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PIPELINE CORRIDORS THROUGH WETLANDS — IMPACTS ON PLANT COMMUNITIES: BAYOU POINTE AUX CHENES, TERREBONNE PARISH, LOUISIANA

TOPICAL REPORT

(August 1991-April 1994)

Prepared by

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For

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16. Abstract (Limit 200 words)

The goal of the Gas Research Institute Wetland Corridors Program is to document impacts of existing pipelines on the wetlands they traverse. To accomplish this goal, 12 existing wetland crossings were surveyed. These sites varied in elapsed time since pipeline construction, wetland type, pipeline installation techniques, and right-of-way management practices. This report presents the results of a survey conducted on August 22, 1991, in an emergent intertidal estuarine wetland in Terrebonne Parish, Louisiana. The site includes three pipelines installed between 1958 and 1969. Vegetation within the site comprises three native tidal marsh grasses: *Spartina alterniflora, Spartina patens*, and *Distichlis spicata*. All three species occurred over the pipelines, within the right-of-way and in both natural areas. Vegetative differences attributable to the installation or presence of the pipelines were not obvious over the pipelines or in the habitat east of the pipelines. However, because of the presence of a canal west of the 1969 pipeline, vegetation was less abundant in that area, and *D. spicata* was absent from all but the most distant plots of the transects. Data obtained in the study indicate that when rights-of-way through brackish marsh are restored to their original elevations, they are revegetated with native vegetation similar to that in surrounding areas.

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Research Summary

Title	Pipeline Corridors through Wetlands — Impacts on Plant Communities: Bayou Pointe Aux Chenes, Terrebonne Parish, Louisiana
Contractor	Argonne National Laboratory
Principal Investigators	G.D. Van Dyke, L.M. Shem, and R.E. Zimmerman
Report Period	August 1991-April 1994
Objective	Document the historical impacts of pipeline rights-of-way (ROWs) on wetlands.
Technical Perspective	The impact of pipeline construction in wetlands is a very sensitive issue and one that is under strict regulatory control. Neither the natural gas industry nor the regulatory community has a documented basis to define the type, value, or environmental consequences of past pipeline activities in wetlands. This is one of a series of reports documenting these impacts. This data report is the result of field studies in an intertidal estuarine wetland in Terrebonne Parish, Louisiana. Extensive areas of this type of coastal marsh occur in Gulf Coast states and are often affected by gas transmission pipelines. The ROW at the study site included three parallel pipelines installed between 1958 and 1969.
Results	Vegetation throughout the site included three species of native tidal marsh grasses. All three species occurred within the ROW, in areas both over and away from the pipelines. No differences could be detected among the vegetation over the pipelines, that in other portions of the ROW, and that in adjacent natural areas (NAs) except for the area of an open canal that was devoid of emergent vegetation. This canal, not associated with the installation of the pipelines, occupied portions of the west side of the ROW and the west NA. A mosaic consisting of areas of vegetation, open water, and exposed muck was observed both within the ROW and in adjacent NAs away from the canal.
Technical Approach	A relatively homogeneous study site was selected within this coastal marsh wetland. The area selected occupied at least 1,000 meters along the ROW. Data on soils, hydrology, and plant coverage were collected from transect plots within both sides of the ROW and from

NAs on either side of the ROW. Plant data were analyzed to determine similarities and differences between the two sides of the ROW and the two adjacent NAs. ROW plots above the three pipelines were compared with those that did not overlie the pipelines.

Project Implications

This study shows that, within 22 years after installation of the pipeline, the ROW through this emergent intertidal estuarine wetland was revegetated by the same native perennial grasses occurring in the adjacent NAs without seeding, planting, or fertilization. The soil surface within the ROW had been restored to its approximate original contours. A canal, of unknown origin, within the study site remained open and provided access for local recreational traffic.

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Pipeline Corridors through Wetlands — Impacts on Plant Communities: Bayou Pointe Aux Chenes, Terrebonne Parish, Louisiana

by

G.D. Van Dyke, L.M. Shem, and R.E. Zimmerman

1 Introduction

1.1 Background

Pipelines for the distribution of natural gas traverse all types of terrain, including wetlands. Prior to the wetlands regulatory climate of the late 1980s and the early 1990s, the construction of right-of-way (ROW) corridors through wetlands was often welcomed by landowners and local communities; ROW corridors opened up wetlands, thereby providing public access. With the promulgation of more stringent regulations related to development activities (including no-net-loss wetland policies), an assessment of the historical impacts of pipeline ROWs through wetlands is needed to evaluate construction and reclamation methods, assist in future permit application processes, and evaluate future construction costs.

The Gas Research Institute (GRI) Wetland Corridors Program was designed to evaluate impacts of gas-pipeline construction and subsequent maintenance on wetlands. The data gathered through this GRI program provide a better understanding of the type, degree, and duration of impacts of various pipeline-construction techniques. This information will enable the industry to evaluate current construction practices and provide factual input to regulatory bodies.

Careful evaluation of the impacts of pipeline installation on wetlands is necessary because specific impacts may be beneficial to some plant and/or animal species and detrimental to others. Some impacts may appear to be detrimental when, in fact, they improve conditions for certain sensitive species or provide for greater diversity of species and habitat.

The initial questions addressed by the GRI Wetland Corridors Program are as follows:

1. Do ROW construction and/or management practices lead to differences in ROW plant communities with respect to adjacent wetland communities?

2. Does the ROW alter the diversity of the adjacent wetland community? If so, how far do the impacts extend?

3. Does the ROW enhance species diversity of the wetland?

4. Are there ROW construction and management practices that can enhance the positive contributions of ROWs to wetlands and minimize detrimental impacts?

Answers to these broad questions will provide information related to a number of more specific questions. Data on the type of plant communities that develop on ROWs in various wetlands when specific pipeline construction and management practices are utilized and comparison of the ROW plant communities with the plant communities in areas adjacent to the ROW will provide a basis for comparing environmental impacts of previous and current construction and management practices. Valuable data for such comparisons include numbers of plant species present, species that are dominant, percentage of the species that are native to the area, and fidelity of the plants to wetlands. Other measures of the quality of species present are also valuable, but those data are not available at present.

Concern exists as to whether pipeline corridors provide avenues of access for nonnative and invasive plants. Whether such plants become established along pipeline ROWs and from there invade adjacent areas, and the extent to which such invaders modify the plant communities in adjacent areas, are important to determining potential impacts of pipelines on wetlands.

Potential positive impacts are also important to assess. The degree to which ROWs provide habitat for rare or endangered species and other desirable species that are poorly represented in the adjacent areas is important information. Assessments of impacts of pipeline corridors on wetlands should also include the contribution of corridors to both plant and animal species diversity.

Answers to the above questions will assist the industry and regulatory agencies in evaluating current installation and management practices and making modifications that are beneficial to wetland quality enhancement.

1.2 Goals and Objectives

The goal of the GRI Wetland Corridors Program is to document impacts of existing pipelines on the wetlands they transverse. To accomplish this goal, 12 existing wetland crossings were surveyed. The sites evaluated differed in years since pipeline installation (ranging from 8 months to 31 years), wetland type, installation technology used, and management practices. Each wetland survey had the following specific objectives:

- Document vegetative communities existing in the ROW and in adjacent wetland communities;

- Evaluate similarities and differences between the plant communities in the ROW and in the adjacent wetland communities;

- Document qualitative changes to the topography, soils, and hydrology attributable to ROW construction; and

- Identify impacts caused by ROW construction on rare, threatened, endangered, or sensitive species.

These individual wetland objectives were fulfilled by the collection and analysis of field data and the presentation of those data and their analysis in nine individual site reports. An upcoming summary report further synthesizes and interprets the data from all individual sites.

The following sections constitute a data report on a field survey conducted on August 22, 1991, along an existing pipeline corridor traversing a tidal marsh wetland in Terrebonne Parish, Louisiana. The site includes three pipelines; the newest was installed 22 years prior to this study.

2 Description of Study Area

2.1 Site Selection and Location

Staff from a local pipeline company assisted the Argonne National Laboratory (ANL) team in selecting a site classified as a "Jurisdictional Wetland" under Section 404 of the Clean Water Act (see Appendix A). The site selected is near Bayou Pointe Aux Chenes in the Mississippi River Delta, approximately 50 miles southwest of New Orleans, Louisiana. The site is within the United States Geological Survey (USGS) Lake Bully Camp Quadrangle of Terrebonne Parish, approximately 300 m* south of Bayou Pointe Aux Chenes. The location of the study site is shown in Figure 1.

