ECOLOGICAL REVIEW

Delta Management at Fort St. Phillip
CWPPRA Priority Project List 10
State No. BS-11

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Delta Management at Fort St. Phillip (BS-11)

In August 2000, the Louisiana Department of Natural Resources (LDNR) initiated the Ecological Review to improve the likelihood of restoration project success. This is a process whereby each restoration project's biotic benefits, goals, and strategies are evaluated prior to granting construction authorization. This evaluation utilizes monitoring and engineering information, as well as applicable scientific literature, to assess whether or not, and to what degree, the proposed project features will cause the desired ecological response.

Introduction

The purpose of the Delta Management at Fort St. Phillip (BS-11) project is to enhance marsh growth in the Mississippi River Delta by diverting fresh water and sediment through constructed crevasses into shallow, open-water receiving areas. Earthen terraces will also be constructed in one selected open water area to further trap sediments, promote marsh building processes, and offset recent land loss. The proposed project will be located near Fort St. Phillip on the east side of the Mississippi River in Plaquemines Parish, directly across the river from Fort Jackson (see Appendix A).

This area has experienced a great deal of land loss over the past century. From 1932 to 1974, the American Bay mapping unit (BS-11 is contained within this area) lost >12% of marsh from subsidence, erosion, and dredging operations. The loss rate dropped to 10.7% from 1974 to 1990, but nearly 14,000 acres (33%) are projected to be lost by the year 2050 (LCWCRTF & WCRA 1999). U.S. Army Corps of Engineers' land loss rates for the project area indicate 4.1%/yr of emergent marsh was lost in Area 1 between 1974 and 1990, while Area 2 experienced a loss rate of 1.6%/yr (Dunbar *et al.* 1992) (see Appendix A). However, this data does not reflect the accretion of new marsh which has occurred in this area as indicated by areal photography of 1990, 1995, and 1998 (USFWS 2000).

I. Goal Statement

The goals of this project are:

- to create 25 acres of emergent marsh through the construction of linear terraces and vegetation plantings; and
- to create 251 acres of emergent marsh by enhancing the natural processes of delta growth and sediment trapping in the project area.

II. Strategy Statement

Project goals will be achieved through the following strategies/project features:

- reintroduction of alluvial sediments through seven constructed crevasses; and
- sediment trapping by the construction of earthen terraces with vegetation plantings

III. Strategy-Goal Relationship

Delta management through sediment diversion and terrace construction will attempt to build marsh in shallow, open-water areas adjacent to the Mississippi River. Sediment will be delivered to the project area via seven constructed crevasses, with the dredge material from crevasse construction being beneficially used to create marsh adjacent to each crevasse. By delivering sediment to the area, the natural processes of subdelta growth will be enhanced.

Settlement of suspended sediment will be promoted by earthen terraces in the open water area near crevasse 1A (see Appendix A). Terrace construction will not only directly create marsh habitat, but will also facilitate marsh building by trapping sediments within the terrace field. Terraces will also reduce wave energies thereby reducing wave-induced erosion and protecting edges of surrounding marsh habitat. Effectiveness of the terraces also depends on their stability. Plantings of seashore paspalum (*Paspalum vaginatum*) on the crowns and smooth cordgrass (*Spartina alterniflora*) on the slopes of terraces will facilitate vegetation colonization of the terrace and to provide stability to terrace sediments. Another notable benefit of the vegetation plantings will be the immediate creation of edge habitat for fish and wildlife. The "edge effect" concept states that an increase in edge habitat leads to an increase in both species diversity and density (Brewer 1988).

IV. Project Feature Evaluation

The proposed project will include the construction and maintenance of seven crevasses along channel banks. These crevasses will connect shallow, open-water areas with a source of freshwater and sediment (parent channel) and promote the building of emergent marsh. Proposed crevasse dimensions (Width x Length x Depth) are as follows:

1A: 75' x 2,000' x 8'
1B: 75' x 450' x 6'
1C: 75' x 700' x 6'
Alternate 2A: 75' x 625' x 8'
2B: 75' x 900' x 8'
2C: 75' x 1500' x 8'
2D: 75' x 500' x 8'

Deep crevasses (> 6 feet) may have a higher potential for creating an efficient channel than shallow crevasses, where the channel may experience premature infilling (Kelley 1996). Artificial crevasses have historically been constructed at a 60° down-angle from the parent pass (Kelley 1996, Boyer 1996, Trepagnier 1994), and this angle is thought to provide optimal conditions for sediment capture (USFWS 2000). All proposed crevasses are planned to be constructed at this angle except 1B, which appears to have an angle of 120°. Despite the general acceptance of the "60° rule," little scientific evidence is available that indicates the crevasse angle at which efficiency of sediment capture is maximized (E. Turner, personal communication).

Earthen terraces are also proposed as a project feature and will be constructed in the shallow, open-water area near crevasse 1A. A total of 164 terraces (32,800 linear feet) in eleven staggered, northeast/southwest-orientated rows will be constructed with the following dimensions:

Length: 200'
Top Width: 10'
Gap Length (between terraces): 50'
Gap Length (between rows): 200'
Side Slope Ratio: 6H:1V
Final Settled Elevation: 3.5' NAVD-88

The geotechnical investigation, performed in January 2002 by Professional Service Industries, Inc., concluded that the generally soft clays found in the project area are adequate for earthen terrace construction (Professional Service Industries, Inc. 2002). The geotechnical investigation estimated that the proposed terraces will settle as high as one foot, with 50% of settlement occurring during construction (Professional Service Industries, Inc. 2002). Terrace dimensions were calculated in order to maximize emergent marsh creation acreage within the available open-water area. The side slope ratio, gap lengths, and terrace orientation were based on available space for terraces. Terraces will be planted with seashore paspalum and smooth cordgrass due to the prevalence of these species in the immediate area.

