August 1991

Belle Isle Marsh Restoration Environmental and Engineering Evaluations

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The purpose of this restoration effort is to increase the amount of salt marsh and vegetation diversity within the bermed area and to reduce the amount of common reed (Phragmites australis). Based on the findings of initial appraisals of this investigation, a goal was developed to create approximately seven acres of tidally influenced vegetation consisting of a mixture of stunted Phragmites and salt meadow grass (Spartina patens), black grass (Juncus gerardi), and spike grass (Distichlis spicata) in the northwest portion of the bermed area. Phragmites is considered a relatively low value species ecologically because it tends to grow in dense stands, excluding other species of vegetation, therefore, reducing the benefits which accrue to the marsh environment with diversity of vegetation. Also, Phragmites biomass value is limited, its production is unavailable to food webs due to the coarseness of its stems and leaves and its hairy seeds. In addition, Phragmites cover is a potential fire hazard, and Roman et. al. (1984) have described stagnant Phragmites marshes as prime mosquito breeding areas.

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BELLE ISLE MARSH RESTORATION
ENVIRONMENTAL AND ENGINEERING EVALUATIONS

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I. INTRODUCTION

A. LOCATION AND BACKGROUND

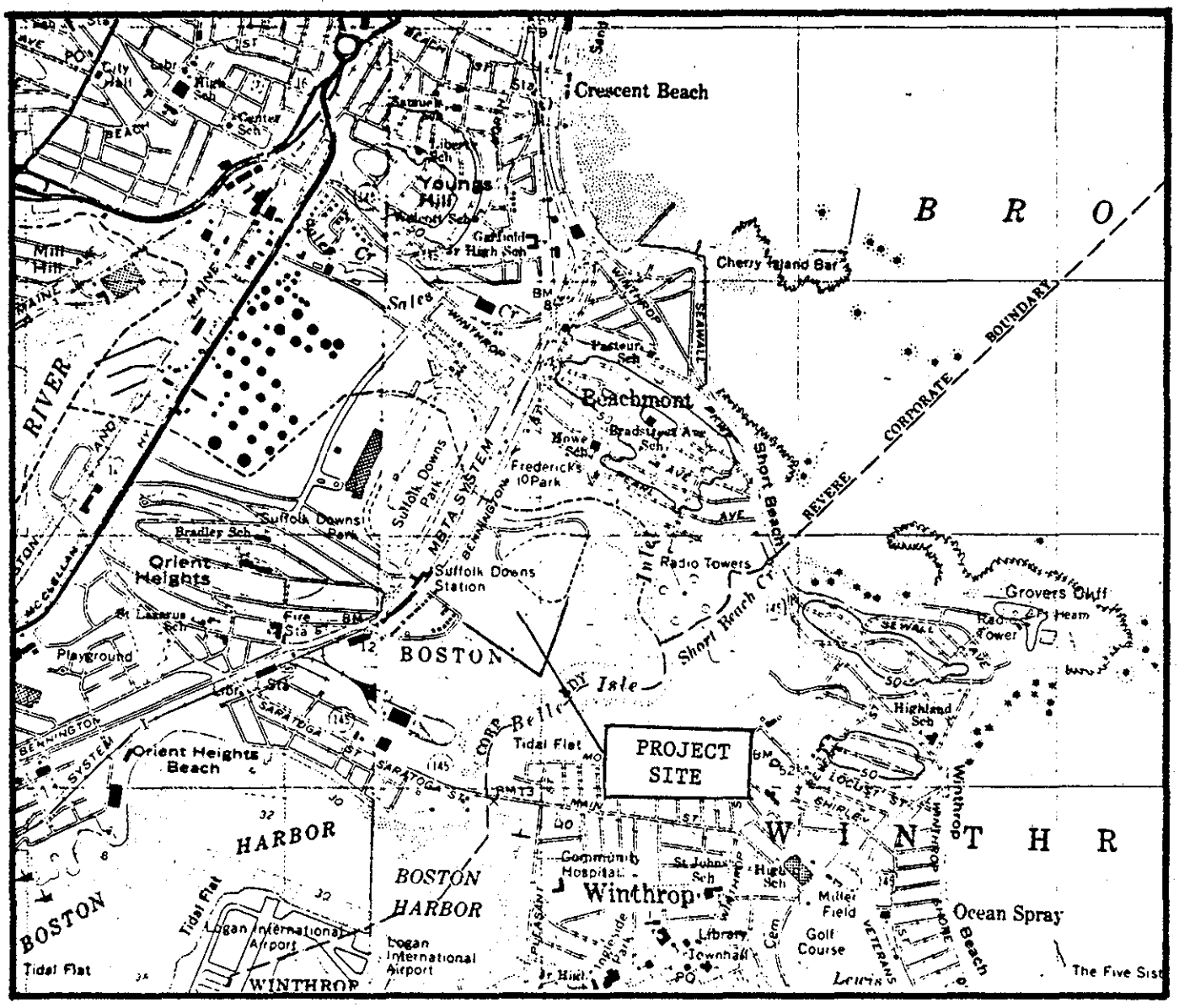
Belle Isle Marsh is located in a highly urbanized portion of northeastern Massachusetts within the municipalities of Boston, Revere, and Winthrop (Figure 1). Boston's Logan International Airport is located less than one-half mile directly south of the marsh. Approximately 275 acres of salt marsh, common reed (Phragmites australis) (hereafter referred to as Phragmites) marsh, and tidal flat make up the Belle Isle Creek/Marsh Estuary. Belle Isle Inlet flows beneath the Saratoga Street Bridge to Winthrop Bay in Boston Harbor and receives fresh-water inflow from Sales Creek. Short Beach Creek, a fairly large tidal spur, flows toward Winthrop Parkway to Short Beach and Broad Sound.

Belle Isle Marsh is recognized as the last remaining significant salt marsh in Boston (Nuttle and Harvey, 1987) which contained expansive salt marshes before European settlement. Its urban location notwithstanding, Belle Isle Marsh is a very productive system. It supports apparently large numbers and diversity of wildlife, including waterfowl, wading birds, and mammals. In 1988 Belle Isle Marsh was designated, with sections of Revere and Saugus and the Rumney Marshes, as an Area of Critical Environmental Concern, attesting to its high ecological value. This designation affords the marsh additional protection under the Commonwealth's environmental regulations.

The Metropolitan District Commission (MDC) administers and maintains the Belle Isle Marsh Reservation on the portion of Belle Isle Marsh within East Boston. (Note: MDC administers a majority of the Reservation under a permanent care and control agreement with MASSPORT.) The Reservation contains about 28 acres of upland park with walking trails, an observation tower, and other amenities. An area of about 25 acres of marsh within the MDC Reservation has been altered through the construction of a bermed dredged material disposal site. This alteration is believed to have occurred in the 1930's. (See the Historic and Archaeological Report, Appendix C.) Construction of the berm resulted in the elimination of tidal flooding to that portion of the marsh; and the disposal of dredged material, in addition to directly smothering the vegetation, altered the elevation and substrate. Creation of four breaches in the berm since its construction has resulted in the reclamation of approximately 10 acres of salt marsh and salt marsh/low Phragmites mix. Vegetation behind the berm now consists of areas of salt marsh, salt marsh/Phragmites mix, upland shrubs and grasses, and Phragmites.

B. PURPOSE AND GOALS OF THE PROJECT

The purpose of this restoration effort is to increase the amount of salt marsh and vegetation diversity within the bermed area and to reduce the amount of Phragmites. Two specific goals were developed based on the findings of initial appraisals of this investigation: 1) to create approximately 7 acres of tidally influenced vegetation consisting



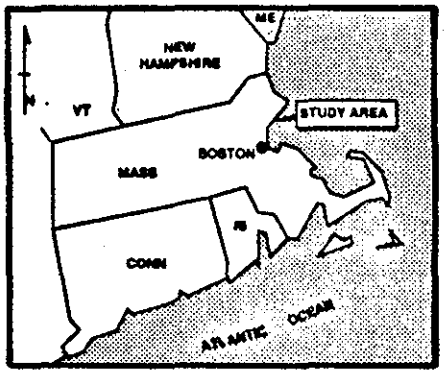


FIGURE 1. PROJECT LOCATION

of a mixture of stunted Phragmites and salt meadow grass (Spartina patens), spike grass (Distichlis spicata), and black grass (Juncus gerardi) in the northwest portion of the bermed area (Area A, Figure 2); or 2) to increase tidal flooding in the area dominated by Phragmites in the northeast portion of the bermed area (Area B, Figure 2) in order to reduce the cover of Phragmites and to increase the salinity of the adjacent pond. The second option (at Area B) has been removed from further consideration because it does not provide significant benefits.

Phragmites is considered a relatively low value species ecologically, compared to salt marsh species which are generally recognized as having high ecological value. The tendency of Phragmites to grow in dense stands which exclude other species of vegetation reduces the benefits which accrue to the marsh environment with diversity of vegetation. Although its productivity is apparently quite high, the value of its biomass is limited. Whereas a portion of salt marsh production is exported to the aquatic and terrestrial food webs, Phragmites production is, to a large extent, unavailable to food webs. It has relatively low value as a food item because of the coarseness of its stems and leaves and its hairy seeds. In addition, Phragmites cover is a potential fire hazard, and Roman et. al. (1984) have described stagnant Phragmites marshes as prime mosquito breeding areas.

C. LEGAL BACKGROUND

As part of the settlement of the federal lawsuit against the Commonwealth of Massachusetts over the pollution of Boston Harbor, funds were placed in the Massachusetts Bays Environmental Trust (now the Massachusetts Environmental Trust). These funds, totaling $2 million, were earmarked for specific projects described in the Stipulation and Order Agreement issued by the Federal court in August 1988. According to the terms of the Stipulation and Order, all funds must be encumbered by July 31, 1990, and all projects must be completed no later than July 31, 1992. This is, therefore, the deadline for completion of the Belle Isle Restoration Project.