The study site includes three parallel natural gas pipelines, which cross Bayou Pointe Aux Chenes just north of the site. This site was selected because of the presence of a wetland that extended at least 200 m along the ROW and at least 50 m beyond each side of the ROW.

2.2 Soil

The soil in the Bayou Pointe Aux Chenes study site is classified as a Clovelly soil (Soil Conservation Service [SCS] 1984) — a dark grayish-brown or black, brackish, peaty soil that is very level, poorly drained, and found in saline marshes. These low-strength soils tend to liquefy when disturbed and are very poor for all uses other than for wildlife and recreation areas. Clovelly soil is further described by the SCS as a hydric soil (SCS 1991).

2.3 Hydrology

The water table at the study site is at the surface. The tidal range is about 0.2 m; the semifloating vegetative mat moves vertically with the tide so that it becomes inundated or fully exposed only during extreme weather events. Canals in the area remain full to their banks. The water is brackish, averaging about one half the salinity of sea water.

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* Measurements are given in metric units except where they were actually measured in English units; in these cases, metric equivalents are given in parentheses.

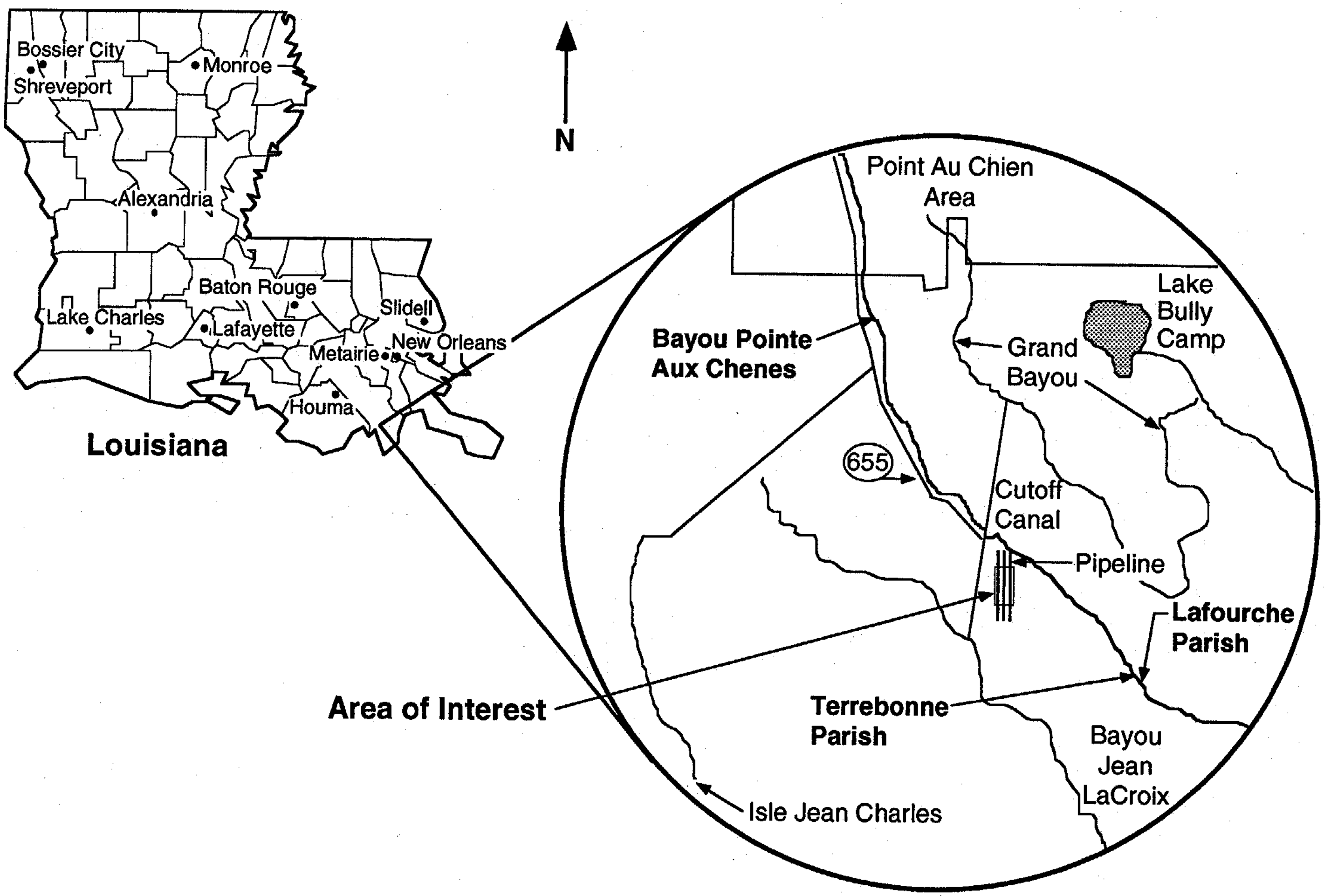

FIGURE 1 Location of the Bayou Pointe Aux Chenes Study Site in Terrebonne Parish, Louisiana

2.4 Climate

Terrebonne Parish has long, hot, humid summers and brief warm winters. Annual precipitation is 60 in. (152 cm), more than half of which occurs between April and September. The temperature ranges from 14°F (-10°C) to 97°F (36°C). The average summer temperature is 81°F (27°C), while winter temperatures average 54°F (12°C). The area is prone to hurricanes and subject to frequent winter storms off the coast (SCS 1984).

2.5 History and Management Practices

Area History. The Louisiana coastline is made up mostly of wetland marshes created by the deposition of sediments of the Mississippi River Delta. Since humans first started manipulating the flow of the Mississippi, with the establishment of New Orleans in the 1700s, the deposition of sediments has decreased and the wetlands of the delta have been subsiding (Chatry and Gagliano 1970). Other factors, such as rising sea levels, high wave energy at shorelines, gas exploration and production, hurricanes, and winter storms have also been determined to contribute to the loss of deltaic wetlands (Handley 1991). Between 1956 and 1978, approximately 700,000 acres of wetlands were lost in Louisiana (Handley 1991). In 1991, D.J. Reed reported that annual land loss from the Louisiana coast was more than 75 km^2.

The area surrounding the study site is criss-crossed by pipelines and by both natural and artificial canals. The Lake Bully Camp Quadrangle is considered to be one of the most active in the delta in terms of land loss and disturbance (Davis 1991). The topography consists of flat coastal marsh that includes a mosaic of slightly elevated mats of salt marsh grasses and areas of open water. Occasional muskrat lodges are scattered throughout the area.

Pipeline Construction. The three adjacent parallel pipelines, which lie 5 m apart, traverse the Bayou Pointe Aux Chenes study site within a ROW measuring 30 m wide. These pipelines were installed by conventional construction technology; a barge-mounted dredge was used for trenching and backfilling. The eastern pipeline is 18 in. (46 cm) in diameter and operates at 680 psi. The center pipeline, a 30-in.-diameter (76-cm-diameter) pipeline, operates at 688 psi. These two pipelines were installed between 1958 and 1964. The western pipeline, a 36-in.-diameter (91-cm-diameter) pipeline, was installed in 1969. This western pipeline was not in use at the time of the study but was maintained at a pressure of 50 psi. The pipelines are primary trunks in a natural gas collection system for a nearby compressing station. Figure 2 is a generalized cross-section of the study site, showing the location of the canal and the three pipelines. Plastic poles marked the location of the center pipeline along the ROW.

Post-Construction Activities and ROW Maintenance. No seeding of the ROW was performed after construction of any of the pipelines. Revegetation of the ROW was from naturally available seed banks and vegetative reproductive structures.