The project features were proposed based upon sound engineering design in order to effectively achieve the desired biotic goals. The construction of terraces alone will result in the immediate creation of approximately 16.5 acres of marsh. Dredged material from crevasse construction will be side-cast, resulting in the immediate creation of land as well. Following construction, sediment passing through the crevasse will likely settle out (promoted by terraces) in shallow water thereby mimicking natural marsh building processes. Proposed features will work collectively to create emergent marsh within open-water areas and offset historic land loss.

V. Assessment of Goal Attainability

Crevasses

Employing artificial crevasses as a restoration method is attractive because crevasses are relatively inexpensive, easy to construct, and results are quickly realized (Roberts *et al.* 1992, Davis 1993). Crevasses have been used as a management tool to combat wetland loss in the Mississippi River Delta since the early 1980s (Troutman and MacInnes 1999). Crevasses are breaks in levees or spoil banks that allow freshwater flow and movement of sediment into adjacent receiving areas. This essential land-forming process has historically occurred in the Mississippi River Delta, and archaeological evidence suggests these features were natural phenomena that served as safety valves in directing flood waters away from the main channel (Davis 1993), while building marsh in areas adjacent to the river. From the late 1860s to the 1980s deltaic crevasses served as conduits for sediments, building subdeltas that accounted for more than 80% of the new land built around the modern Mississippi River Delta complex (Gagliano *et al.* 1981, Davis 1993). Man-made levees built for flood control have reduced nature's ability to produce these phenomena, and current coastal restoration efforts have an opportunity to reverse this trend.

Crevasse projects have experienced a high level of success in coastal restoration efforts and a wealth of literature is available documenting their ability to build subaerial land and nourish coastal marshes. However, man-made breaches of channel banks which created crevasse splays have occurred years prior to the initiation of state and federal coastal restoration efforts. One such example was a 1973 accidental breaching of the south bank of Brant Bayou in the Cubits Gap subdelta that created one square mile of emergent wetlands (van Heerden and Wood 1991). Recent crevasse construction projects have mimicked this natural land-building process and yielded positive results as well. Three crevasse projects in the Pass-a-Loutre Wildlife Management Area were evaluated by LDNR/CRD from 1986 to 1991. A crevasse on Pass-a-Loutre produced subaerial growth of 170.5 acres. The South Pass crevasse yielded 353.1 acres of emergent marsh, and a crevasse on Loomis Pass created 113.7 acres (LDNR 1993). While these examples demonstrate the land building ability of crevasses, it should be noted that the cross-sectional area of these three crevasses was 3+ times larger than the crevasses proposed for BS-11.

Crevasse success has also been documented by Trepagnier (1994), Boyer *et al.* (1997), and Kelley (1996). The creation of approximately 400 acres of subaerial land from 1990-1993 in the outfall area of four constructed crevasses within Pass-a-Loutre Wildlife Management Area was reported by Tregagnier (1994). Twenty-four artificial crevasses were constructed in the Delta National Wildlife Refuge (DNWR) between 1983 and 1995 producing emergent wetlands at an average rate of 11.6 acres/year with a total splay development area of 711.7 acres by January 1995 (Boyer *et al.* 1997). Results from the Small Sediment Diversion (MR-01) project show substantial land gains ranging from 0.5 to 103.5 acres per crevasse over a three-year period, and cumulative land gain from all 13 crevasses was 313.4 acres from 1993 to 1996 (Kelley 1996). The Channel Armor Gap Crevasse (MR-06) project has yielded no subaerial land in the project area after two years of monitoring (1997-1999). However, shoals were evident in areas of the receiving bay nearest the artificial crevasses, and land-building will likely occur after subaqueous infilling of the bay is complete (Troutman and MacInnes 1999).

Although the land-building ability of crevasse projects is well documented, certain parameters affecting crevasse splay development should be considered during the design phase of this project to ensure success. The most successful crevasse is one that discharges from a large pass into a large, open-ended receiving basin that allows water to flow efficiently through the system (Trepagnier 1994). Important elements to crevasse success include: 1) crevasse channel cut angle; 2) receiving bay size, gradient, and outflow ability; 3) crevasse and parent channel cross-sectional areas; 4) number of bifurcations; 5) crevasse depth and slope, and; 6) application of innovative techniques (Boyer 1996). The performance of MR-01 crevasses was found to be related to characteristics of the parent pass (size, channel order, etc.), and the percent flow of the Mississippi River captured by the parent pass. For example, the oldest and largest crevasse in the MR-01 complex created more than 100 acres of marsh in 10 years. This crevasse was located close to the main Mississippi River channel, at the origin of Pass-a-Loutre, one of the river's largest primary distributary channels (Kelley 1996). Available data describing these parameters should be taken into account when designing future crevasse projects.

