastal waterhyssop), *Baccharis halimifolia* (saltbush), *C. odoratus*, *Eleocharis cellulosa* (gulfcoast spikesedge, *Hydrocotyle spp*. (pennywort), *Ipomea sagittata* (marsh morning glory), *Phyla nodiflora* (turkey tangle frogfruit), *Polygonum pensylvanicum* (pink smartweed), *S. lancifolia*, *Scirpus americanus* (bulrush), *Solidago sempervirens* (seaside goldenrod), and *V. luteola* (Chabreck 1970; Palmisano and Chabreck 1972; Chabreck and Condrey 1979).

DISCUSSION

The interpretation of the direct effects of the siphon on mean project area salinity was influenced by factors other than siphon operation, particularly seasonal variability. The prevalence of months of major discharge (20 of the 22) coincide with periods of high river stages (winter - mid summer) (table 2). This is a characteristic of the project design, because sufficient head differential between river stage and marsh stage is necessary for proper operation of the siphons. However, the Barataria estuary is naturally fresher during this time of the year, because of the Mississippi River's influence on the estuary (Swenson and Swarzenski 1995). Similarly, 13 of the 22 months of noflow occurred between August and December, when there was low river stage and thus insufficient head differential to operate the siphons. The low river stages at this time of the year have historically resulted in higher salinities in the estuary (Swenson and Swarzenski 1995).

Additional factors that may have contributed to periods of siphon inoperation are "faulty" valves that cause air to leak into the siphon tubes, limited manpower available to operate the structure, and various oil spills on the river. From September 1994 to July 1995, the structure was not operated because of pending litigation (Appendix 1). Moreover, despite a pre-planned effort to reduce siphon operation to 25% during the months of March and April, siphons operated at a near average discharge during this time. This was partially influenced by the difficulties associated with operating the structure without any real-time estimates of flow. Additionally, the primary reason to limit flow in March and April originates from concerns over potential flooding. However, data indicate that flooding is not as serious a problem as was thought prior to structure operation. Sediment load is relatively high in the river during this period, consequently increased flow should aid the marsh by facilitating more sediment introduction (Mossa and Roberts 1990). Average discharge during major and minor periods of operation collectively was 997 cfs or 54% of maximum capacity. It should be noted that maximum discharge is only possible with extreme head differential between the river and the marsh. Therefore, it was not expected that the structure could maintain maximum flow throughout the year, even with all 8 pipes operating.

Individually, stations 5, 6, 7, 8, 9, and 10 had the highest overall salinities due primarily to spatial location. These stations are located in the southern portion of the project area which is influenced by saltwater entering the area via Bayou Dupont and the Barataria Bay Waterway (BBW). The BBW is a man-made canal that is directly connected to Barataria Bay. It serves as a conduit for saltwater intrusion into more upper portions of the Barataria estuary. The discrete data showed a decrease in salinity at each of these stations when the siphon was operating (figure 4). Therefore, it seems that freshwater from the siphon affected mean salinity, even at the most southern portion of the project area. This result could lead to the conclusion that the structure may affect salinity outside the project area. Therefore, benefits may be underestimated in future analysis of vegetation and landloss. Stations located nearest to the siphon had lower mean salinities, but nonetheless experienced a decrease in salinity when the siphons were operated.

Although water level was affected by siphon operation at station 14, located in the immediate outfall area, the siphons apparently had little or no effect on the water levels within the greater project area.

Table 2. Number of months during which the Naomi Freshwater Diversion was at (a) major discharge or (b) not operating.

a.

High River Stage Months	**Months of major discharge**	**Low River Stage Months**	**Months of major discharge**
January	1	August	0
February	3	September	0
March	4	October	1
April	4	November	0
May	4	December	1
June	3		
July	1		
	Σ = 20		Σ = 2

b.

High River Stage Months	**Months of no siphon discharge**	**Low River Stage Months**	**Months of no siphon discharge**
January	3	August	0
February	1	September	1
March	1	October	4
April	1	November	4
May	1	December	4
June	1		
July	1		
	Σ = 9		Σ = 13

Water level recorded at stations 1, 3, and 16, which were closest to the diversion siphon, showed only slight (and not statistically significant) increases in water level resulting from increases in siphon discharge. However, water level at stations 6, 10, and 11, which were located farthest from the outfall, was not influenced by the diversion. The project area contains many channels and canals which serve as conduits for the introduced freshwater. These channels are large enough to quickly disperse incoming river water further south, instead of allowing sheet flow across the marsh. This was possibly the reason that water levels in the southern end of the project were unaffected by siphon operation. The minimal variation in water level that was observed at these southern stations was potentially due to effects of wind and tidal events. By not significantly increasing water level, the potential for vegetation stress as a result of structure induced flooding is reduced. Waterlogged soils and subsequent changes in oxygen content along with other chemical conditions significantly limit the number of rooted plants that can survive in this environment (Bedinger 1981).