The Agreement specified that $100,000 should be spent on Belle Isle Marsh for clean-up, restoration, or a study of the sublethal effects of contaminants on the marsh flora and fauna. The Board of Trustees appointed for the Trust decided that the project should be focused on restoration efforts, including an evaluation of the current biological status to provide a baseline for future comparisons. Rosie's Pond in Belle Isle is included in clean-up efforts carried out under a separate project under the Stipulation and Order.

A Working Group was convened late in the summer of 1989 to determine the scope of a project that would be feasible, affordable, and beneficial for Belle Isle Marsh. The Working Group includes representatives of EPA Region I; Friends of Belle Isle Marsh; Massachusetts Coastal Zone Management Office; Army Corps of Engineers, New England Division; and

MDC. The Working Group toured the marsh on November 18, 1989, visiting both the MDC Reservation and portions of the marsh located outside the Reservation in Winthrop and Revere. The Working Group recommended that the restoration project be carried out on the portion of the marsh located within the boundary of the MDC Reservation.

II. CHARACTERIZATION OF BELLE ISLE INLET AND SALT MARSH

A. MAPPING

1. Wetland Types

Vegetation at Belle Isle Marsh is, in most locations, typical of other salt marshes in Massachusetts. Marsh vegetation was mapped for this effort on 1"=500' color-infrared aerial photography. The vegetative types from interpretation of aerial photography are shown on Attachment 1. The dominant vegetation is described by area divided for convenience into subdivisions (shown on Figure 2) in the following paragraphs. (Figure 2 also shows the two potential restoration areas considered, delineated by dotted lines.)

In general, the majority of Belle Isle marsh is high marsh which extends, roughly, from mean high water (MHW) to the level of the highest lunar tides. On the high marsh, salt meadow grass (Spartina patens) is dominant and spike grass (Distichlis spicata) is second most dominant. Large areas of high marsh are dominated by short salt marsh cordgrass (Spartina alterniflora), especially where the effects of ditching are less evident or drainage is constricted. The various high marsh subdominants such as black grass (Juncus gerardi), sea lavender (Limonium nashii), glassworts (Salicornia spp.), and marsh orach (Atriplex patula) are also present. Areas dominated by tall salt marsh cordgrass that extend roughly to the level of mean high water are referred to as low marsh. Low salt marsh borders Belle Isle Inlet and most of the tidal creeks. The largest area of Phragmites (Phragmites australis) is located behind the berm adjacent to Belle Isle Park. Detailed plant species information collected through transect sampling by the Massachusetts Audubon Society in the vicinity of the bermed area is presented in Section II.B.

AREA 1. This area abuts the bermed area to the south and contains Rosie's Pond*. Its vegetation has been influenced by an extensive network of mosquito ditches, and as a result supports a lower diversity of vegetation than non-ditched portions of the marsh. The majority of the vegetation in this area is high marsh vegetation dominated by salt meadow grass and spike grass with typical high marsh sub-dominants of sea

* Rosie's Pond is the area generally designated by the Massachusetts Natural Heritage Program as Estimated Wetlands Wildlife Habitat due to the presence of breeding terns.

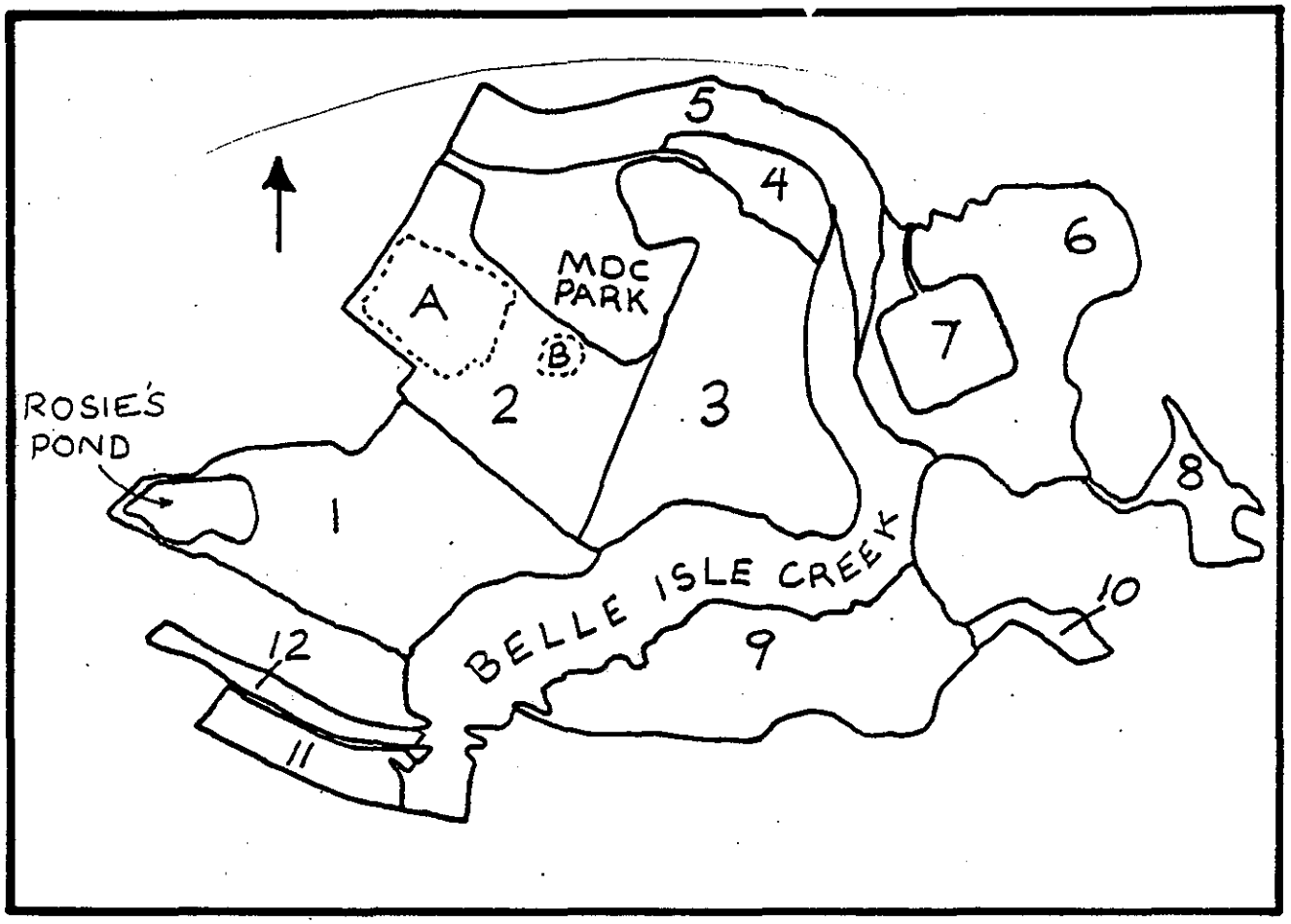


FIGURE 2. BELLE ISLE MARSH WETLAND AREAS
Areas A and B are potential restoration areas.
Areas 1-12 are described by vegetation type in
Section II.A.1.

lavender and glassworts. Three major tidal creeks are located in this area, as well as Rosie's Pond. The tidal creeks support a border of tall salt marsh cordgrass which is low marsh vegetation and, usually, a high marsh zone of short salt marsh cordgrass. A border along the northern upland edge is influenced by the deposition of flotsam and supports a combination of dead vegetation, short saltmarsh cordgrass and spike grass. Small areas dominated by a combination of short salt marsh cordgrass and salt meadow grass are also present, including the rim of Rosie's Pond.

AREA 2. This area is located behind the berm and the vegetation is influenced by restricted tidal flooding. There are four major vegetation types in this area. The easternmost portion of the area contains salt marsh maintained by breaches in the berm. The vegetation consists of short salt marsh cordgrass, salt meadow grass, spike grass, and typical high marsh sub-dominants. An area containing tall Phragmites and a pond is present in this area adjacent to the MDC Belle Isle Park and the shrub community. This is restoration Area B. There are a number of large algal mats and ponds. Moving westward from this area is an area of mixed stunted Phragmites and high marsh vegetation, including black grass and salt meadow grass. Pockets of 100% cover of Phragmites are present in both these areas where elevations increase. Upland shrubs, saplings, grasses and Phragmites mix to form the next portion of the site which nearly divides the site into halves and forms a border along the southern and western edges. This portion of the site is followed by a large area vegetated almost entirely by Phragmites (including restoration Area A) and containing a number of varying sized ponds. The berm surrounding this area supports mostly Phragmites.

AREA 3. Area 3 is less influenced by mosquito ditching than Area 1 and therefore supports a wetter, more diverse high marsh habitat. Ditched areas on the north and south ends of this area support mostly salt meadow grass and spike grass with smaller pockets of short cordgrass. The large area in the center supports a number of permanent ponds and short cordgrass dominated marsh. Two major creeks including the inlet surrounding the lookout tower and the Belle Isle Inlet border support low salt marsh, tall cordgrass.

AREA 4. Area 4 supports mostly salt meadow grass and spike grass but a major portion of the site supports a stunted growth form of these species, mostly likely as a result of compacted soils. A fairly large area of Phragmites, most likely on upland, is present on the west side of this area.

AREA 5. Area 5 surrounds Belle Isle Inlet and is dominated by tall salt marsh cordgrass (low marsh) with fringes of salt meadow grass and Phragmites.

AREA 6. This area, similar to Area 1, is heavily ditched and supports mostly salt meadow grass-dominated high marsh vegetation. Fringes of wrack influenced marsh are present along the marsh/upland border, and particularly along the western edge of Area 7. Short salt marsh cordgrass

is present in locations including the vicinity of the berm/walkway to Area 7 where drainage is impeded. Two large branching creeks support a fringe of tall salt marsh cordgrass.