An additional parameter that must be considered is the order of the channel (known as the parent channel) off which the crevasse will be constructed. A crevasse will likely deliver more water and associated sediment from a 1st order parent channel than a 2nd order channel. Parent channel order determination for this project is made difficult due to the numerous pipeline canals that bisect parent channels (especially in Area 2 where parent channels are pipeline canals). Previous calculations of splay growth rates in the Wetland Value Assessment (WVA) is project may have been generous since splay growth was based on the sediment delivery capability of 2nd order parent channels. It is unclear how much water and associated sediment are diverted into the pipeline canals; therefore, calculations of splay growth may be overestimated. Parent channel order of crevasse 1C should especially be re-evaluated and considered as 3rd (or possibly 4th) order (see Appendix A). Similarly, the omission of crevasse 2A, considered to be 2nd order, and subsequent incorporation of crevasses Alternate 2A and 2D, both considered 3rd order, will also affect the accuracy of prior splay growth estimates (see Appendix A). For purposes of this Ecological Review and associated data analysis, crevasses 1C, Alternate 2A, and 2D are considered 3rd order. All other crevasses are considered 2nd order. Determination of parent channel order for this Ecological Review was made following Figure 1 from Boyer *et al* (1997).

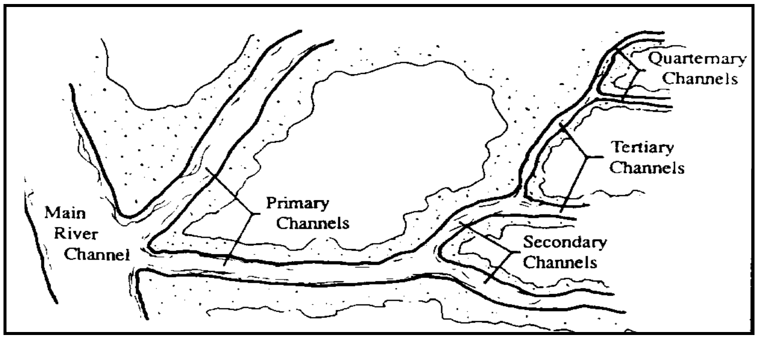

Figure 1: Schematic showing parent channel order determination technique (from Boyer *et al.* 1997)

Unfortunately, very little data is available on growth rates from >2nd order crevasses. Boyer (1996) reported the growth rate for a 3rd order crevasse was 1.5 acres/year and almost no measurable growth occurred after four years at a 4th order crevasse. A 3rd order crevasse was also evaluated as part of the Small Sediment Diversion Project (MR-01) and yielded a growth rate of 0.5 acres/year (Kelley 1996). However, a crevasse cut in 1986 from Loomis Pass (3rd order) in the Pass-a-Loutre Wildlife Management Area produced subaerial growth of 113.7 acres after only five years (LDNR 1993). It is likely that a number of parameters are important in splay growth (i.e., sediment load of the water column, flow velocity, etc.), with channel order telling only a portion of the story.

Combined effects of crevasse parameters likely determine growth rate of subaerial land in the receiving bay (hereafter called growth rate). Therefore, a multiple linear regression analysis was performed to explore the linear relationship between the parameters and growth rate. Growth rates for the BS-11 crevasses were predicted based on data gathered from the MR-01 (Small Sediment Diversion) project (n = 13), Boyer (1996) (n = 14), and LDNR/CRD (1993) (n = 3). Crevasse parameters used to predict growth rates included: 1) parent channel order; 2) parent channel width; 3) crevasse age; 4) crevasse cross-sectional area; and, 5) receiving bay area. Using a correlation coefficient matrix, only receiving bay area was highly correlated with growth rate (>0.7). Because no two parameters were highly correlated (Table 1), all parameters were used in the multiple linear regression analysis.

Growth rate predictions from both the full and reduced models are shown in tabular form in Appendix B, and are based on the multiple linear regression equations shown below (parameter abbreviation explanation can be found in Table 1):

Table 1. Correlation coefficients between five crevasse parameters and growth rate, as based on data from MR-01, Boyer (1996), and LDNR/CRD (1993). PO = Parent Order, PW = Parent Width, CA = Crevasse Age, CCSA = Crevasse Cross-sectional Area, RA = Receiving Area.

	PO	**PW**	**CA**	**CCSA**	**RA**
PW	-0.5224				
CA	-0.1462	0.2555			
CCSA	-0.3254	0.6558	0.2585		
RA	-0.2441	0.3451	0.2443	0.5493	
Growth Rate	-0.3025	0.4680	0.1757	0.5929	**0.7398**

Full: $Y = 3.097 - 1.299(PO) + 0.002(PW) - 0.324(CA) + 0.039(CCSA) + 0.004(RA)$

Reduced$_1$: $Y = 1.433 - 1.203(PO) + 0.002(PW) + 0.038(CCSA) + 0.004(RA)$

Reduced$_2$: $Y = 5.016 - 2.859(PO) + 0.0000424(PW) + 0.106(CCSA)$

Reduced$_3$: $Y = 2.5703 + 0.00538\ (RA)$

The regression model (full) explains roughly 51% (Adjusted r-squared = 0.5140) of the variation in growth rate, yet is highly significant (p = 0.0003). This significance indicates that some combination of the tested parameters has an effect on growth rate.