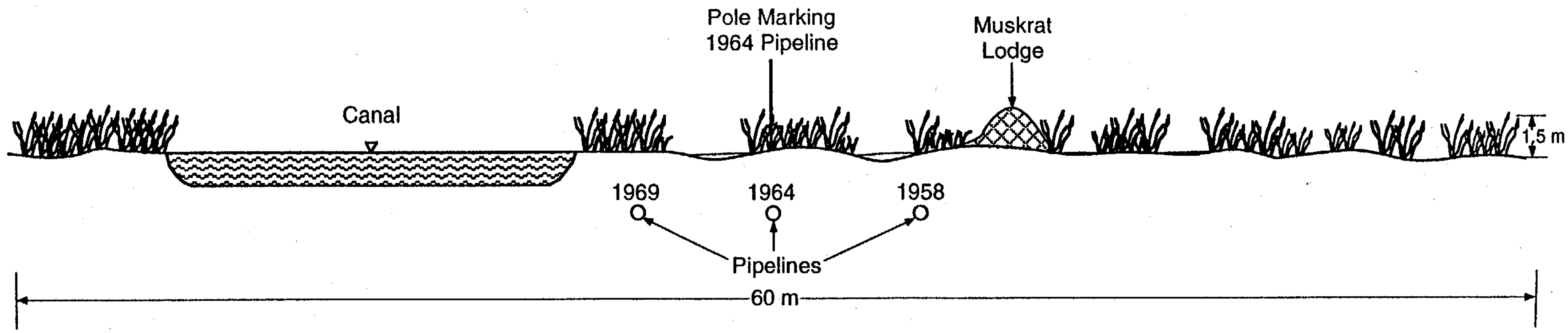

FIGURE 2 Generalized Cross-Section of the Study Site Showing the Location of the Canal and the Three Pipelines

Management practices consist of routine maintenance performed on the ROW to maintain access to the pipeline. At the Bayou Pointe Aux Chenes site, pipeline and ROW maintenance has been limited to required monitoring. Vegetation in this area does not interfere with the pipelines, and the concrete-weighted pipes have remained buried despite the unconsolidated state of the soil. If the pipes were to become exposed by severe storms or hurricanes, fill material like that used to fill the original trenches would be used to cover them. In 1992, Hurricane Andrew's winds buffeted this area; however, no damage requiring repair to the pipelines or ROW was reported (Estay 1993).

3 Approach and Methods

3.1 General Approach

The primary objectives listed in the Introduction (Section 1.2) provided the general guidelines for this study. To allow comparison of results across sites, methodologies for site reconnaissance, vegetation data collection, and data analysis used at this site were similar to those used at the other sites.

The vegetation on the ROW at this site was similar to that in the adjacent natural areas (NAs) and consisted of an herb stratum only. Because the ROW included three pipelines of different ages and a canal along the western edge, sampling techniques were adjusted to allow comparison of the vegetative communities within different sections of the ROW and the adjacent NAs.

3.2 Habitat Description

Three parallel pipelines of different ages traverse the study site in a south-to-north direction. The location of the center pipeline was marked by a series of plastic poles (see Figure 2). The other two pipelines are 5 m on either side, and the ROW extends 15 m to either side of the center pipeline, located approximately 8 m east of the open canal. The locations of the pipelines and the zones of disturbance associated with installation of each were not obvious from the vegetation or topography; it was impossible to visually determine the boundaries between habitats undisturbed by the pipeline activity (NAs) and those that had been disturbed.

3.3 Sampling Design for Vegetational Studies

Boundaries between the ROW and the adjacent NAs were not visible. For this reason and for reasons mentioned in Section 3.1, sampling was performed across habitats by using a technique designed to detect differences that might occur among the areas over the pipelines (5 m to either side of the plastic poles), within the ROW (15 m to either side of the poles), along the canal (8-20 m west of the poles), and in areas undisturbed by pipeline installation and maintenance.

Transects. Five transect stations were established, at 30-m intervals, along the line of poles marking the center pipeline. At each of these stations, transects were established at right angles to the pipeline and extending 30 m in either direction from the center of the pipeline (Figure 3). Consecutive 1-m × 1-m plots were marked along each transect, giving 30 plots per transect on either side of the pipeline, for a total of 300 plots.

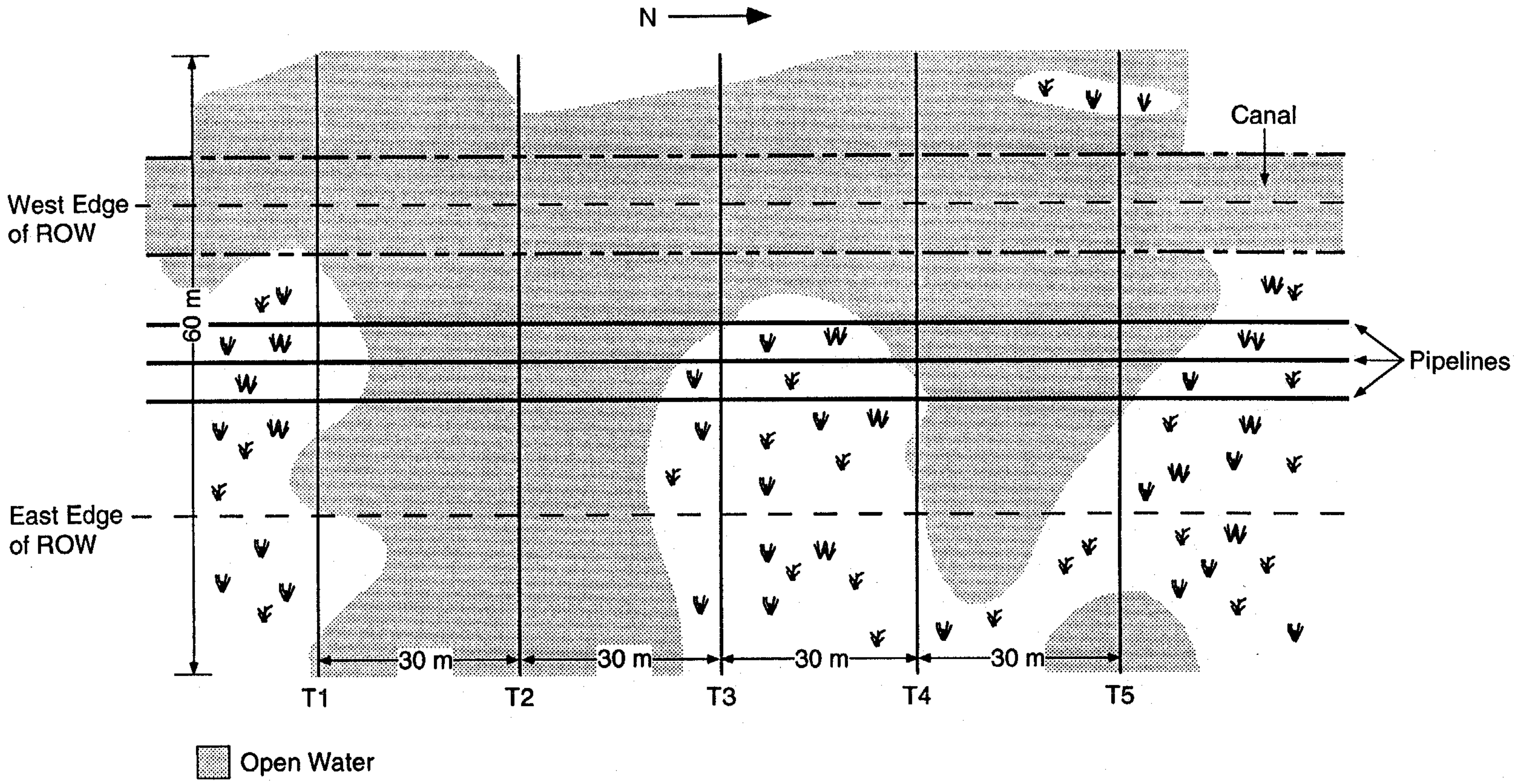

FIGURE 3 Plan View of the Study Site Showing Transect Length and Spacing

Sampling Procedures. A visual estimate of the percent of areal coverage was determined for each species present in each plot. Because plants of different species are frequently intermixed and may overlap, the sum of coverages for individual species on a plot may be more than 100%. Estimates were also made of the percentage of the soil surface covered by standing water and the percentage of exposed soil not covered by vegetation.

3.4 Data Analysis

Analyses of vegetative data collected from sampling plots for all 17 sites studied as part of the GRI Wetland Corridors Program were consistent. Analyses focused on comparing the plant communities on the ROW with those in the NAs and determining hydrophytic characteristics of the plant communities in each area. Particular attention was given to dominant species because they are used in several wetland delineation methods. Although the number of species dominant, species richness, and the variety of plant life-forms present are all aspects of community diversity, no diversity indices were calculated. Diversity indices that use coverage values as measures of species importance were considered, but they were judged inappropriate because of differences in the number of strata in the ROW and NAs for the sites included in the Wetland Corridors Program and because coverage values are not additive across strata.