AREA 7. This area is enclosed by a berm which constricts drainage, but the area is still influenced by salt water flooding. The area supports a large number of ponds and short salt marsh cordgrass, as well as a diversity of high marsh dominants and subdominants. A few small areas are dominated by common glasswort (Salicornia europea). Remnants of ditching remain; however, the level of ponding has reduced their impact on the marsh's diversity.

AREA 8. This area is isolated by surrounding upland and receives tidal flooding through one major creek. The area has been heavily ditched but still supports a good diversity of short salt marsh cordgrass and high marsh dominants. Disturbed areas and wrack deposits are present along the upland edges.

AREA 9. Area 9 is heavily ditched but also contains a large area of low salt marsh with good vegetative interspersion on its western end. A major tidal creek with bordering salt marsh cordgrass runs east to west, bisecting the marsh. Short salt marsh cordgrass forms a fairly wide border along the southern upland edge and is also present on the borders of creeks and ditches. The southern border of this site also contains numerous non-vegetated areas.

AREA 10. This area is connected to Area 9 by a non-tidal creek which flows through shrub uplands into a Phragmites marsh.

AREA 11. Area 11 contains a high salt marsh with a moderate amount of ditching and a low diversity of vegetation. It is surrounded on three sides by roads and commercial upland land use. The southerly border supports an edge of Phragmites vegetation.

AREA 12. Area 12 is almost enclosed by commercial land. Its vegetation ranges from Phragmites on its western end, to constricted short salt marsh cordgrass and ponds in the center, to a small area of high salt marsh then low marsh where it meets Belle Isle Inlet.

2. The Value of Belle Isle Marsh

Belle Isle Marsh provides a wealth of values to the Boston area and beyond. Its diversity of wetland types in an otherwise densely populated area provides excellent habitat for resident and migratory fish and wildlife. The MDC Reservation and the surrounding marsh provide passive recreation opportunities, aesthetic values, and educational opportunities. The value and concern for the marsh is evidenced by the efforts of such groups as the Friends of Belle Isle Marsh, which has worked hard to protect and maintain the marsh. The value and concern for the marsh is further reflected in its designation as part of the Rumney

Marshes Area of Critical Environmental Concern (ACEC) by the Massachusetts Executive Office of Environmental Affairs. The values listed in the nomination included historic sites; shellfish beds; wildlife habitat; rare, threatened and endangered species habitat; and anadromous and catadromous fish runs. All of these values help to make Belle Isle Marsh an important regional resource.

B. RESULTS OF BASELINE STUDIES

This section summarizes a report entitled, "Results of Baseline Studies on the Biota of Belle Isle Carried Out by the Massachusetts Audubon Society: North Shore as of May 20, 1991". This report was prepared by the Massachusetts Audubon Society: North Shore under a separate contract to the Massachusetts Environmental Trust. The complete report is attached as Appendix A. This study focused on Area 2, behind the berm, where restoration is considered (referred to as "the study area" in this section).

1. Vegetation

Baseline vegetation surveys were conducted by Mass Audubon: North Shore to describe the existing plant community in the study area and set up a series of permanent transects so that changes in the plant community from restoration efforts can be monitored over time. Analyses of species composition, relative frequency, relative cover, and relative importance for each species were conducted. Vegetation height in relation to tidal inundation was evaluated and comparisons of biomass were made. Detailed methods and results are presented in Appendix A.

Salt marsh vegetation typical of New England marshes, i.e. the cordgrasses Spartina alterniflora and S. patens, dominates an area of roughly four acres in the southeast corner of the study area (Appendix A, Table 2). The only salt marsh species that occurred outside the berm, but was not located within the study area, was Triglochin maritima.

To the northwest of this salt marsh zone is an area (ca. 6.5 acres) transitional between salt marsh and Phragmites australis. Phragmites forms the "canopy" of this area and is the most visually obvious plant; however, salt marsh species, especially S. patens and Juncus gerardi, dominate in terms of cover (see Appendix A, Figures 1a-1c). Another typical "understory" plant in this area is seaside goldenrod (Solidago sempervirens). A specimen of Calamagrostis epigeios, a grass native to the Caspian Sea area that was previously unknown in the Boston area, was collected within this area. The identification of this plant was done by Bruce Sorrie, Botanist with the Massachusetts Natural Heritage and Endangered Species Program.

The remainder of the bermed area is dominated by P. australis. Scattered patches of shrubs such as bayberry (Myrica pennsylvanica) and staghorn sumac (Rhus typhina) occur in drier areas. This Phragmites area was not well characterized in the surveys, since only a small part of vegetation transect #3 included it.

All three transects include pannes. Some are more or less permanently inundated; others are flooded only at extremely high spring tides (greater than 12 ft MLW) and contained stunted S. alterniflora, Salicornia europaea, Sa. bigelovii, or an algal mat. Species in the algal mat consist mostly of filamentous cyanobacteria (non-heterocystis forms like Microcoleus lyngbyaceus and possibly Lyngbya confervoides) plus a variety of cocoid green algae (e.g., Chlorella/Chlorococum types) and pennate diatoms (naviculoid types). Algal mat species were identified by Art Mathiesen of the University of New Hampshire. He noted that the two types of cyanobacteria are quite common in salt marsh habitats, particularly disturbed surfaces (e.g., ice rafted areas).

Vegetation height along the transects was greatest on the berm itself and in the area of mixed Phragmites and salt marsh (Appendix A, Figures 2a-2c). This is obviously related to the height of Phragmites. The 1990 data on heights will be valuable for future, post-alteration comparisons, since greater tidal flushing can be expected to result in greater stunting of Phragmites. The only place where Sp. alterniflora was greater than one meter tall, indicative of relatively good tidal flushing, was in the part of transect 1 seaward of the berm.

Importance values of plants along the three transects differed (Appendix A, Table 3). Transect 1 is dominated by Sp. patens, J. gerardi, and P. australis, transect 2 by Sp. alterniflora, Sp. patens, and D. spicata, and transect 3 by P. australis, J. gerardi, and D. spicata. These differences are likely related to differences in elevation, transect 2 being relatively "wet" and transect 3 relatively "dry" compared to the others.

The biomass of Sp. patens was greater outside the berm than within the study area (Appendix A, Table 4). This suggests that some characteristic of the study area, such as less tidal flushing or differences in elevation, results in lower aboveground production within the study area. The end of the season biomass values (600-800 g/m^2) of Sp. patens both within and outside the study area are fairly typical of productivity values for New England high salt marshes (Nixon, 1982).

2. Benthos

Baseline surveys of benthic fauna were conducted by Mass. Audubon: North Shore. Benthic samples were taken from ten stations in Belle Isle Marsh in August 1990. The sampling regime was selected in order to provide an initial inventory of the intertidal benthic fauna of the marsh, and to provide a comparison of the benthic fauna within and outside of the berm.

Stations A1 and A2 were located in the main channel and Stations B1, B2 and B3 were situated in ditches which cut through the marsh towards the berm (Appendix A, Figure 3). Samples were collected at low tide and represented sites which were flooded throughout much of the tidal cycle.

Stations I1 and I2 were taken from the edge of standing pools (salt

pannes) inside the berm area, while Stations O1 and O2 were in a similar habitat outside the berm. Station M was in a wet bacteria mat within the berm area.

At each station 3, replicate $0.003m^2$ cores were collected. All samples were sieved through a 0.3mm mesh screen, stained with rose bengal, preserved in 10% formalin, and sorted and identified to species under a dissecting microscope.

The sediments at Stations A, B, and M were all fine grained muds with most of the sediment washing through the 0.3mm mesh screen. Station A2 had slightly more sand than the others. All samples from Stations A and B contained broken shell material. Stations I and O contained fine grained muds with some fragments of plant material.

The faunal composition of Stations A1&2 and B1-3 was very similar (Appendix A, Table 1). In all cases Oligochaetes and the spionid polychaete, Streblospio benedictii, were the dominant taxa. Together the two types of worms accounted for between 89% and 93% of all individuals found at the five stations. The dominance of these two taxa is characteristic of the intertidal fauna of Boston Harbor, usually accounting for between 50% and 90% of the animals found (New England Aquarium, 1983; Keay, 1988; Gallagher and Grassle, 1988; M. Hall, unpublished data). The other species found in the present study (Appendix A, Table 1) are all typically minor components of the intertidal fauna found by these other researchers.

The number of species found at the five stations at Belle Isle (15) was identical to the species number found on the north side of the airport opposite to the inlet to Belle Isle (New England Aquarium, 1983). However, studies of the intertidal fauna of Savin Hill Cove (Keay, 1988; Gallagher and Grassle, 1988) and of the Marina Bay area in Quincy (M. Hall, unpublished data) have found more species (23 to 30) and less dominance by Olgiochaetes and Streblospio benedictii.

The density of animals found at the five Belle Isle stations (22,900 to $63,400/m^2$) is similar to what has been found off Logan Airport (New England Aquarium, 1983) and off Marina Bay, but is an order of magnitude less than what has been found at Savin Hill Cove (Keay, 1988; Gallagher and Grassle, 1988). The higher densities at Savin Hill reflect the increase in nutrient availability due to the proximity of the Cove to the Fox Point Combined Sewer Overflow.

The intertidal benthic community found at Stations A1&2 and B1-3 appears to be the typical intertidal fauna found in Boston Harbor. Extension of the ditches into the bermed area will presumably create favorable habitat for this community and lead to an increase in faunal diversity behind the berms.

Stations I and O were sampled in order to compare similar habitats (salt pannes) inside and outside the berm. The low number habitat was far from ideal for traditional benthic communities. Quantitatively, Station I1 and 2 differed little from Station O1 and 2. However, the differences

in the species found at the stations was significant. Calliopius laeviusculus, a pelagic-benthic amphipod, was only found in the O Stations. This species is a prey item for small fish. Interestingly, fish were observed in the salt pannes from which samples for Station O were taken. No fish or amphipods were found in the Station I salt pannes.

Station M was in an inundated bacteria mat behind the berm. Only two species of worms were found. Benthic invertebrates apparently do reside in very low densities in these mats. Presumably any increase in the frequency of tidal flooding in these habitats will increase the probability of colonization by invertebrates and provide more suitable conditions for their long-term survival.