Growth rate predictions from this model are positive for all proposed crevasses at year zero, but growth slows over time (see Appendix B, Tables B-1 and B-2). The low adjusted r-squared indicates that other parameters, which are not included in this model, are important in determining growth rates as well. Parameters such as receiving bay depth, sediment load of the water column, flow velocity, river stage, and distance from main river channel could further explain the variability found in growth rates, but these were unavailable for the regression analysis. Using the available data, predictions of splay growth rates over the 20-year project life indicate that approximately 306 acres of emergent marsh may be achieved (see Appendix B, Table B-2).

Due to data quality concerns, some parameters were dropped from the analysis and reduced models were then re-calculated. For example, constructed crevasses are often re-dredged several years after the original construction date. Re-dredging may affect growth rates of the splay, causing growth to occur as if the crevasse was newly constructed. For this reason, crevasse age (CA) was dropped from the analysis, yielding a new regression equation (Reduced_1 – see above). This reduced model was highly significant ($p < 0.0001$) and explained nearly 53% of the variability in crevasse splay growth rates (Adjusted r-squared = 0.5284). This model projected a combined average growth rate of nearly 12 acres/year (see Appendix B, Table B-3). It is possible that receiving bay area is not a useful parameter to explain splay growth without also including receiving bay depth. Since receiving bay depth data was incomplete, a second reduced model was generated (Reduced_2 – see above) after dropping both receiving bay area (RA) and crevasse age (CA). Although this model yielded the highest growth estimates, it explained just 29% of the variability in growth (Appendix B, Table B-4), indicating that, in fact, receiving area is an important parameter in predicting growth rate.

Because the Reduced_2 model indicated the importance of receiving area in predicting growth rate, and receiving area was the only parameter highly correlated with growth rate (Table 1), a simple linear regression was performed to explore the relationship between receiving area and growth rate (Reduced_3). This model explained nearly 53% (r-squared = 0.5281) of the variability in growth rate and was highly significant ($p < 0.0001$). Growth rate predictions using this model yield, on average, nearly 24 acres/year (see Appendix B, Table B-5). This model explains nearly the same variability in growth rate as the full model, yet it indicates that other, unknown parameters are important in predicting growth rates as well.

It is important to look closely at the reduced models and realize that Reduced_1 gives the strongest estimation of splay growth as compared to the other models (explains 53% of the growth rate). Using this model, splay growth of 235.3 acres is projected after 20 years. While Reduced_2 and Reduced_3 project larger growth rates, Reduced_2 explains very little variability in growth rate (29%), and Reduced_3 takes into account only one crevasse parameter (see Appendix B). The discrepancy between the WVA and Ecological Review projected growth rates, 251 and 235 acres over 20 years, respectively, can be attributed to:

1. differences in data sources utilized,
2. use of a series of linear regressions in the WVA analysis as opposed to a multiple linear regression in this Ecological Review,
3. the designation of crevasse 1C as 2nd order in the WVA as opposed to 3rd order in this Ecological Review, and
4. the incorporation of project feature modifications into this Ecological Review analysis (i.e., the omission of crevasse 2A, due to the location of an existing pipeline, in favor of crevasses Alternate 2A and 2D).

It is worth noting that neither the WVA or the Ecological Review model accounted for the 120° angle of construction for crevasse 1B (see Appendix A). Emergent marsh building at this site may not meet projections which were based on the performances of previous crevasses built almost exclusively at the recommended 60° angle from the parent pass.

The regression models used in this Ecological Review are one method of predicting splay growth rates based on a set of parameters. Unfortunately, complete data on only five parameters were available for this analysis. Because the combination of these parameters explains roughly half of the variability in growth rate, it is likely that other parameters are important in determining the land-building ability of crevasses. Data on additional parameters (receiving bay depth, sediment load, water velocity, etc.) would be very useful in more accurately predicting splay growth rates for future projects. Based on previous literature showing the ability of artificial crevasse to enhance growth of emergent marsh, it is likely that marsh will be created over the 20-year life of the project. The total acreage of marsh that will be created, however, remains unclear. The data set (Appendix B, Table B-6) used in regression analysis is the most comprehensive currently available and it yielded growth predictions very similar to those from the project information sheet for wetland value assessment.

Terraces

Terrace construction is a sediment-trapping technique currently used in both Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) and state-funded restoration projects including Little Vermillion Bay Sediment Trapping (TV-12) and Sabine Terraces (CS-ST). Since 1991, the Sabine terraces have significantly reduced wave heights, decreased erosion, increased primary productivity, increased vegetation coverage, and re-established marsh (LDNR 1999). TV-12 terraces have shown extensive growth of vegetation and appear to be holding up well in the high-energy environment of Little Vermillion Bay. Vegetation plantings have progressed steadily since they were installed in mid to late summer of 1999. Most of the terraces are almost completely covered with vegetation, dominated by the spread of the *Spartina alterniflora* plantings (D. Castellanos, personal communication). However, based on observations of the 1996 Shell mitigation project, other terraces constructed from the dredged spoil of Little Vermillion Bay eroded at a rate of 4ft/yr (National Marine Fisheries Service 1999). The overall success of the BS-11 terraces may depend upon the survival of seashore paspalum and smooth cordgrass plantings on the crown and slope of the terraces, thus making the source and planting of the vegetation a vital component to project success.

VI. Summary of Findings:

Based on the evaluation of available engineering and ecological information, and the use of statistical analysis to determine the relationship between several independent crevasse parameters and splay growth rates, LDNR is confident that the project's physical effects will cause the desired ecological response. It is recommended that the Delta Management at Fort St. Phillip project be approved for CWPPRA Phase 2 funding.