Species Richness, Wetland Indicator Categories, and Species Characteristics. The total number of species present (species richness) was determined for each side of the ROW, for the total ROW, for each NA, and for the NAs combined. Wetland indicator categories (Reed 1988) were identified for each species in the study plots. These categories are defined in Appendix B, Section B.1. The number of species in each category was determined for each area by stratum and for all strata combined. Because one plant species could occur in any or all strata, when data from different strata were combined, each species was considered only once, independent of the number of strata in which it occurred. Species characteristics, including life-forms and origins, were also determined from Reed (1988). Symbols for life-forms and species origins are given in Appendix B, Section B.2.

Dominant Species. The definition of and methodology for the determination of dominant species in this study were taken from the 1989 Federal Manual (FICWD 1989). In the manual, dominance refers "strictly to the spatial extent of a species that is directly discernible or measurable in the field," as opposed to number of individuals present. Using this definition, dominant species were identified by plant stratum, rather than by total community. For each area, the dominant species were determined for each stratum by ranking each species in a plant stratum in descending order relative to total areal coverage of all plants in that stratum. The highest ranking species, which make up 50% of the total areal coverage or half of the total relative percent coverage (RPC), are the dominant species for that stratum. Any remaining species with 20% or more RPC are also considered dominant.

Community Similarity Indices. Sørensen's coefficient of community index (CC_S) was used to measure similarity between vegetative communities (Brower, Zar, and von Ende 1990). This index uses the following formula:

$$CC_S = 2c/(a+b) \tag{1}$$

where

a = the number of species in community A,

b = the number of species in community B, and

c = the number of species in common between communities A and B.

A CC_S value of 1.00 indicates 100% similarity in species composition between communities A and B. A value of 0.00 represents no species in common. Community similarity indices that use coverage values as measures of species importance were considered, but they were judged inappropriate because of differences in the strata present in the plant communities on the ROW compared to those in the NAs and because of the nonadditive characteristic of coverage data.

Comparisons were made between the combined ROWs and combined NAs, the two portions of the ROW, each portion of the ROW and its adjacent NA, and the two NAs.

Prevalence Index Values. Prevalence index values (PIVs) were calculated according to methods outlined in the 1989 Federal Manual (FICWD 1989), substituting RPC data from quadrat coverage estimates for relative frequencies from intercept data. This substitution is logical because both relative frequency and RPC are estimates of relative coverage (Bonham 1989). The PIV is an average wetland indicator value ranging from 1.0 to 5.0 and weighted by the RPC. Because areal coverage was determined by stratum, the PIVs were calculated for each area by stratum only. The average RPCs for each species in the five plots in each area were used in calculating the PIV for the area. The equation for calculating a PIV is presented in Appendix B, Section B.3.

Average Wetland Values. Average wetland values (AWVs) (Zimmerman et al. 1991) were calculated for the species in each of the five areas. This index is an average of the wetland indicator values for all plants present. It differs from the PIV in that it is not weighted by RPC; rather, all plants present are represented equally, regardless of their frequency of occurrence. Because areal coverage is not considered, the calculation of an index value is not restricted to one vegetative stratum. An overall site AWV was determined, as well as values for each stratum. See Appendix B, Section B.4, for the equation.

4 Results

4.1 General Ecology

This site is located in an emergent intertidal estuarine system as defined by Cowardin et al. (1979). Except for the canal, it consists of stands of marsh grasses with varying density and open water. At the time of sampling, the water was brackish, with a salinity of approximately 1.8% (approximately half that of seawater), and the tidal range at the site was approximately 0.2 m (Rozas 1991).* In some areas, unvegetated peaty soil (muck or semiconsolidated matter) was exposed above the water level, especially at low tide.

A canal occupied the area between 8 and 20 m west of the center pipeline markers. This canal was approximately 1 m deep at the time of sampling. It appeared that vegetation in areas adjacent to the canal was less dense than that throughout the general area. No vegetation occurred in any transects between 9 and 19 m west of the markers, and only one transect contained any vegetation between 8 and 9 m and between 19 and 20 m west of the markers.

It was not possible to visually distinguish the boundaries of the ROW. The vegetation over the pipelines appeared no different than that in areas east of the ROW. Also, it was not possible to distinguish the boundaries of disturbance of ROW vegetation related to the installation of the most recently placed pipeline (1969).

In densely vegetated areas, the rhizomes and fibrous roots of the grasses stabilized the soils enough to allow easy walking. In other areas, the vegetative mat would not support the weight of a person. In areas of exposed soil and areas of open water, solid footing occurred about 75 cm below the surface.

4.2 Plant Community

Vegetation within the site was composed of three native tidal marsh grasses: saltmarsh cordgrass (*Spartina alterniflora*), saltmeadow cordgrass (*Spartina patens*), and seashore saltgrass (*Distichlis spicata*). Table 1 lists the field numbers, scientific authorities, wetland indicator categories, origins, and life-forms for these species. All three species were present within the sampling plots.

Field data, consisting of percent areal coverage estimates by plant species, percentage of exposed soil at the surface, and percentage of the surface covered by standing water for each plot, are given in Appendix C. Tables in Appendix C present the data for the east and west transects.

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* Rozas provided estimates of percent salinity and tidal range on the basis of his knowledge and working experience in the area.

TABLE 1 Plant Species Found in the Bayou Pointe Aux Chenes Study Site

Field Number	Scientific Name and Authority	Common Name	Region 2 Wetland Indicator Category[a]	Life-Form/ Origin[b]
1	*Distichlis spicata* (L.) Greene	Seashore saltgrass	FACW+	PNG
2	*Spartina alterniflora* Loiseleur	Saltmarsh cordgrass	OBL	PNEG
3	*Spartina patens* (Ait.) Muhl.	Saltmeadow cordgrass	OBL	PNG

[a] Wetland indicator categories are assigned to plants in the United States on a regional basis. Louisiana is in Region 2. FACW = facultative wetland, OBL = obligate wetland. A "+" indicates a frequency toward the high end of the category (more frequently found in wetlands).

[b] Plant characteristics and life-forms assigned to each species are indicated in this column: P = perennial, N = native, E = emergent, and G = grass. See Appendix B for more detailed information.

Average values were calculated separately for the five individual meter-square plots, which were equidistant from the center pipeline along the five transects for the east and west habitats. Table 2 presents these average percent coverage values for individual species, the sum of individual species coverages, exposed soil, and surface water.

In addition, average percent coverages were calculated for the following intervals east and west of the markers: the east and west sides of the ROW (0-15 m east and west of the markers), the areas over the pipeline (0-5 m east and west of the markers), the east and west portions of the ROW not over the pipeline (5-15 m east and west of the markers), and the east and west NAs (15-30 m east and west of the markers). Averages for the west transects were also calculated, without including the canal area (8-20 m west of the markers). Table 3 presents the averages calculated by interval for the east and west transects.

Summing the coverages of individual species gave a total average percent coverage of 50.0% for the east transect area and 23.5% for the west transect area, excluding the canal. Open water covered 58.6% of the surface in the east transect area and 74.4% in the west transect area when canal plots were excluded. When canal plots were included, open water covered 84.7% of the west transect area. Exposed soil constituted 7.0% of the surface area along the east transects and 10.5% along the west transects (with canal plots excluded).