3. Fish

Data was collected using steel minnow traps and seines. Detailed methods and results are presented in Appendix A.

One of the major functions of salt marshes, as noted in the Massachusetts Wetlands Protection Regulations, is their connection to fisheries resources. Salt marshes are considered valuable for fisheries resources in that they serve as nursery areas for the juveniles of commercially important species. Species such as winter flounder (Pseudopleuronectes americanus) may inhabit salt marsh creeks and adjacent habitats for part of their life cycle. By feeding directly on the marsh surface during high tides, mummichogs (Fundulus heteroclitus) transfer marsh productivity to marsh creeks and the nearshore community. Thus an examination of the fish populations within the study area and other parts of Belle Isle would provide an indication of the value of this area to fisheries resources.

More mummichogs were caught in the minnow traps in October than in February (Appendix A, Table 7). The numbers caught in 1.75 hours (hr) at the breach of the SE creek were roughly comparable to numbers Massachusetts Audubon has caught in a "pristine" salt marsh creek in Ipswich in 24 hr. Thus, the impression is that the creeks leading up to the study area and the breaches within the study area support high populations of mummichogs.

The low numbers of mummichogs in February suggest that mummichogs avoid these relatively shallow mosquito ditches in colder weather. Alternatively, populations may be lower because of the absence of recruitment into the population through reproduction.

Mummichogs were absent from the largest salt panne within the study area, based on seining on November 8. Only once, immediately after a spring high tide, were fish observed within this panne. This panne may be too shallow to support fish between spring tides.

Species lists derived from seining in the fall of 1990 and winter of 1991 indicate that the most abundant fish in the mosquito ditches seaward of the berm were mummichogs (Appendix A, Table 8). An occasional nine-spined stickleback was caught. In May 1991 three-spined-sticklebacks and mummichogs were commonly caught by seining these ditches. In samples collected by seining and dip netting salt pannes and mosquito ditches outside the study area during the summer, Gard (1984) reported three- and four-spined sticklebacks (Gasterosteus aculeatus and Apeltes quadracus), striped killifish (Fundulus majalis), and juvenile eels (Anguilla rostrata). We have also caught two species of shrimp, Paleomonetes pugio (abundant) and Crangon septemepinosus (occasional), in these mosquito ditches.

Seining within Belle Isle Inlet itself was difficult due to the softness of the substratum. Several silversides (Menidia sp.), American eel, mummichogs and Paleomonetes pugio were caught in the Inlet. This species probably spawns in the nearby Saugus/Pines Estuary (USACOE, 1989) and may also spawn in Belle Isle Inlet.

Winter flounder are commonly caught by recreational fisherman in the Inlet (Gard, 1984). This species spawns in nearby Saugus/Pines estuary in March and April and juveniles occur there through the summer (USACOE, 1989). This fish may also spawn in Belle Isle Inlet.

4. Birds

Birds are the most obvious wildlife in the study area, and are a significant reason the area is attractive to naturalists. Because of their value as environmental indicators of habitat changes, bird data was collected from a number of sources to assess how restoration efforts might impact bird numbers in the area. Birds sampling will continue in the study area over the next year, especially in the spring for nesting birds.

The information collected by amateur birders and cited in an earlier study of Belle Isle Marsh (Gard, 1984) is not specific to the area behind the berm. Instead it focuses on areas of the marsh where birds (hence bird watchers) tend to be abundant. However, this baseline information regarding what the overall habitat supports is valuable for comparison with results from the study area. For this study, three types of data were collected: historical data, routine observations of birds with binoculars while working in the study area, and quantitative assessment by sampling along three bird transects. Transect locations and methods are described in Appendix A.

The value of the attempts to quantify bird use of the study area by transect censusing was limited by the low number of birds observed during these censuses. Use of the study area by birds is too sporadic to obtain reliable quantitative data without sampling much more often than is feasible.

The overall qualitative assessment, based on observations made during field visits to the study area, is that the study area is used by fewer birds than other parts of the marsh (Appendix A, Table 6). Typical marsh birds that were commonly observed along Belle Isle Inlet or in Rosie's Pond but were rarely observed in the study area include snowy egrets, black-bellied plovers, greater and lesser yellowlegs, and gulls. Mallards and black ducks were occasionally observed in the study area, but were more common in other areas of Belle Isle.

Nonetheless, some bird species may be more common in the study area than in other areas of the marsh. In late summer and fall 1990 and winter 1990-91, these included sharp-tailed sparrows, American bittern (a state listed "species of concern"), black-crowned night-herons (several roost during the day around a pond in the Phragmites according to Leo Rogers), and a short-eared owl (a state listed endangered species). The Phragmites area is also the principal area within Belle Isle Marsh as a whole for nesting of red-winged blackbirds (L. Rogers, pers. comm.).

Phragmites marshes are not considered valuable bird habitats in the eastern United States. The Phragmites part of the study area at Belle Isle Marsh is not, however, without some value to birds and other wildlife. In addition to the species mentioned above, black ducks have been observed in the small freshwater ponds in the Phragmites area, where the tall growth of this reed apparently provides good cover. The Phragmites provides an aesthetic buffer from the activities and traffic of Bennington Street, a buffer that might also be important in reducing disturbance to wildlife. Scrubby upland areas created by dredged material within the Phragmites may provide nesting areas for a number of birds that forage on the marsh but need drier habitats for nests. Based on the bird list for Belle Isle (Zendeh, 1988) these might include song sparrows, American kestrels, and killdeer.

Waterlogged short Spartina alterniflora marshes are typical foraging habitats of sharp-tailed sparrows. The nest of this species is typically built on the ground, hidden within Spartina patens or Juncus gerardii zones of marshes (Hill, 1968). Sharp-tailed and seaside sparrows are suspected nesters in the salt marsh within the study area (S. Zendeh, pers. comm.)

C. HYDROLOGY

1. General Tide Information for Belle Isle Marsh

The maximum predicted astronomic high water at the NOAA gauge in Boston Harbor is 12 feet mean low water (MLW), the mean spring high water level is 10.3 feet MLW, and the mean high water level is 9.5 feet MLW. Actual tides inside Belle Isle Creek have not been defined; however, they are most likely slightly less than these maximums because of the restriction at the inlet from Boston Harbor under Saratoga Street (see

Figure 1). At the Saugus River estuary just north of the project site, spring high tide levels were found to be 0.1 to 0.5 feet lower in the estuary than at the mouth of the Saugus River (US Army Corps of Engineers, 1989). This variation was due to surface friction, the effects of constrictions, and the size of the marsh storage area. Behind the berm at Belle Isle marsh near existing openings, evidence of tidal flooding is present up to elevation 11.8 MLW based on the presence of salt marsh vegetation (Agrostis stolonifera, Juncus gerardi, Spartina patens) intermixed with Phragmites. At the exterior of the berm where tide levels are not impeded by the berm itself, Phragmites becomes dominant at about this same elevation. This suggests there is little impedence of tide levels within the open bermed area and that the maximum astronomic tide at this point in Belle Isle Inlet is about 11.8 feet MLW. (The controlling tide level must be slightly higher than 11.8 because 11.8 must be inundated to support salt marsh vegetation.)

2. General Salt Marsh Hydrology

Salt marshes are divided into two types based on the frequency of tidal flooding and the resulting vegetation composition: low marsh and high marsh. Low marsh, classified as regularly flooded salt marsh under the US Fish and Wildlife Service Classification System (Cowardin et. al., 1979), extends roughly to the level of mean high water (MHW) and is flooded approximately twice each day in New England (Lefor et. al., 1987). High marsh extends from the inland limit of low marsh to the level of the highest lunar tides (Lefor et. al., 1987) and has at least ten continuous days of exposure to the atmosphere (Mitsch and Gosselink, 1986). The transition from high marsh to upland occurs at about the elevation of mean spring high water (Niering and Warren, 1980).

III. CHARACTERIZATION OF THE RESTORATION AREA

A. VEGETATION

Vegetation distribution behind the berm is influenced by physical and competitive factors, most notably elevation and hydrology. In the southeastern third of the site a majority of the vegetation is representative of salt marsh or a mixture of salt marsh vegetation and low Phragmites. The southeastern third of this portion of the site can be broken down further into an area of approximately 3.0 acres which supports nearly complete cover of salt marsh vegetation. The remaining portion of this area, measuring approximately 6.5 acres, supports mostly a mixture of low or stunted Phragmites and salt marsh vegetation (black grass, salt meadow grass, and short salt marsh cordgrass). According to baseline studies performed by Mass Audubon: North Shore (see Section III.B.1 for a detailed description of the vegetation), salt meadow grass and black grass dominate in this area in terms of cover, even though Phragmites is the most visually obvious species. Area B, which is no longer considered for

alteration, contains tall Phragmites surrounding a fresh water pond.

In the center of the site elevations increase and the vegetation changes to a mixture of upland plant species and Phragmites. The upland tree and shrub species consist of bayberry, Eastern cottonwood (Populus deltoides), and staghorn sumac. Upland grasses are present as well.

The remaining portion of the site (Area A), at the northwestern end, supports nearly 100% vegetation cover of Phragmites except where ponds are present. Approximately 15 small ponds are also present in this area. Duck weed was observed in one of these ponds during a site visit in February 1991.

B. WILDLIFE AND FISH USE

The wildlife value of the area behind the berm results from the type of vegetation and its relationship to other vegetation and physical characteristics of the site. The wildlife value is greater in terms of diversity in the areas behind the berm that presently support shrub/sapling habitat, salt marsh, or salt marsh/Phragmites mixture than in Area A where Phragmites is the dominant vegetation. These areas contain a greater diversity of vegetation and, therefore, support a greater diversity of wildlife.