In order to improve the CWPPRA project planning and selection process, post-construction monitoring should include the collection of receiving bay depths (some depth transects were taken during a site visit on August 24, 2001, see Appendix A), crevasse dimensions (both pre- and post-construction), distances water must flow from main river channel to crevasse, sediment loads of the water column, and water flow velocities through crevasses at certain river stages. Although these data are not necessary to determine project success, they would be invaluable additions to regression models that predict splay growth rates for future projects of similar design.

The U. S. Army Corps of Engineers is currently sponsoring the CWPPRA project Delta Building Diversion North of Fort St. Philip (BS-10), located immediately upstream of BS-11. The proposed project area for BS-10 overlaps BS-11 project area A. The conveyance channel proposed for BS-10 will be dredged near crevasse 1C. This conveyance channel may change flow patterns around crevasse 1C, thus changing the performance of the crevasse. Consultation between the respective CWPPRA project sponsors will be necessary so as not to undermine the goals of either restoration project.

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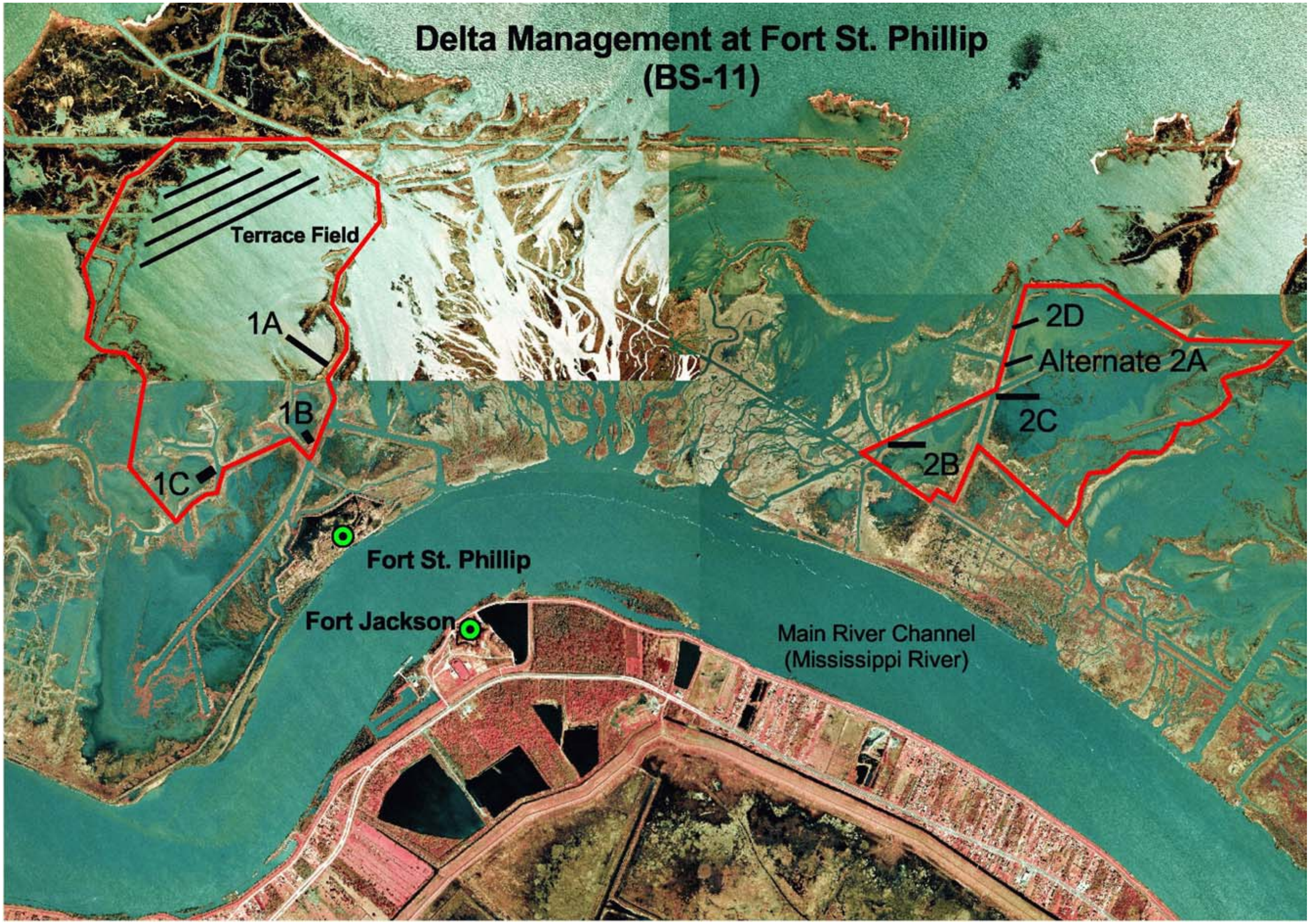
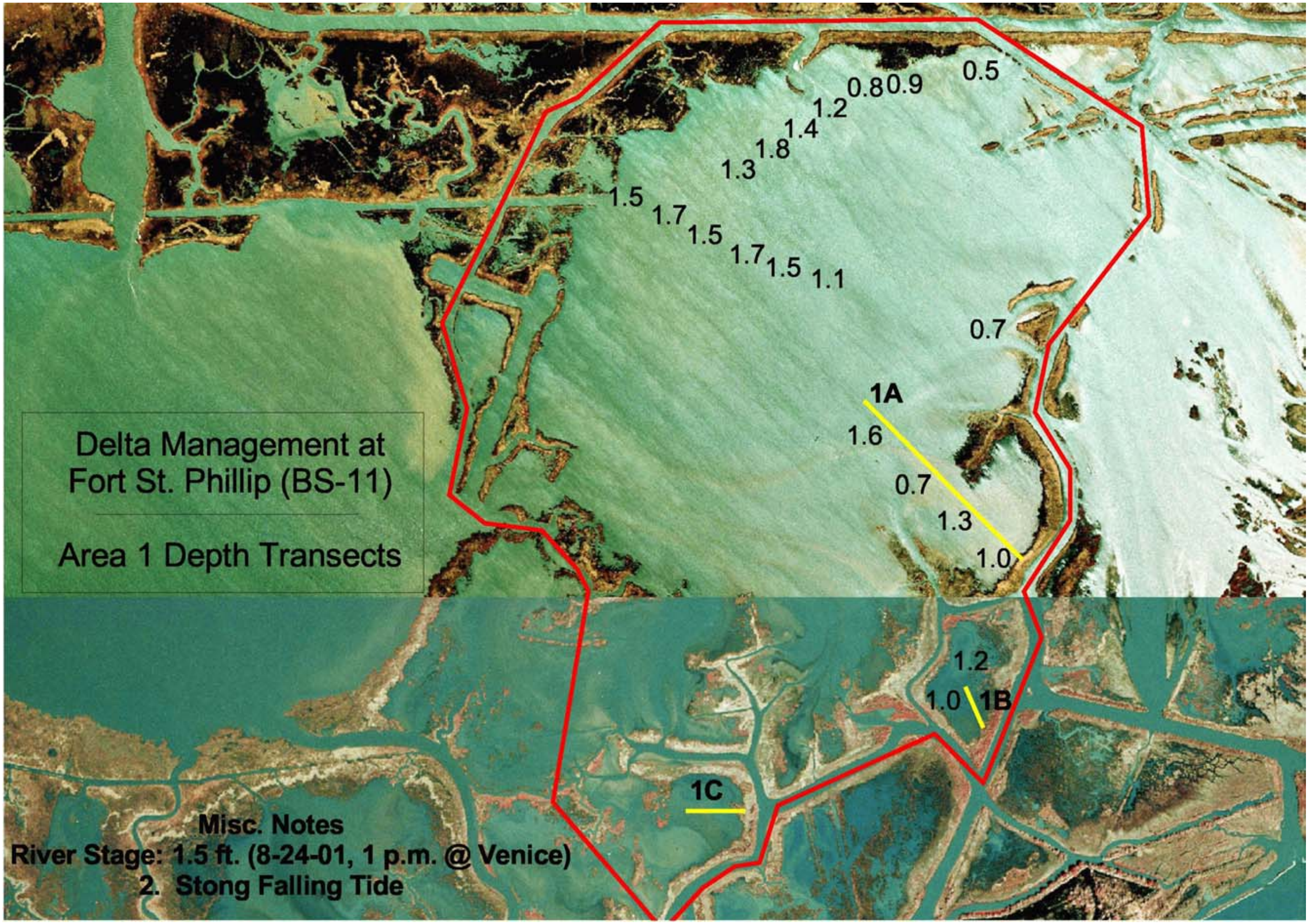
Appendix A