Although the vegetation data was not statistically analyzed, qualitative reviews of the data indicate similar spatial patterns between the pre-construction and 5 year post-construction periods. This is encouraging in that at least no fresh/intermediate marsh has been lost. Moreover, while the western and southern portions of the project area are still classified as brackish marsh, vegetation species more indicative of less saline conditions (i.e., *A. subulatus*, *B. monnieri*, *B. halimifolia*, *S. americanus*, *Eleocharis spp*., *Hydrocotyle spp*., and *S. lancifolia*) were observed. Their occurrence may be influenced, at least partially, by the fact that salinities have been reduced in these areas. Species richness was used in the analysis because it is useful as an index of environmental stress and/or shift in community type because species richness generally increases along a gradient from saline to intermediate to fresh marsh (Palmisano and Chabreck 1972). It is very important to note that it is not clear at this time if the difference in the plant community or species richness data between 1992 and 1997 resulted from the difference in the locations (i.e., spatial variability), difference in the salinity regime, difference in number of stations, or from the difference over time (i.e., temporal variability). A more comprehensive evaluation of the vegetation data will become possible as these data are collected with a more consistent sampling protocol.

CONCLUSIONS

The freshwater diversion siphon at Naomi appears to be making gradual improvements on the project area marsh since its initial opening on February 3, 1993. One of the primary goals of the Naomi project is the reduction of ambient salinity. This objective has been met even at the most southern reaches of the project area. However, the salinity data may have been influenced at least partially by seasonal variability and therefore discretion should be used when interpreting these results. The next progress report will attempt to account for the seasonal variability by utilizing outside data sources in the salinity analysis. While it does not appear that the fresh / intermediate marsh is expanding, it is at least not being reduced. However, evaluating influences of the diversion on vegetative species richness and composition were very difficult due to the extreme differences in sampling methodologies. As vegetation data are collected in a more consistent manner, it will be possible to make stronger conclusions. The final goal of the project concerning marsh to open water ratios was not evaluated, as only pre-construction aerial photography was available. Aerial photography will be obtained in 1999 that will be used to evaluate marsh to open water ratio in future reports. The Naomi Freshwater Diversion Outfall Management Project is scheduled to be constructed in the summer of 1999. This project seeks to distribute the introduced freshwater in a more productive fashion (i.e., reduce freshwater lost to large channels) and to reduce saltwater influx. Monitoring data obtained from the outfall management project should aid in the evaluation of the Naomi siphon project by providing additional data that currently are unavailable.

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Appendix 1. Average monthly siphon discharge (cfs) November 1992 - July 1998.

Month	Avg. Discharge	Month	Avg. Discharge	Month	Avg. Discharge
November ‘92	0.00	October ‘94	0.00	September ‘96	90.18
December ‘92	0.00	November ‘94	0.00	October ‘96	0.00
January ‘93	0.00	December ‘94	0.00	November ‘96	389.58
February ‘93	1398.49	January ‘95	0.00	December ‘96	1821.32
March ‘93	1558.86	February ‘95	0.00	January ‘97	1333.66
April ‘93	451.80	March ‘95	0.00	February ‘97	1650.16
May ‘93	1765.87	April ‘95	0.00	March ‘97	1987.49
June ‘93	1512.3	May ‘95	0.00	April ‘97	1874.13
July ‘93	1554.79	June ‘95	0.00	May ‘97	772.63
August ‘93	934.14	July ‘95	0.00	June ‘97	1071.51
September ‘93	704.52	August ‘95	252.01	July ‘97	411.58
October ‘93	1137.84	September ‘95	206.15	August ‘97	21.66
November ‘93	296.22	October ‘95	0.00	September ‘97	0.00
December ‘93	543.13	November ‘95	0.00	October ‘97	0.00
January ‘94	92.5	December ‘95	0.00	November ‘97	0.00
February ‘94	953.95	January ‘96	0.00	December ‘97	0.00
March ‘94	2001.03	February ‘96	854.60	January ‘98	1027.81
April ‘94	1747.46	March ‘96	826.25	February ‘98	1539.87
May ‘94	1398.39	April ‘96	1168.83	March ‘98	1959.61
June ‘94	536.59	May ‘96	1888.78	April ‘98	1305.51
July ‘94	270.48	June ‘96	2151.79	May ‘98	1104.80
August ‘94	99.24	July ‘96	832.95	June ‘98	833.49
September ‘94	64.20	August ‘96	31.39	July ‘98	411.26