Phragmites is dominant in Area A where restoration to salt marsh is proposed. In general, Phragmites is considered to have a relatively low wildlife value and, as the dominant vegetation in the bermed area, it limits the wildlife value. However, the Phragmites area does provide species specific habitat for black-crowned night-herons which roost in the Phragmites around a pond, black ducks which use the ponds, nesting red-winged blackbirds (see Section B.4), and muskrats (Ondatra zibethicus). This area contains a number of ponds which enhance its wildlife value over that of a Phragmites marsh without interspersed open water. These ponds and the surrounding vegetation provide habitat for wildlife, including waterfowl, muskrats, red fox (Vulpes vulpes), skunks (Mephitis mephitis) and raccoons (Procyon lotor). Four muskrat houses were observed on the edges of ponds while investigating the depth of ponds for this study, but the total number of houses on the site is most likely greater. Mallards and black ducks were observed flying in the direction of these ponds during September 1991 and are believed to make use of them for resting and possibly for nesting and brood rearing. Fox scat was also observed in the area during this study. This area is also important for nesting of red-winged blackbirds.

C. EXISTING ELEVATIONS AND HYDROLOGY

Elevations relative to mean low water in the restoration area were

determined through a topographic survey conducted by the Corps in November 1990. The quantity of elevation data which could be collected was limited by availability of funds. Five transects were established perpendicular to Bennington Street at 200 foot intervals. Elevations were measured at approximately 20 foot intervals along the transects.

The topography of the restoration site can be described as follows. In general, the elevation of the interior bermed area is approximately 1 foot higher than the elevation of the adjacent salt marsh. The lowest elevations in the bermed area occur in the southeastern third of the site where a majority of the vegetation is representative of salt marsh or a mixture of salt marsh vegetation and low Phragmites. The elevation of the marsh plain in this area, excluding creeks, ranges from 10.0 to 11.8 feet MLW. This southeastern third of the site can be broken down further into an area of approximately 3.0 acres which supports nearly complete cover of salt marsh vegetation and ranges in elevation between 10.0 and 11.0 feet MLW. The remaining portion of this area, measuring approximately 6.5 acres, supports mostly a mixture of low or stunted Phragmites and salt marsh vegetation. It ranges from 11.0 to 11.8 feet MLW. The quantity of Phragmites in this area can potentially be reduced further by increasing the frequency of tidal inundation.

In the center of the site, elevations increase and the vegetation changes to a mixture of Phragmites and upland plant species including bayberry, cottonwoods, and staghorn sumac. Elevations in this area range from 11.8 to 13.5 feet MLW. This area measures approximately 3.5 acres.

The remaining portion of the site, at the northwestern end, is vegetated by nearly 100% cover of Phragmites. The elevations in this area, exclusive of side slopes, range from 10.7 to 12.4 feet MLW. This portion of the site contains restoration Area A. The 7 acre portion of this area below 11.8 feet MLW may be affected by an increase in tidal flushing. A number of small ponds are present in this area with the largest measuring about 0.25 acre. The maximum depth of the largest pond is 3.6 feet (1.1 meter), and the depth at the edge of the pond is about 20 inches (50 centimeters). The two other ponds measured were 20 and 30 inches (50 and 70 cm) deep in the center and 4 and 8 inches (10 and 20 cm) deep on the edges. An average depth of water in the flooded portion of this Phragmites area is estimated at 8 inches (20 cm).

One-time salinity measurements collected in the bermed area revealed low salinity levels. Soil water (water within the soil but not necessarily ground water) salinity levels were measured on February 6, 1991 at several locations on Belle Isle marsh using a Model 33 Yellow Springs Instrument Company salinometer (Appendix A, Figure 3). As would be expected salinity levels decreased on the gradient from salt marsh vegetation to Phragmites areas. Location 1 was outside the berm in high salt marsh. Location 2 is an area within the berm of salt marsh vegetation (S. patens, D. spicata, Limonium nashii, and S. europea), Location 3 has a mixture of salt marsh vegetation and short Phragmites (S. patens, J. gerardi, S. sempervirens, and P. australis), and Locations 4

and 5 are dominated by almost total coverage of Phragmites. Location 6 is a pond. The measured salinity levels are relatively low compared to expected values for the vegetative types where they were recorded. This data does show that a salinity gradient exists between vegetative types on the marsh. If these values are increased linearly based on the expected values for an unrestricted salt marsh (as at Location 1), the gradient explains the difference in vegetative types.

TABLE 1. Belle Isle Marsh Soil Water Salinity Levels (February 1991)

LOCATION	VEGETATION	TEMPERATURE (°C)	SALINITY (ppt)
1	Salt marsh	3.0	9.2
2	High marsh	4.0	5.8
3	Short Phragmites/high marsh	0.8	1.6
4	Tall Phragmites/goldenrod	1.0	1.4
5	Tall Phragmites	1.2	0.4
6	Pond	1.8	1.0

Data from Massachusetts Audubon's Boston Harbor Monitoring Program shows that tidal water entering the marsh from Belle Isle Inlet averages around 30 parts per thousand (ppt).

D. SUBSTRATE

1. Physical Soil Analyses

The soils behind the berm were analyzed to determine their physical characteristics. The size of the sediments and the lack of organic material within the interstices has implications for its stability in channels designed for this project. Smaller grain non-cohesive sediments are more likely to erode, and smaller grain sized cohesive sediments are more likely to maintain a vertical side slope. Larger grain sizes require more horizontal slopes and could require protection to reduce sloughing.

Nuttle (1988) described the sediments of the undisturbed Belle Isle salt marsh as consisting of a layer of clayey peat 70 cm deep which grades into a layer of gray, silty clay. This is underlain by an impermeable layer of clay at 170 cm. Behind the berm, this layer is overlain by varying thicknesses of dredged material as described below.

Subsurface Explorations. Subsurface explorations performed at the site are as described in the following paragraph. Locations of the explorations are shown on Figure 3.

Seven hand auger borings were performed at the site by Corps personnel on 26 February and 14 March 1991. The augers consisted of either two or four inch hand augers driven to depths of 3 to 4 feet. The auger boring

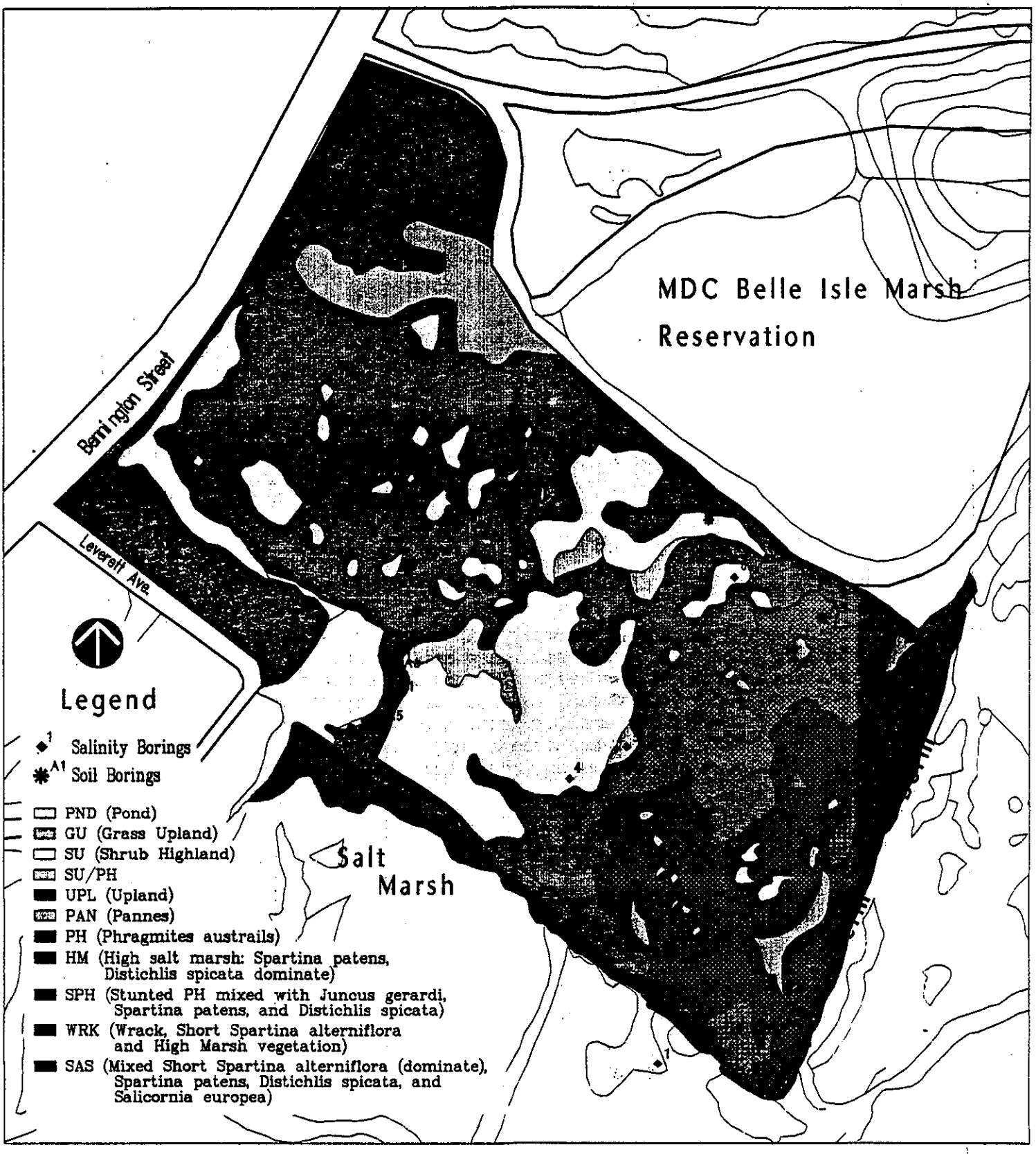

MDC Belle Isle Marsh
Reservation
Bennington Street
Leverett Ave.
Salt
Marsh
Legend
Salinity Borings
Soil Borings
PND (Pond)
GU (Grass Upland)
SU (Shrub Highland)
SU/PH
UPL (Upland)
PAN (Pannes)
PH (Phragmites austrails)
HM (High salt marsh: Spartina patens, Distichlis spicata dominate)
SPH (Stunted PH mixed with Juncus gerardi, Spartina patens, and Distichlis spicata)
WRK (Wrack, Short Spartina alterniflora and High Marsh vegetation)
SAS (Mixed Short Spartina alterniflora (dominate), Spartina patens, Distichlis spicata, and Salicornia europea)

Figure 3.

logs and soil test results are included in Appendix B. Soil samples were visually classified on site in accordance with ASTM D 2488, "Description of Soils (Visual - Manual Procedure)". Lab testing performed on the soil samples is discussed below. Chemical sampling tubes were driven adjacent to augers A-1, A-2 and A-3 to collect soil samples for chemical analysis.