Delta Management at Fort St. Phillip (BS-11)

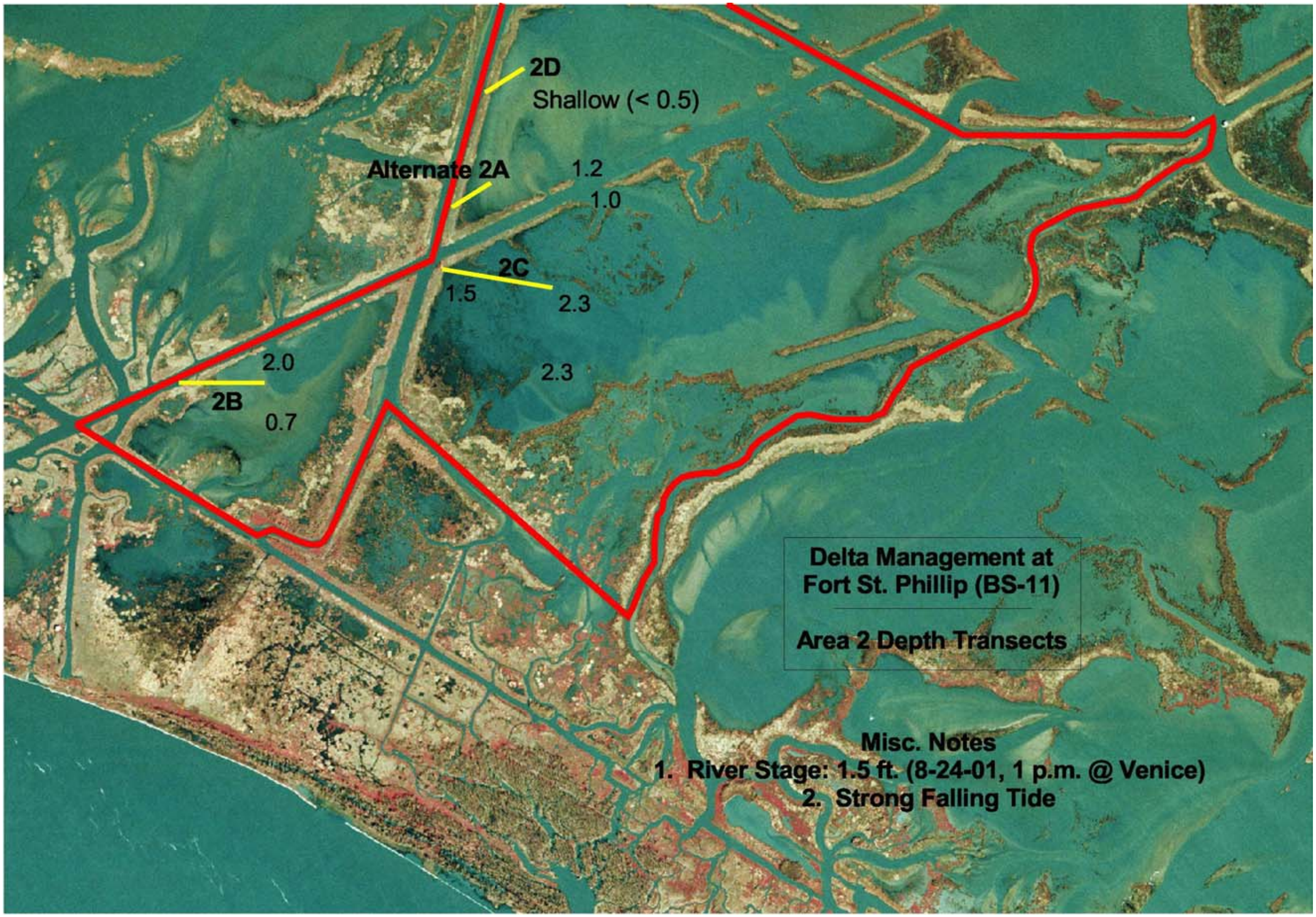




Delta Management at Fort St. Phillip (BS-11)

Area 1 Depth Transects

Misc. Notes
River Stage: 1.5 ft. (8-24-01, 1 p.m. @ Venice)
2. Stong Falling Tide



Delta Management at Fort St. Phillip (BS-11)

Area 2 Depth Transects

Misc. Notes

1. **River Stage: 1.5 ft. (8-24-01, 1 p.m. @ Venice)**
2. **Strong Falling Tide**

Appendix B

Table B-1. Growth rate predictions from proposed crevasses based on multiple linear regression equation (**Full**). Note that in the second grouping, crevasse age 4 is actually year 10 of the project life (TY10). The crevasse age is only 4 at this point due to the proposed re-dredging effort following TY5. Crevasse age 4 in the third grouping is actually year 20 of the project life (TY20) due to the re-dredging effort following TY15.

$$Y = 3.09722 - 1.29948(PO) + 0.00173(PW) - 0.32399(CA) + .03938(CCSA) + 0.00433(RA)$$

p = 0.0003
Adj. R-squared = 0.5140

Crevasse	Parent Order	Parent Width (yd)	Crevasse Age	Crevasse CSA (yd2)	Receiving Area (acres)		Growth Rate (acres/yr)
YEAR 1							
1A	2	120	0	66.7	610		5.97
1B	2	120	0	50	10		2.72
1C	3	80	0	50	17		1.38
Alt. 2A	3	90	0	66.7	45		2.18
2B	2	90	0	66.7	90		3.67
2C	2	90	0	66.7	295		4.56
2D	3	90	0	66.7	45		2.18
						Total	**22.65**
YEAR 10							
1A	2	120	4	66.7	610		4.68
1B	2	120	4	50	10		1.42
1C	3	80	4	50	17		0.08
Alt. 2A	3	90	4	66.7	45		0.88
2B	2	90	4	66.7	90		2.37
2C	2	90	4	66.7	295		3.26
2D	3	90	4	66.7	45		0.88
						Total	**13.58**
YEAR 20							
1A	2	120	4	66.7	610		4.68
1B	2	120	4	50	10		1.42
1C	3	80	4	50	17		0.08
Alt. 2A	3	90	4	66.7	45		0.88
2B	2	90	4	66.7	90		2.37
2C	2	90	4	66.7	295		3.26
2D	3	90	4	66.7	45		0.88
						Total	**13.58**

Table B-2. Growth rate predictions based on full regression model shown in Table B-1.