For the east transects, the sum of the average areal coverages for the three individual species in the plots over the pipelines, 43.4%, was higher than the 37.6% coverage in the portion of the ROW east of the pipelines but lower than the 61.7% coverage in the NA. The percentage of

TABLE 2 Average Percent Coverage for Individual Species, All Species, Exposed Soil, and Standing Water by One-Meter Intervals from the Center Pipeline

Distance from Center Pipeline (m)	Average Coverage (%)											
	Transects in Area East of Center Pipeline						Transects in Area West of Center Pipeline					
	SA[a]	SP[b]	DS[c]	Total[d]	Soil[e]	Water[f]	SA	SP	DS	Total	Soil	Water
0-1	14.0	9.0	2.0	25.0	20.0	60.0	20.0	19.0	0.0	39.0	17.0	60.0
1-2	9.0	20.0	0.0	29.0	13.0	60.0	12.0	17.0	0.0	29.0	16.0	61.0
2-3	38.0	11.0	5.0	54.0	5.0	55.0	8.0	9.0	0.0	17.0	6.00	85.6
3-4	37.0	13.0	1.0	51.0	8.0	45.0	6.8	5.0	0.0	11.8	17.0	78.0
4-5	30.0	20.0	8.2	58.2	21.0	32.0	0.0	1.0	0.0	1.0	19.0	80.0
5-6	34.0	16.2	16.0	66.2	20.0	28.0	0.6	4.0	0.0	4.6	16.0	80.0
6-7	24.0	16.8	4.0	44.8	9.4	55.6	0.0	0.0	0.0	0.0	20.0	80.0
7-8	16.0	14.0	1.0	31.0	4.0	75.0	1.0	3.0	0.0	4.0	16.0	80.0
8-9	12.0	9.0	12.0	33.0	0.0	75.0	4.0	0.0	0.0	4.0	0.0	98.0
9-10	10.0	15.0	2.0	27.0	0.0	82.0	0.0	0.0	0.0	0.0	0.0	100.0
10-11	11.0	11.0	0.0	22.0	0.0	88.0	0.0	0.0	0.0	0.0	0.0	100.0
11-12	16.0	20.0	0.0	36.0	3.0	67.0	0.0	0.0	0.0	0.0	0.0	100.0
12-13	18.0	22.0	2.0	42.0	5.0	67.4	0.0	0.0	0.0	0.0	0.0	100.0
13-14	17.0	17.0	2.0	36.0	5.0	61.6	0.0	0.0	0.0	0.0	0.0	100.0
14-15	13.0	17.0	8.0	38.0	2.0	68.0	0.0	0.0	0.0	0.0	0.0	100.0
15-16	20.6	14.0	2.0	36.6	4.0	70.0	0.0	0.0	0.0	0.0	0.0	100.0
16-17	13.2	11.0	2.0	26.2	12.0	71.6	0.0	0.0	0.0	0.0	0.0	100.0
17-18	16.4	14.0	8.0	38.4	20.0	52.0	0.0	0.0	0.0	0.0	0.0	100.0
18-19	18.6	40.0	16.2	74.8	18.0	46.0	0.0	0.0	0.0	0.0	0.0	100.0
19-20	28.4	42.0	3.0	73.4	6.0	46.0	1.0	0.0	0.0	1.0	0.0	99.6
20-21	22.0	52.0	1.4	75.4	1.0	40.0	13.0	4.0	0.0	17.0	0.0	95.6
21-22	18.0	50.0	8.0	76.0	14.0	33.0	7.0	10.0	0.0	17.0	0.0	87.6
22-23	30.2	30.0	5.0	65.2	0.0	66.0	10.0	1.4	0.2	11.6	0.0	88.0
23-24	30.0	45.0	6.0	81.0	1.0	50.0	5.0	5.4	0.0	10.4	0.0	91.8
24-25	40.0	40.0	10.0	90.0	3.0	46.0	5.0	16.0	0.0	21.0	0.0	82.0
25-26	18.0	24.6	10.0	52.6	2.0	69.0	3.0	3.0	0.2	6.20	16.0	79.0
26-27	37.0	26.0	12.0	75.0	0.0	50.0	38.8	8.0	0.0	46.8	16.0	62.0
27-28	30.0	25.0	14.0	69.0	0.0	61.0	45.2	11.0	0.0	56.2	2.0	58.8
28-29	14.0	14.2	18.0	46.2	0.0	69.0	53.0	26.0	0.0	79.0	16.0	34.0
29-30	14.4	15.2	16.2	45.8	4.0	66.8	30.0	22.0	0.0	52.0	12.0	56.0

[a] SA = *Spartina alterniflora.*
[b] SP = *Spartina patens.*
[c] DS = *Distichlis spicata.*
[d] Signifies the sum of coverage values for individual species, rather than total area covered.
[e] Exposed mucky soil.
[f] Standing water.

TABLE 3 Average Percent Coverage for Individual Species, All Species, Exposed Soil, and Standing Water by Various Intervals East and West of the Center Pipeline

Distance from Center Pipeline (m)	Average Coverage (%)											
	Transects in Area East of Center Pipeline						Transects in Area West of Center Pipeline					
	SA[a]	SP[b]	DS[c]	Total Cover[d]	Soil[e]	Water[f]	SA	SP	DS	Total Cover	Soil	Water
0-30	21.5	22.5	6.0	50.0	7.0	58.6						
0-15	19.9	15.4	4.2	39.5	7.7	61.3						
0-5	25.6	14.6	3.2	43.4	13.4	50.4						
5-15	17.1	15.8	4.7	37.6	4.8	66.8						
15-30	23.4	29.5	8.8	61.7	5.7	55.8						
0-8												
20-30							14.4	9.1	0.02	23.5	10.5	74.41
0-8							6.1	7.1	0.0	13.2	15.8	75.58
5-8							0.5	0.5	0.0	2.9	17.3	80.0
20-30							21.0	10.7	0.04	31.7	6.30	73.4

[a] SA = *Spartina alterniflora.*
[b] SP = *Spartina patens.*
[c] DS = *Distichlis spicata.*
[d] Signifies the sum of coverage values for individual species, rather than total area covered.
[e] Exposed mucky soil.
[f] Standing water.

the surface covered by water was lower over the pipelines than in the remainder of the ROW or the NA. The percentage of exposed soil was highest over the pipelines.

For the west transects, exposed soil constituted 15.0% of the surface in plots over the pipelines, 17.3% in plots between the pipelines and the canal, and 6.3% in plots in the NA west of the canal. In individual plots, the percentage covered by standing water ranged from 0 to 100% and the percentage of exposed soil ranged from 0 to 80%.

Species Richness and Similarity Indexes. With only three species present, species richness was obviously very low. All three species occurred in every habitat except the west side of the ROW, where seashore saltgrass was absent. Thus, all community similarity indexes, used in comparing habitats, are equal to 1 except those involving the west side of the ROW, which equal 0.67.

Of the 240 plots (excluding the canal), 220 contained two or more species. Twenty-seven of these contained all three species. Saltmarsh cordgrass occurred alone in 19 plots, saltmeadow cordgrass occurred alone in one plot, and seashore saltgrass did not occur alone in any plot.

Dominance. Two grasses, saltmarsh cordgrass and saltmeadow cordgrass, were co-dominant species in both sides of the ROW and in the NAs. Table 4 gives the relative percent coverage for each species within each area. In all subareas except the east NA, these two species constituted more than 90% of the total relative coverage. The percent coverage for these two species within the four subareas was similar. The difference in relative coverage of seashore saltgrass, 12% in the east transects and less than 1% along the west transects, was much greater than the differences for the two cordgrasses.

TABLE 4 Relative Percent Coverage for Dominant Species in Various Areas within the Sampling Site

	Relative Percent Coverage by Dominant Species	
Area of Interest	*Spartina alterniflora*	*Spartina patens*
Both NAs[a]	45	44
East NA	38	48
West NA[a]	66	34
Total ROW[a]	51	43
East side of ROW	52	40
West side of ROW[a]	46	54

[a] These values are based on averages of all plots in the area, excluding plots within the canal boundaries (between 8 and 20 m west of the marker poles).

Wetland Indicator Categories, Prevalence Index Values, and Average Wetland Values. PIVs and AWVs are presented in Table 5. The two cordgrass species are obligate wetland (OBL) species. The seashore saltgrass is a strong facultative wetland (FACW+) species. Calculation of PIVs and AWVs (Table 5) by using the methods described in Section 3.4 results in AWVs of 1.33 for all habitats east of the 1969 pipeline, because all habitats involve all three species. PIVs for the various areas of the study site differ little — ranging from 1.07 for the area over the pipelines to 1.14 for the NA east of the ROW. Because the seashore saltgrass is a minor component of these habitats, it has only small effects on the PIVs.

The PIVs for all areas west of the 1969 pipeline are equal to 1.00, because only a very small amount of the seashore saltgrass was present. Its presence in the NA resulted in an AWV for that area of 1.33, while all other areas had values of 1.00.