Subsurface Soil Conditions. Based on hand auger samples A-1, A-2, A-4, A-5 and A-6, the subsurface soils at the site generally consist of a 1 to 3 foot layer of loose silty medium-fine sand (SM) with traces of peat to depths of 3 to 4 feet, overlying a thin, 2 to 3 inch, layer of soft clay (CH). The top 6 to 9 inches of surface material consists mostly of marsh vegetation and roots. Dark gray and black peat was encountered 32 inches below the ground surface in auger A-1 which is assumed to be the original marsh ground surface prior to placement of dredged material. Auger refusal was encountered in auger A-2 at 39 inches indicating an area of gravel or cobbles; no sample was recovered. The silt content of the upper silty medium-fine sand stratum ranged from 25 to 35 percent, while the underlying clay layer contained 5 to 15 percent sand.

Auger A-3, located in the eastern corner of the site, encountered a layer of loose sandy silt (ML) from 11 to 18 inches below the surface, overlying soft clay (CH) with a trace of peat to the bottom of the boring at 53 inches. The 11 inches of surface material consisted of vegetation and roots with glass fragments and miscellaneous debris. The extent and depth of the clay zone is not known.

Groundwater was observed at or within 6 inches of the ground surface in all holes. Augers A-2 and A-4 were taken in 9 and 4 inches of water, respectively.

Laboratory Soil Tests. Representative samples of the silty sands, sandy silts and the clays were taken for soil testing. Laboratory tests consisted of grain size analyses on the silty sands and sandy silts, and both grain size analyses and Atterberg limits on the clays. The soil test results are presented in Appendix B. The soil test results confirm the visual classification of the soils.

2. Sediment Chemistry

A total of three sediment cores were collected on March 13, 1991 for physical soil testing and bulk chemistry analysis. Standard EPA procedures for handling and preserving samples and cleaning of sampling tools were followed. Two samples were located in Area A and one in Area B (Figure 3). The analyses for total organic carbon (TOC) (EPA Method 9060) and total petroleum hydrocarbons (TPH) (EPA Method 9070/418.1) were performed by the New England Division at the Barre Falls Environmental Laboratory in Massachusetts. Analyses for metals, pesticides and polychlorinated biphenyls (PCB) were performed by Industrial Environmental Analysts in Billerica, Massachusetts. The analyses for PCBs and and pesticides followed the methodology described in Tetra Tech, 1986. The procedures and detection limits are consistent with those recommended in both the National Protocol (EPA/DOA, 1991) and the Draft Regional Protocol (NED/EPA Region I, 1989).

TABLE 2

Soil Chemistry Analysis

Constituent	Concentration (mg/kg)						Limits	Source
	A-1a	A-1b	A-1c	A-2	A-3a	A-3b		
Mercury	0.21	0.29	0.063	0.064	0.063		10	(1)
Arsenic	4.6	4.8	2.3	2.1	16		<10	(3)
Selenium	1.1	2.3	1.1	1.1	1.2			
Beryllium	0.69	1.4	0.65	0.67	0.64			
Cadmium	0.69	1.4	0.65	0.67	0.64		2	(1)
Chromium	19	26	12	11	14		1000	(1)
Copper	21	29	5.4	4.5	40		1000	(1)
Nickel	9.7	13.1	8.6	6.4	11		200	(1)
Thallium	2.2	4.7	2.3	2.1	2.5			
Lead	33	107	4.7	2.2	17		300	(1)
Zinc	51	49	20	18	40		2500	(1)
Antimony	6.9	14	6.5	6.7	6.4			
Silver	0.69	1.4	0.65	0.67	0.64			
Cyanide	1.81	3.11	1.59	1.58	1.67	1.99		
Total Organic Carbon (TOC)	0.27	1.20	0.17	0.09	0.23	0.71		
Total Petroleum Hydrocarbons (TPH)	38	62	10	<10	10	44	100	(2)
PCB	Composite Sample, See Appendix B						1	(1)
Pesticides	Composite Sample, See Appendix B							

(1) Division of Water Pollution Control, "Recommended DEQE Policy Regarding Upland Disposal of Dredged Material" (June 2, 1986)

(2) Management Procedures for Excavated Soils Contaminated with Virgin Petroleum Oils, Policy #WSC-89-001. Massachusetts Department of Environmental Protection.

(3) Massachusetts Dredged material classifications prepared by Sasaki Associates (1983).

The constituents measured and results are listed in Table 2 and Appendix B. The chemical results were evaluated using the Massachusetts Bureau of Waste Site Cleanup, Management Procedures for Excavated Soils Contaminated with Virgin Petroleum Oils, Policy # WSC-89-001; the Division of Water Pollution Control "Recommended DEQE Policy Regarding Upland Disposal of Dredged Material" (June 2, 1986); and the Massachusetts Dredged material classifications prepared by Sasaki Associates (1983). Based on the low levels of the constituents measured in comparison to these criteria, the material is suitable for upland use at the MDC Belle Isle Park.

IV. RESTORATION ALTERNATIVES

Three options exist to restore tidal flooding to the bermed area:
1) partial or complete removal of the berm;
2) construction of channels through the berm and on the surface of the bermed area; and
3) complete removal of the berm and grading the marsh surface to the level of the preexisting salt marsh.

All of these options would improve hydraulic conveyance and tidal circulation by reducing the hydraulic restriction. Based on effectiveness and cost constraints under the present level of study, Option 2 (onstruction of hydraulic conveyance channels in Area A) was selected.

A. BERM REMOVAL

1. Constraints

The height of the berm is approximately two feet above the level of the Phragmites marsh behind it in the bermed area and about two to four feet above the level of the salt marsh. Removing all or a portion of the berm to the level of the adjacent marsh would allow tidal water to flow into a large portion of the Phragmites marsh in the form of sheet flow. This would remove the major tidal restriction to the area behind the berm. It would require the disposal of approximately 700 cy of material. Removal of the berm without construction of hydraulic conveyance channels would require that all of the flow over the marsh surface occur through sheet flow. Sheet flow, however, is impeded by surficial and vegetative friction which reduces the area which can be flooded during the short period when the tide is above 11 ft. MLW. A more reasonable approach would be to combine smaller, strategic openings in the berm with hydraulic conveyance channels within the interior area. The channels would fill up quicker and provide a more substantial weir length for providing sheet flow than that provided by removing only the outer berm.

2. Effects

Complete removal of the berm is not necessarily the most desirable condition from the perspective of wildlife use. The berm and its cover of Phragmites provide a visual buffer and an upland island which may serve to enhance wildlife use. On one occasion during this study an American bittern was observed using the berm as cover.

The restriction caused by the berm may, during extremely high tides when the berm is overtopped, cause retention of salt water behind the berm since flow during the ebb tide conditions may be restricted by the berm openings. This can increase the vegetation's salinity and flooding exposure and may act to reduce Phragmites dominance. Mitsch and Gosselink (1986) indicated that tidal creeks and steep slopes can lower soil water salinity over poorly drained conditions.

If this salinity condition does not occur with only partial removal of the berm, then complete removal of the berm would increase the quantity of tidal sheet flow into the bermed area and result in some level of increase in salt marsh vegetation, particularly in the area adjacent to the center portion of the berm which runs perpendicular to Bennington Street. A channel must be constructed to increase tidal flooding of Area A even with complete removal of the berm because higher elevations between exterior tidal flooding and the lower elevation Area A will preclude tidal flooding. Sheet flow alone would not provide sufficient hydraulic conveyance to the entire area.

B. CONSTRUCTION OF HYDRAULIC CONVEYANCE CHANNELS

1. Design Considerations

Hydraulic Considerations. The purpose of hydraulic conveyance channels is to allow tidal water to rapidly enter the site and spread across the marsh plain to increase tidal inundation. Based on predicted maximum tide levels from the National Ocean Service tide tables, construction of hydraulic conveyance channels would have resulted in 10 flooding tides during 1989, 11 during 1990, and 4 during 1991.

Mitsch and Gosselink (1986) described the sequence of tidal marsh flooding as follows: "Typically on a rising tide, water flows up tidal creek channels until the channels are bank full. It overflows first at the upstream end, where tidal creeks break up into small creeklets that lack natural levees. The overflowing water spreads back downstream over the marsh surface. On falling tides the flows are reversed." Applying this to the proposed restoration, channels create an additional weir length, at a greater distance inside the marsh, for water to flow over the marsh surface and increase the area of tidal inundation.

Procedures for the design of hydraulic conveyance channels for salt marsh restoration have been described by Haltiner and Williams (1987).

This work describes procedures for sizing channels in relation to the upstream tidal prism and dominant discharge to approximate equilibrium conditions where excessive erosion or sedimentation will be minimized. Because of the periodic nature of tides, there is a limited amount of time during which water can spread out over the marsh surface. Hydraulic conveyance channels allow water to rapidly enter the marsh area before it reaches the height where it can spread across the marsh plain. At the proposed Belle Isle restoration site (Area A) (Area B was excluded from further consideration because of limited positive effects), the berm and high interior elevations create an additional delay to the normal friction provided by the marsh surface.