Project Life	**Crevasse Age**	**Growth Total (acres)**	**Cumulative Total (acres)**
0-1	0	22.65	22.65
1-2	1	20.38	43.03
2-3	2	18.11	61.15
3-4	3	15.85	76.99
4-5	4	13.58	90.57
5-6*	0*	22.65	113.22
6-7	1	20.38	133.60
7-8	2	18.11	151.72
8-9	3	15.85	167.56
9-10	4	13.58	181.14
10-11	5	11.31	192.45
11-12	6	9.04	201.49
12-13	7	6.77	208.27
13-14	8	4.51	212.78
14-15	9	2.24	215.01
15-16*	0*	22.65	237.66
16-17	1	20.38	258.05
17-18	2	18.11	276.16
18-19	3	15.85	292.01
19-20	4	13.58	305.58
	Total	**305.58**	

** re-dredged making crevasse age essentially 0 at years 5 and 15*

Table B-3. Growth rate predictions based on reduced model (**Reduced$_1$**) after dropping crevasse age from the analysis.

$$Y = 1.43268 - 1.20334(PO) + 0.00168(PW) + 0.03758(CCSA) + 0.00428(RA)$$

$p < 0.0001$
Adj. R-squared = 0.5284

Crevasse	Parent Order	Parent Width (yd)	Crevasse CSA (yd^2)	Receiving Area (acres)	Growth Rate (acres/yr)
1A	2	120	66.7	610	4.34
1B	2	120	50	10	1.15
1C	3	80	50	17	-0.09
Alt. 2A	3	90	66.7	45	0.67
2B	2	90	66.7	90	2.07
2C	2	90	66.7	295	2.95
2D	3	90	66.7	45	0.67
				Total	**11.76**
				Acreage after 20 years	**235.29**

Table B-4. Growth rate predictions based on reduced model (**Reduced$_2$**) after dropping crevasse age and receiving area from the analysis.

$$Y = 5.01606 - 2.8592(PO) + 0.00004238(PW) + 0.10631(CCSA)$$

$p = 0.0075$
Adj. R-squared = 0.2899

Crevasse	Parent Order	Parent Width (yd)	Crevasse CSA (yd^2)	Growth Rate (acres/yr)
1A	2	120	66.7	6.39
1B	2	120	50	4.62
1C	3	80	50	1.76
Alt. 2A	3	90	66.7	3.53
2B	2	90	66.7	6.39
2C	2	90	66.7	6.39
2D	3	90	66.7	3.53
			Total	**32.62**
			Acreage after 20 years	**652.40**

Table B-5. Growth rate predictions based on reduced model (**Reduced$_3$**), using only receiving area.

$$Y = 2.5703 + 0.00538(RA)$$

$p < 0.0001$
R-squared = 0.5281

Crevasse	Receiving Area (acres)	Growth Rate (acres/yr)
1A	610	5.85
1B	10	2.62
1C	17	2.66
Alt. 2A	45	2.81
2B	90	3.05
2C	295	4.16
2D	45	2.81
	Total	**23.97**
	Acreage after 20 years	**479.49**

Table B-6. Cumulative crevasse data from MR-01, Boyer (1996), and LDNR/CRD (1993). Data set used for multiple linear regression analysis.

Crevasse ID	Growth Rate (acres/yr)	Parent Order	Parent Width (ft)	Crevasse Age (yr)	Crevasse CSA (yd^2)	Receiving Area (acres)	Receiving Depth	Crevasse Length
PAL-1[1]	11	1	2750	10	346.7	3178	0.7	780
PAL-2[1]	7.94	1	1000	6	200	93	1.7	1400
MP-1[1]	13.6	1	1690	4	100	419		317
OP-1[1]	7.15	1	440	4	44.4	184		275
RP-1[1]	9.59	1	215	4	40	110	0.8	250
USFWS-1[1]	1.1	2	125	3	66.7	217		175
USFWS-2[1]	2.3	2	300	3	33.3	64		275
USFWS-3[1]	2.2	2	260	3	66.7	42		575
USFWS-4[1]	0.2	2	190	3	66.7	143		250
LDWF-2[1]	3.9	2	560	3	33.3	154	0.8	340
LDWF-3[1]	4	2	435	3	33.3	205	0.9	400
LDWF-4[1]	5.4	1	2125	3	50	88	1.3	858
LDWF-5[1]	0.5	3	125	3	33.3	192		75
83.1*	10.5	1	873	12	66.7	2520		1600
83.2*	1.5	2	341	12	66.7	2520		750
85.1*	8.2	2	1732	10	66.7	1829		925
86.1*	8.6	2	269	9	66.7	561		689
86.2*	5.7	2	262	9	66.7	561		722
86.3*	6.7	2	262	9	66.7	343		823
86.4*	6.5	2	262	9	66.7	343		
87.1*	24.6	1	1732	8	66.7	2108		1498
92.7*	1.6	3	262	3	66.7	173		1000
92.8*	3.7	2	217	4	66.7	4324		1282
92.9*	3	1	1693	4	66.7	529		1540
93.1*	0.6	2	167	2	66.7	4324		1130
92.6*	0.08	4	223	3	66.7	114		1000
93.2*	0.1	1	545	2	66.7	161		1000
PAL^	34.1	1	3169	5	241.6	3178	2	
SP^	74.6	1	1319	5	247	9005	1.3	
LP^	22.7	3	397	5	113	319	1	

1 = from MR-01 Monitoring Report (Kelley 1996)
* = from Boyer (1996) thesis
^ = from LDNR/CRD (1993) Accretion and Hydrologic Analysis of Three Existing Crevasse Splay Marsh Creation Projects at the Mississippi Delta

*** NOTE:** Five crevasses from Boyer (92.1, 92.2, 92.3, 92.4, and 92.5) were omitted because they were replicates of crevasses from MR-01. Data from MR-01 were used instead of Boyer (1996) data due to the finer scale of aerial photography used in MR-01.

Parent Order	Average Growth Rate	N
1	16.80	12
2	3.94	14
3	8.27	3
4	0.08	1