TABLE 5 Prevalence Index and Average Wetland Values for the East and West Sampling Areas and Habitats within Areas

Area Represented	Distance from Center Pipeline (m)	Transects in Area East of 1969 Pipeline		Distance from Center Pipeline (m)	Transects in Area West of 1969 Pipeline, (Excluding Canal)	
		PIV	AWV		PIV	AWV
Total habitat	0-30	1.12	1.33	0-30	1.00	1.33
ROW habitat	0-15	1.10	1.33	0-15	1.00	1.00
Area over pipelines	0-5	1.07	1.33	0-5	1.00	1.00
ROW not over pipelines	5-15	1.12	1.33	5-8	1.00	1.00
NA	15-30	1.14	1.33	20-30	1.00	1.33

5 Discussion

Neither general observations nor the results of data analysis revealed any obvious differences between the vegetation that occupies the area previously disturbed by pipeline installation and that in the area east of this, beyond the direct effects of such disturbance. Analysis of data by intervals allowed the various areas to be represented. The ROW was subdivided into two sides, and each side was subdivided into the area over the pipelines (0-5 m) and the area not over the pipelines (5-15 m). The NA on each side was also treated as a separate area. Because the canal that crossed the transects west of the 1969 pipeline contained no vegetation, it was excluded from species data analyses.

Although specific construction details are not available, stabilization of the pipelines with backfill may account for the higher percentage of exposed soil over the pipelines and between the pipelines and the canal. However, general observations of the area around the study site indicate that such variations in exposed soil also occur randomly and may be related to natural phenomena, such as muskrat activity, tides, and storm action.

Vegetation throughout the area is patchy, as indicated by transect data. Saltmarsh cordgrass is the most robust of the three plants occupying this site, reaching heights of 2 m and often forming monotypic stands in areas adjacent to open water with relatively high salinity from frequent tidal inundation (Eleuterius 1990). Saltmarsh cordgrass was the leading dominant in the plots of the west transects adjacent to the canal, where wave action from boats using the canal would be most severe; east of the pipeline, it was also more abundant than saltmeadow cordgrass, but by a smaller percentage. Saltmeadow cordgrass is reported as being abundant in dense stands on higher elevations of saline marsh; within the study plots, it was most abundant within established clumps of saltmarsh cordgrass. Seashore saltgrass is described by Eleuterius as having culms 15-45 cm tall, making it the smallest of the three species present. The saltgrass had the least areal coverage and was almost completely limited to the east transect plots. It is also described as being abundant on the higher elevations of tidal marshes; it is possible that the wave action from boats using the canal excludes saltgrass from transect plots that lie within 10 m on either side of the canal. The species did occur in plots over the pipelines.

Two OBL species and one FACW+ species were present in the transect plots. All three species occurred over the pipelines, within the ROW, and in the NAs. All AWVs and PIVs depicted extremely hydric vegetation because the two dominant species were both OBL species.

The level of disturbance directly attributable to pipeline construction may be insignificant when compared to that arising from other changes affecting this delta. Handley (1991) cites rising sea levels, subsidence, high wave energy, loss of sediment input, hurricanes, winter storms, urbanization, agriculture, and oil and gas exploration and production as factors contributing to the loss of wetlands along the Louisiana Gulf coast. Numerous papers describe how these factors affect brackish marshes. Reed (1988) reports on sediment deposition and the rising sea level. Cahoon (1991) also addresses sediment dynamics in coastal marshes. Nyman and DeLaune (1991) discuss hurricane influences involving increased tidal turbidity (brought inland by offshore winds as the hurricane approaches) and accumulated sediment, along with some previously deposited organic matter (washed back out to sea by onshore rains that follow the hurricane inland).

The high degree of similarity among the areas east of the 1969 pipeline (including the area over the pipelines), the remainder of the ROW, and the NAs suggests that lasting impacts associated with pipeline installation and maintenance are slight. The less dense vegetation and absence of seashore saltgrass on the west portion of the ROW and in all but the most distant plots in the west NA seem to be related to the presence of the canal. Human impacts in this study site appear to be associated most directly with the canal, which runs just west of and parallel to the pipelines. It was not possible to determine the origin of the canal; however, pipeline representatives claimed that it did not result from installation of the pipelines. Use of the canal by recreational and fishing boats and for pipeline surveillance has maintained it as an open waterway. Local canals were being used at the time field sampling was conducted.

6 Summary and Conclusions

6.1 Summary

As stated in Section 1, the primary goal of the GRI Wetland Corridors Program is to identify and evaluate the impacts of pipeline construction and ROW maintenance on the wetlands that the pipelines and ROWs traverse. To accomplish this goal, pipelines crossing various wetlands throughout the eastern United States were surveyed. The objectives for each study site were to document the vegetative communities on the ROW and on adjacent NAs that were not disturbed by pipeline construction; evaluate the similarities and differences between the plant communities on the ROW and on the adjacent NAs; document changes to the topography, soils, and hydrology attributable to ROW construction; and identify impacts caused by ROW construction on rare, threatened, endangered, or sensitive species.

This study involved collecting and analyzing data from a site in the Louisiana coastal delta, a brackish marsh near Bayou Pointe Aux Chenes and just south of the Bayou Pointe Aux Chenes levee. The site contained three pipelines, installed between 1958 and 1969. No vegetative differences attributable to the installation or presence of the pipelines could be found in transects running east from the center of the center pipeline, crossing the eastern pipeline, and projecting into the natural vegetation east of the ROW. The same three native coastal marsh grasses occur at the same relative percentages over the pipelines and on the ROW as in the NA to the east.

Transects running west from the central pipeline and crossing the western pipeline and the canal depict the impact of the canal (these areas are void of vegetation). One of the grasses, seashore saltgrass, was absent from all but the westernmost plots in these transects; the other two grasses were present in lesser amounts in the west transects than east of the pipeline. No non-native species were present in either area.

6.2 Conclusions

Evidence presented in this report supports the conclusion that ROWs through this type of brackish marsh can and have become revegetated with native vegetation similar to that in surrounding areas within 22 years following pipeline installation if the soil elevation is returned to pre-installation levels. How rapidly revegetation occurred could not be determined. The canal near these pipelines created conditions that retarded revegetation within and adjacent to it. This canal, which allegedly is not associated with the installation of the pipelines, demonstrates the detrimental effects such canals can have on revegetation and stabilization of the canal banks.

Both the field data collected during this study and general observations in the area around the study site indicate that the impacts of pipeline installation in this area are temporary when original contours are restored. Native species present in the area reinvaded the ROW and no new species were introduced following development of the ROW. The percentage of the surface area consisting of vegetative coverage, standing water, and exposed soils was similar in the ROW and adjacent NAs.

7 References

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Appendix A:

Definition of Jurisdictional Wetlands

Appendix A: Definition of Jurisdictional Wetlands

Wetland identification and delineation necessary to implement Section 404 of the Clean Water Act and the "Swampbuster" (Subtitle B) provision of the Food Security Act of 1985 involves four agencies: the U.S. Army Corps of Engineers (COE), the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (FWS), and the Soil Conservation Service (SCS). On January 10, 1989, these agencies, which had operated with slightly different definitions of wetland, adopted a uniform definition based on hydrology, vegetation, and soils.

The joint agreement stipulates that to be classified as a Jurisdictional Wetland, an area must have hydrotrophytic vegetation, hydric soils, and a wetland hydrology. All three criteria are mandatory; without any one criterion, the area is not a Jurisdictional Wetland. A schematic diagram of this delineation process is shown in Figure A.1. See the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* for a more detailed discussion of the various terms and criteria (FICWD 1989).

Problems uncovered during field trials of the 1989 Federal Manual and disagreement among the four agencies on revisions in 1991 resulted in the EPA and the COE reverting to use of the 1987 *COE Wetlands Delineation Manual*, which also defines wetlands on the basis of vegetation, hydric soils, and hydrology, but with slightly different definitions of these parameters. In January 1994, the four agencies entered into a joint Memorandum of Agreement, "Concerning the Delineation of Wetlands for Purposes of Section 404 of the Clean Water Act and Subtitle B of the Food Security Act," which, in broad terms, stipulates that the EPA and the COE will accept SCS procedures for delineating wetlands (SCS 1988) on agricultural lands and that SCS will use the 1987 *COE Wetlands Delineation Manual* (COE 1987) for areas that are not agricultural lands.

The individual reports on the pipeline crossings through wetlands that are part of the GRI Wetland Corridors Program use the definition and criteria of the 1989 Federal Manual that were in effect during 1990 and 1991, the first two years of these studies. The use of the rigorous criteria of the 1989 manual should provide sufficient information for application to other procedures in the evolving field regulatory procedures for delineation and preservation of jurisdictional wetlands.