The size of the interior conveyance channels required from a hydraulic standpoint is small since the volume of the flooding is less than 2.5 acre-feet in Area A. As a result, the sizes of the channels were based more on buildability requirements and erosion-limiting velocities than on conveyance capacity. That is, the size of the channels based on geotechnical considerations is larger than the minimum channel size based on hydraulic considerations; therefore, the channels were designed to the geotechnical standard.

The invert was specified, at approximately elevation 8 MLW, nearly as low as the invert of the exterior ditch, to allow all water to drain out during low tide. The slope of the ditch system should be a minimum of 0.001 feet/foot based on measurements made for a similar tidal ditch system located in the Saugus Marsh area. The minimum slope will extend from the first junction of the channels upstream to the farthest extremes of the newly flooded area. Haltiner and Williams (1987) suggest establishing hydraulic conveyance channels so that they are located within 100 feet of all areas to be flooded.

Construction of hydraulic conveyance channels within the bermed area will result in erosion of the existing salt marsh ditch leading up to the new channel. This ditch currently measures approximately 2 ft. wide by 2 ft. deep. The inflow into the interior area will result in faster velocities in the exterior channel until the exterior channel increases to a new equilibrium. Up until that time a majority of the flow will occur through sheet flow through the new opening in the berm during the occurrences of high tide when lake-like conditions will exist over the salt marsh plain. On the ebb tide the additional flooding of the interior area will result in flow levels which exceed the capacity of the outer channel, resulting in erosion until the channel reaches an equilibrium.

In the southeastern area, the size of the interior conveyance channels required from a hydraulic standpoint is small since the volume of the flooding is less than 1 acre-foot. As a result, the sizes of the channels were based more on constructability requirements and erosion-limiting velocities than on conveyance capacity. Based on geotechnical considerations, the side slopes will be constructed with 3H:1V sideslopes. The invert was specified nearly as low as the invert of the exterior ditch to allow all water to drain out during low tide. The boring exploration program had found loose, fine sandy soils with little

or no organic material in the interior area. This may require construction of channels with flatter side slopes due to the instability of the material. The slope of the ditch system should be a minimum of 0.001 feet/foot based on measurements made for a similar tidal ditch system located in the Saugus marsh area. The minimum slope will extend from the berm area upstream to the farthest extremes of the newly flooded area such that all areas are within 100 feet of the conveyance channels.

Geotechnical Design and Construction Considerations. The design of hydraulic conveyance channels, as with other earthwork structures, is dependent on the physical characteristics of the soils. Two major concerns relating to the soils have been evaluated: 1) stability of the channel side slopes; and 2) ability of the soils to support construction equipment.

Based on the subsurface explorations performed at the site, it appears the proposed shallow channel excavation would encounter either loose saturated silty medium-fine sand or soft clays. To maintain stable channels in the silty sands, side slopes should be excavated at approximately 1 vertical to 3 horizontal (1V on 3H) or slope protection should be provided. Steeper slopes, 1V on 1H to 1V on 3H, could be maintained in the clays depending on the consistency and peat content. For preliminary design, slopes of 1V on 3H should be used for the silty sands and 1V on 2H for the clays. It should be noted that the thicker layer of clay was only encountered in auger A-3 (Figure 3), and therefore, may be limited to a small area. The bottom width of the trench should be a minimum of 3 feet wide to account for possible sloughing and reduce the need for future maintenance. Every effort should be made to promote vegetative growth on the finished slopes to provide long term stability. Because slope protection is impossible to provide within the project funding limitations, the stability of the side slopes cannot be predicted with absolute certainty.

Construction equipment can access the site from two areas; a residential area just southwest of the site or from the MDC Reservation abutting the northeast boundary of the site. Due to the soft ground conditions and high groundwater at the site, operation of construction equipment on the site requires special considerations. Modified conventional equipment or low-ground-pressure vehicles made especially for soft ground construction are required to excavate the channels and to remove the excavated materials from the site. The availability of low-ground-pressure equipment in this area may be limited. Other options include construction of temporary working platforms over the soft materials upon which equipment can operate. The platforms can be constructed of gravel fill placed over a geotextile or timber matting. The design plans and specifications will allow the contractor to use only the timber matting option or propose other methods subject to approval to minimize environmental disturbance.

Subsurface Drainage. Construction of channels through the restoration area has a potential to increase drainage of surface water through the soil water. According to Nuttle and Harvey (1987) lateral drainage in

salt marsh sediments is controlled by: 1) the morphology of the marsh surface; 2) the time between successive tidal flooding events; 3) the hydraulic properties of the sediment; and 4) the rate of evapotranspiration. They found that the greatest water flux occurs within 2.5 meters (m) of the creek banks; that virtually no lateral water movement toward the creek occurred at distances greater than 15 m from the creekbank; and that a transition zone exists between 2.5 m and 15 m from the creek where lateral soil water flow is driven by the alternating periods of flooding and non-flooding associated with the spring-neap tidal cycle. This information was used to determine the potential to cause excessive drying of the marsh surface and to locate hydraulic conveyance channels.

Hydrological calculations were performed using field data obtained from Belle Isle Marsh to determine the level of risk of ponds draining due to subsurface flow to hydraulic conveyance channels. Samples from the marsh were tested and determined to range from silty medium sand to silty clay in size. The hydraulic conductivity of sediments of this size range from 11 feet per day to 1.3 feet per day (Fetter, 1980). In a previously cited paper, Nuttle and Harvey (1987) determined the hydraulic conductivity of the sediments in the area to be approximately 0.5 feet per day. This report is taking a more conservative approach by using the higher values.

The concern addressed here is that if new channels are constructed too near existing ponds, the ponds might be drained. Analysis was performed to obtain certain "safe distances" which could be used to site the channels without unduly draining nearby ponds. The "stream tube" method of analysis, commonly discussed in standard references, was used in this report. In this analysis the discharge in gallons per day from the pond to the channel was determined by assuming a certain hydraulic conductivity, estimating the hydraulic head from the elevation of the ponds and the water in the channel, the width and depth of the pond, and the distance from the pond to the channel. A series of calculations were performed to arrive at an array of safe distances based on varying assumptions.

The volume of water in a pond was divided by the daily discharge from the pond to determine the number of days (drainage days) necessary to completely drain the pond. The matrix shown below displays the "drainage days" based on a variety of assumptions. Variables used are

1: (W) Width of the ponds 120 90 30 feet

2: (L) Distance between channel and ponds 25 50 75 100 feet

3: (K) High value of conductivity 11 feet/day

4: (k) Low value of conductivity approximately 1 foot/day

5: (H low) Hydraulic head at low tide 6.6 feet

6: (H mid) Hydraulic head at mid tide 3.3 feet

TABLE 3 SOIL DRAINAGE DAYS

Drainage Day Matrix (all distances in Feet)

W	L	H low at K	H low at k	H mid at K
120	25	32 days	256 days	64 days
	50	64 days	512 days	128 days
	75	96 days	768 days	192 days
	100	128 days	1024 days	256 days

W	L	H low at K	H low at k	H mid at K
90	25	24 days	192 days	48 days
	50	48 days	384 days	96 days
	75	72 days	576 days	144 days
	100	96 days	768 days	192 days

W	L	H low at K	H low at k	H mid at K
60	25	16 days	128 days	32 days
	50	32 days	256 days	64 days
	75	48 days	384 days	96 days
	100	64 days	512 days	128 days

W	L	H low at K	H low at k	H mid at K
30	25	8 days	64 days	16 days
	50	16 days	128 days	32 days
	75	24 days	192 days	48 days
	100	32 days	256 days	64 days

The drainage days for each of the various assumptions are highlighted with underlining in Table 3.

Table 3 shows that, assuming the highest level of hydraulic conductivity and further assuming that the maximum head is present between the pond and the channel at all times, none of the ponds will drain during the intervals between flood tides if the distance between the pond and channel is 50 feet or greater. This "safe distance" is a very conservative measure because it assumes a constant low tide condition (and thus maximum head difference) as well as assuming that the sediments through which the water passes contain little or no clay. Neither of these conditions apply, but on the assumption that it is prudent for planning purposes to be conservative, it is recommended that wherever possible the channels be dug at distances equal to or greater than 50 feet from the ponds. It is extremely unlikely that any measurable lowering of ponds due to drainage will occur under this scenario. If site conditions require that channels be constructed closer to the ponds, a minimum distance of 25 feet should be maintained. At this distance no significant loss of water would be expected except under rare and extraordinary circumstances such as a low spring tide occurring during a warm period which coincides with a prolonged drought. In the event that channels must be located less than 25 feet from a pond, some temporary lowering of water may occur in the smaller ponds. However, unless the channel-to-pond distance is less than eight feet, even the smaller ponds are not expected to drain completely and in any case will return to the bank-full stage during the flooding of the next spring high tide. It is worthwhile to note that the safe distance of 50 feet arrived at in this analyses agrees very closely with the 15 meter distance used by Nuttle and Harvey (1987).

2. Design Description

The final design of the hydraulic conveyance channels based on the above considerations calls for channels approximately 4 feet deep below elevation 12.0 MLW, matching the invert of the exterior channel, with 1 foot vertical by 3 feet horizontal side slopes (1V on 3H) and a 3 foot wide base (See details). The channel invert elevation will maintain a level of approximately 8 feet MLW from the end of the existing salt marsh ditch outside the berm to the junction of the conveyance channels, then taper to approximately 9.5 feet MLW at the most upstream end of the conveyance channels. A total of approximately 1,500 feet of channels would be constructed as shown on Attachment 2. To the extent possible, channels will be located within 100 feet of areas to be flooded and at least 25 feet from permanent ponds.

Construction is expected to begin with the first channel length between the berm and the junction of the conveyance channels to allow water to drain from the site prior to construction operations in the interior of the site. Low ground pressure equipment will be required to perform the excavation. Timber matting will be required to operate hauling equipment on the marsh. A path connecting the work area to the

staging area must be constructed for equipment access to the site. Vegetation in this area consists of shrubs, saplings, and grass.