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COE: see U.S. Army Corps of Engineers.

Federal Interagency Committee for Wetland Delineation, 1989, *Federal Manual for Identifying and Delineating Jurisdictional Wetlands,* U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S. Department of Agriculture, Cooperative Technical Publication, Washington, D.C.

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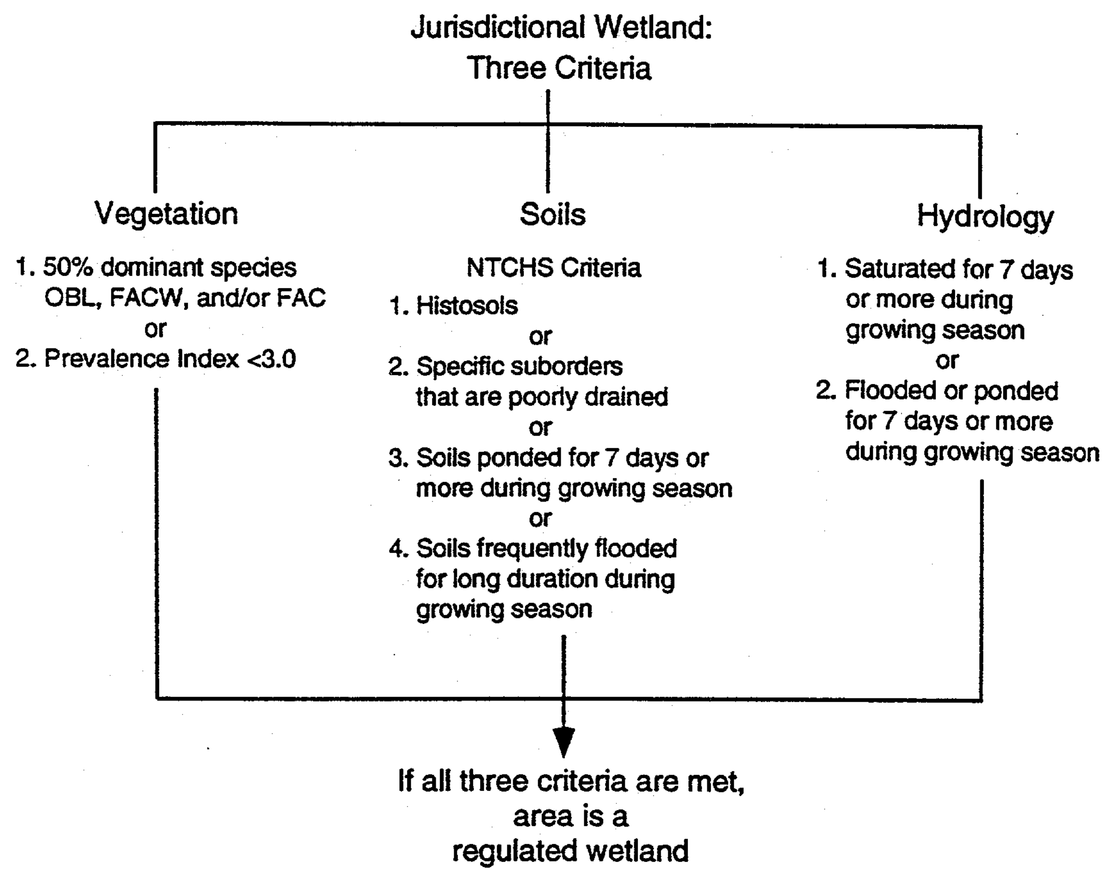

FIGURE A.1 Schematic Diagram of the Wetland Delineation Process (Source: FICWD 1989)

Appendix B:

Data Analysis — Definitions and Equations

Appendix B: Data Analysis — Definitions and Equations

B.1 Wetland Indicator Categories

Wetland indicator categories used in this report to classify the types of plant species were taken from Reed (1988). The five basic categories, commonly called the "wetland indicator status," are based on frequency of occurrence in wetlands. They are defined as follows:

Category	Value	Definition
Obligate wetland (OBL)	1.0	Plants that almost always occur in wetlands under natural conditions (estimated probability >99%)
Facultative wetland (FACW)	2.0	Plants that usually occur in wetlands (estimated probability 67-99%) but occasionally are found in nonwetlands
Facultative (FAC)	3.0	Plants that are equally likely to occur in wetlands or nonwetlands (estimated probability 34-66%)
Facultative upland (FACU)	4.0	Plants that usually occur in nonwetlands (estimated probability 67-99%) but occasionally are found in wetlands (estimated probability 1-33%)
Obligate upland (UPL)	5.0	Plants that almost always occur in nonwetlands under natural conditions (estimated probability >99%)

B.2 Life-Form and Origin

The life-form and origin symbols are used for describing plant characteristics. The following symbols are used:

Symbol	Life-Form or Origin
A	Annual
B	Biennial
E	Emergent
F	Forb
F3	Fern
G	Grass
GL	Grasslike
H2	Horsetail
I	Introduced
N	Native
P	Perennial
S	Shrub
T	Tree
V	Herbaceous vine
WV	Woody vine

Symbols are combined to describe the life-form and origin; for example, ANG means annual native grass and PIEF means perennial introduced emergent forb. For further description refer to the report by Reed (1988).

B.3 Prevalence Index Value

The prevalence index value (PIV) was determined by using the method outlined in the 1989 Federal Manual (FICWD 1989). The PIV, modified for this report to use relative percent areal coverage instead of relative frequencies as described in the 1989 Federal Manual, is defined as

$$PIV = \frac{RPC_o + 2RPC_{fw} + 3RPC_f + 4RPC_{fu} + 5RPC_u}{100} \quad (B.1)$$

where

RPC_o = Relative percent coverage (RPC) of obligate wetland species,

RPC_{fw} = RPC of facultative wetland species,

RPC_f = RPC of facultative species,

RPC_{fu} = RPC of facultative upland species, and

RPC_u = RPC of upland species.

B.4 Average Wetland Value

The average wetland value (AWV), defined in Zimmerman et al. (1991), differs from the PIV in that it is not coverage data or frequency of occurrence that is used in determining the AWV, but rather the total number of species present. Thus, all species present are represented equally in the AWV. The AWV is defined as

$$AWV = \frac{N_o + 2N_{fw} + 3N_f + 4N_{fu} + 5N_u}{N_o + N_{fw} + N_f + N_{fu} + N_u} \quad (B.2)$$

where

N_o = number of obligate wetland species,

N_{fw} = number of facultative wetland species,

N_f = number of facultative species,

N_{fu} = number of facultative upland species, and

N_u = number of upland species.

B.5 References

Federal Interagency Committee for Wetland Delineation, 1989, *Federal Manual for Identifying and Delineating Jurisdictional Wetlands,* U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S. Department of Agriculture, Cooperative Technical Publication, Washington, D.C.

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Appendix C:

Plant Species List, Areal Coverage Data, and Species Distribution

TABLE C.1 Areal Coverage Estimates for Individual Species, Surface Water, and Exposed Soil in Consecutive, Meter-Square Plots within East Transects

Distance from Center Pipeline (m)	Areal Coverage (%)														
	Transect 1					Transect 2					Transect 3				
	SA[a]	SP[b]	DS[c]	SO[d]	SW[e]	SA[a]	SP[b]	DS[c]	SO[d]	SW[e]	SA[a]	SP[b]	DS[c]	SO[d]	SW[e]
0-1	-	25	5	70	-	-	-	-	-	100	70	20	5	30	-
1-2	15	40	-	50	-	-	-	-	-	100	30	60	-	15	-
2-3	60	20	5	20	-	-	-	-	-	100	70	25	-	5	5
3-4	60	20	5	20	-	-	-	-	-	100	40	30	-	10	5
4-5	20	10	1	70	-	-	-	-	-	100	80	30	-	5	-
5-6	20	1	-	80	-	-	-	-	-	100	30	70	-	-	-
6-7	60	2	-	40	-	-	-	-	-	100	25	70	-	5	-
7-8	15	5	-	20	60	-	-	-	-	100	60	60	-	-	20
8-9	-	-	-	-	100	-	-	-	-	100	30	40	-	-	50
9-10	-	-	-	-	100	-	-	-	-	100	40	70	-	-	30
10-11	-	-	-	-	100	-	-	-	-	100	50	30	-	-	60
11-12	-	-	-	-	100	-	-	-	-	100	60	60	-	-	15
12-13	-	-	-	-	100	-	-	-	-	100	60	70	-	25	-
13-14	30	5	-	-	70	-	-	-	-	100	25	40	-	25	-
14-15	5	5	-	10	80	-	-	-	-	100	40	40	-	-	30
15-16	1	-	-	20	80	-	-	-	-	100	40	40	-	-	20
16-17	1	-	-	20	80	-	-	-	-	100	40	20	-	40	40
17-18	-	-	-	80	20	-	-	-	-	100	60	50	-	20	20
18-19	1	10	1	80	-	-	-	-	-	100	30	60	-	-	30
19-20	90	20	-	5	-	-	-	-	-	100	20	60	-	20	20
20-21	70	60	-	-	-	-	-	-	-	100	25	80	-	5	-
21-22	25	60	-	-	-	-	-	-	-	100	60	90	-	-	5
22-23	60	10	-	-	30	-	-	-	-	100	60	80	-	-	40
23-24	40	60	-	5	10	-	-	-	-	100	60	85	-	-	10
24-25	60	60	-	10	10	-	-	-	-	100	80	80	-	5	10
25-26	30	3	-	-	70	-	-	-	-	100	60	80	-	10	45
26-27	95	10	-	-	-	-	-	-	-	100	90	90	-	-	30
27-28	80	30	-	-	20	-	-	-	-	100	70	80	-	-	80
28-29	-	-	-	-	100	-	-	-	-	100	70	70	-	-	40
29-30	-	-	-	-	100	-	1	1	-	99	70	70	-	20	20

TABLE C.1 (Cont.)

Distance from Center Pipeline (m)	Areal Coverage (%)									
	Transect 4					Transect 5				
	SA[a]	SP[b]	DS[c]	SO[d]	SW[e]	SA[a]	SP[b]	DS[c]	SO[d]	SW[e]
0-1	-	-	-	-	100	-	-	-	-	100
1-2	-	-	-	-	100	-	-	-	-	100
2-3	20	10	-	-	90	40	-	20	-	80
3-4	60	10	-	10	40	25	5	-	-	80
4-5	10	60	-	30	-	40	-	40	-	60
5-6	90	10	-	10	30	30	-	80	10	10
6-7	10	2	-	2	98	25	10	20	-	80
7-8	-	-	-	-	100	5	5	5	-	95
8-9	-	-	-	-	100	30	5	60	-	25
9-10	-	-	-	-	100	10	5	10	-	80
10-11	-	-	-	-	100	5	25	-	-	80
11-12	-	-	-	-	100	20	40	-	15	20
12-13	10	-	-	-	97	20	40	10	-	40
13-14	10	-	-	-	98	20	40	10	-	40
14-15	-	-	-	-	100	20	40	40	-	30
15-16	2	-	-	-	100	60	30	10	-	50
16-17	5	5	-	-	98	20	30	10	-	40
17-18	2	-	-	-	100	20	20	40	-	20
18-19	2	90	60	10	70	60	40	20	-	30
19-20	2	50	5	5	80	30	80	10	-	30
20-21	5	40	5	-	80	10	80	2	-	20
21-22	5	80	30	-	60	0	20	10	70	-
22-23	1	30	20	-	80	30	30	5	-	80
23-24	20	30	30	-	70	30	50	-	-	60
24-25	-	40	50	-	30	60	20	-	-	80
25-26	-	40	50	-	30	-	-	-	-	100
26-27	-	30	60	-	20	-	-	-	-	100
27-28	-	15	70	-	5	-	-	-	-	100
28-29	-	1	90	-	5	-	-	-	-	100
29-30	2	5	80	-	15	-	-	-	-	100

[a] SA = *Spartina alterniflora*.
[b] SP = *Spartina patens*.
[c] DS = *Distichlis spicata*.
[d] SO = Exposed soil.
[e] SW = Standing water.

TABLE C.2 Areal Coverage Estimates for Individual Species, Surface Water, and Exposed Soil in Consecutive, Meter-Square Plots within West Transects

Distance from Center Pipeline (m)	Areal Coverage (%)														
	Transect 1					Transect 2					Transect 3				
	SA[a]	SP[b]	DS[c]	SO[d]	SW[e]	SA[a]	SP[b]	DS[c]	SO[d]	SW[e]	SA[a]	SP[b]	DS[c]	SO[d]	SW[e]
0-1	-	15	-	85	-	-	-	-	-	100	30	20	-	-	70
1-2	5	5	-	80	5	-	-	-	-	100	25	-	-	-	90
2-3	5	15	-	30	50	-	-	-	-	100	5	-	-	-	98
3-4	10	15	-	85	-	-	-	-	-	100	24	10	-	-	90
4-5	-	5	-	95	-	-	-	-	-	100	-	-	-	-	100
5-6	3	20	-	80	-	-	-	-	-	100	-	-	-	-	100
6-7	-	-	-	100	-	-	-	-	-	100	-	-	-	-	100
7-8	5	15	-	80	-	-	-	-	-	100	-	-	-	-	100
8-9	20	-	-	-	90	-	-	-	-	100	-	-	-	-	100
9-10	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
10-11	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
11-12	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
12-13	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
13-14	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
14-15	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
15-16	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
16-17	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
17-18	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
18-19	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
19-20	-	-	-	-	100	-	-	-	-	100	-	-	-	-	100
20-21	-	-	-	-	100	-	-	-	-	100	5	-	-	-	98
21-22	-	-	-	-	100	-	-	-	-	100	5	-	-	-	98
22-23	-	-	-	-	100	40	2	-	-	60	-	-	-	-	100
23-24	-	-	-	-	100	25	22	-	-	60	-	-	-	-	100
24-25	-	-	-	-	100	5	80	-	-	20	-	-	-	-	100
25-26	-	-	-	-	100	-	15	-	80	5	-	-	-	-	100
26-27	-	-	-	-	100	30	10	-	80	-	25	10	-	-	80
27-28	1	-	-	-	99	80	15	-	-	15	60	30	-	-	70
28-29	90	-	-	-	20	60	90	-	-	40	70	10	-	-	30
29-30	20	-	-	-	90	-	-	-	-	100	60	40	-	20	20

TABLE C.2 (Cont.)

Distance from Center Pipeline (m)	Areal Coverage (%)									
	Transect 4					Transect 5				
	SA[a]	SP[b]	DS[c]	SO[d]	SW[e]	SA[a]	SP[b]	DS[c]	SO[d]	SW[e]
0-1	-	-	-	-	100	70	60	-	-	30
1-2	-	-	-	-	100	30	80	-	-	10
2-3	-	-	-	-	100	30	30	-	-	80
3-4	-	-	-	-	100	-	-	-	-	100
4-5	-	-	-	-	100	-	-	-	-	100
5-6	-	-	-	-	100	-	-	-	-	100
6-7	-	-	-	-	100	-	-	-	-	100
7-8	-	-	-	-	100	-	-	-	-	100
8-9	-	-	-	-	100	-	-	-	-	100
9-10	-	-	-	-	100	-	-	-	-	100
10-11	-	-	-	-	100	-	-	-	-	100
11-12	-	-	-	-	100	-	-	-	-	100
12-13	-	-	-	-	100	-	-	-	-	100
13-14	-	-	-	-	100	-	-	-	-	100
14-15	-	-	-	-	100	-	-	-	-	100
15-16	-	-	-	-	100	-	-	-	-	100
16-17	-	-	-	-	100	-	-	-	-	100
17-18	-	-	-	-	100	-	-	-	-	100
18-19	-	-	-	-	100	-	-	-	-	100
19-20	-	-	-	-	100	5	-	-	-	98
20-21	-	-	-	-	100	60	20	-	-	80
21-22	-	-	-	-	100	30	50	-	-	40
22-23	-	-	-	-	100	10	5	1	-	80
23-24	-	-	-	-	100	-	5	-	-	99
24-25	-	-	-	-	100	20	-	-	-	90
25-26	-	-	-	-	100	15	-	1	-	90
26-27	40	20	-	-	90	99	-	-	-	40
27-28	5	-	-	-	100	80	10	-	10	10
28-29	20	20	-	-	80	25	10	-	80	-
29-30	30	30	-	-	70	40	40	-	40	-

[a] SA = *Spartina alterniflora*.
[b] SP = *Spartina patens*.
[c] DS = *Distichlis spicata*.
[d] SO = Exposed soil.
[e] SW = Standing water.