Approximately 2,000 cy of material will be excavated in the construction of the conveyance channels. This material will be disposed of on 15,000 square feet of low upland areas on the MDC Belle Isle Marsh Reservation. This quantity of material will cover the area with about 3.6 feet of material. The work is expected to take approximately 2 weeks and would most likely be conducted during the spring of 1992 due to the funding requirements. Approximately 400 truck trips between the construction site and the disposal area would be required to complete the project.

3. Cost Estimate

A cost estimate has been prepared for the work described in the preceding section. Assumptions for the cost estimate included the following: low ground pressure construction equipment consisting of a gradall and a front end loader would be operated on the site; the gradall would place the material adjacent to the excavation in a single pile; the front end loader would transport the material to a 5 cy dump truck on the firm ground; the dump truck would then transport the material to the MDC Reservation disposal site. Based on this construction scenario the estimated construction cost is $23,350.

C. GRADING AS AN OPTION FOR FURTHER RESTORATION OF SALT MARSH

1. Brief Description of Elevations

The option of grading the marsh surface to restore salt marsh is the most complete method offered here. Restoration of proper grades would allow for complete restoration of salt marsh as opposed to the Phragmites/salt marsh mixture which can be obtained with the construction of channels. Grading of the entire bermed area is not recommended, however. The presence of the higher shrub dominated area provides an element of diversity to the habitat which is in short supply. The highest benefit from grading could be achieved by excavating roughly 8 acres in Area A to elevations between roughly 9 to 10 feet MLW and constructing hydraulic conveyance channels. Maintenance of the border provided by the Phragmites would be beneficial because it would provide a buffer zone from exterior disturbances in this urbanized environment and a zone of cover for wildlife use. To the extent possible the existing ponds should be retained to enhance the wildlife value of the area. Open water significantly enhances bird use of salt marshes (Golet, F.C., Associate Professor of Natural Resources Science, University of Rhode Island, pers. comm.).

2. Preliminary Cost Estimate

A preliminary estimate of the cost of excavating Area A to elevation 10 MLW has been developed. The following assumptions were made in developing this estimate: 2 feet of material would be excavated over the 8 acres (i.e., 10 to 12 feet MLW) for a total of 25,813 cy of material; the material would be excavated with a low ground pressure bulldozer which would pile the material at the periphery of the site; a front end loader would be used to load 12 cy dump trucks which would haul the material to a disposal site within 11 miles of the construction site. This estimate includes no provision or contingency for handling problems (i.e., using sealed trucks, restrictions on the use of public roads, or reduced productivity due to the wetness of the site which could require the use of different equipment). Based on these assumptions a preliminary cost estimate for this work is $162,500.

V. EFFECTS OF THE RESTORATION EFFORT

A. INDUCED UPLAND FLOODING

Flood insurance rate maps (FEMA, 1990) have been examined to evaluate the potential of the project to increase flooding of adjacent upland areas. In addition, a single elevation of approximately 15.5 feet MLW (11.0 feet NGVD) was recorded in the parking lot of some new construction located north of Leverett Avenue. The flood insurance rate maps and the surveyed point show that nearly all of the area adjacent to the project in the vicinity of Leverett Avenue is above the elevation of the 100 year flood zone (14.0 feet and 14.5 feet MLW; 9.5 and 10.0 feet NGVD [National Geodetic Vertcal Datum]) (Figure 4). Without an extensive survey and study, the exact amount of change in flooding resulting from the opening of the berms cannot be determined. The proposed restoration alternatives, particularly in the northwestern area (Area A), may cause a minor increase in flood depth since more water will be present in the adjacent inland areas during lower tide conditions. This increased level should have no impact on the developed areas during non-storm conditions since they are above the 100 year flood level (approximately 11.0 feet NGVD). However, during storm conditions, the additional preflooding which occurs would allow wind-induced waves to be higher because of the greater water depth within the bermed area. Based on engineering judgement, it is anticipated that the change will be insignificant.

B. VEGETATIVE RESPONSE

1. Construction Phase Effects

During the construction phase, vegetation in the construction footprint and access paths will be disturbed by construction equipment.

FIGURE 4
FLOOD INSURANCE RATE MAP
SHOWING BELLE ISLE MARSH
PROJECT AREA

COMMUNITY-PANEL NUMBER:
250286 0006 D
NOV. 1990, FEMA

KEY FOLLOWING PAGE

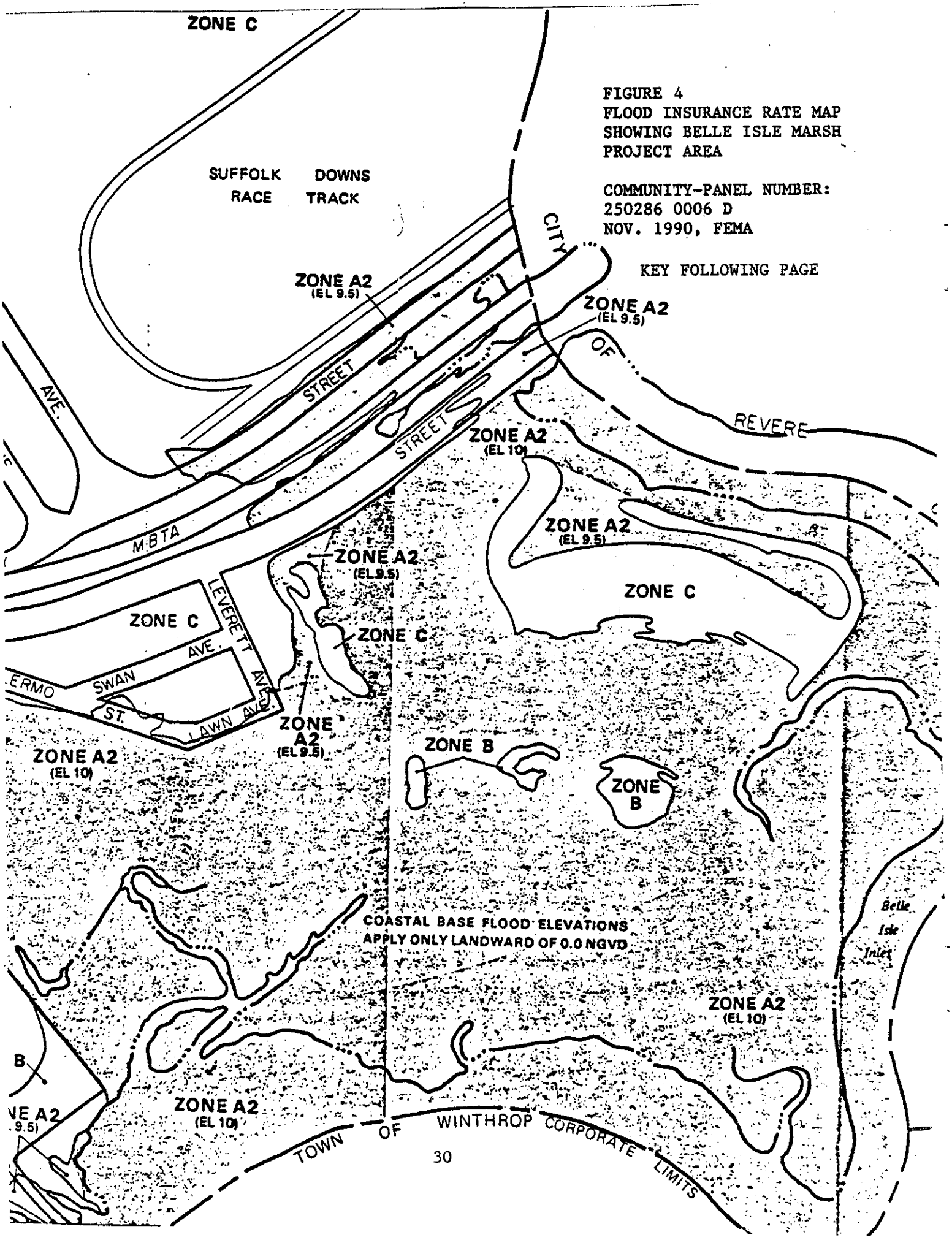


FIGURE 4b

KEY TO MAP

500-Year Flood Boundary	ZONE B
100-Year Flood Boundary	ZONE A1
Zone Designations*	ZONE A5
100-Year Flood Boundary	ZONE B
500-Year Flood Boundary	
Base Flood Elevation Line With Elevation In Feet**	513
Base Flood Elevation in Feet Where Uniform Within Zone**	(EL 987)
Elevation Reference Mark	RM7×
Zone D Boundary	
River Mile	•M1.5

**Referenced to the National Geodetic Vertical Datum of 1929

*EXPLANATION OF ZONE DESIGNATIONS

ZONE	EXPLANATION
A	Areas of 100-year flood; base flood elevations and flood hazard factors not determined.
AO	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; average depths of inundation are shown, but no flood hazard factors are determined.
AH	Areas of 100-year shallow flooding where depths are between one (1) and three (3) feet; base flood elevations are shown, but no flood hazard factors are determined.
A1-A30	Areas of 100-year flood; base flood elevations and flood hazard factors determined.
A99	Areas of 100-year flood to be protected by flood protection system under construction; base flood elevations and flood hazard factors not determined.
B	Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood. (Medium shading)
C	Areas of minimal flooding. (No shading)
D	Areas of undetermined, but possible, flood hazards.
V	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors not determined.
V1-V30	Areas of 100-year coastal flood with velocity (wave action); base flood elevations and flood hazard factors determined.

NOTES TO USER

Certain areas not in the special flood hazard areas (zones A and V) may be protected by flood control structures.

This map is for flood insurance and flood plain management purposes only; it does not necessarily show all areas subject to flooding in the community or all planimetric features outside special flood hazard areas. The coastal flooding elevations shown may differ significantly from those developed by the National Weather Service for hurricane evacuation planning.

For adjoining map panels, see separately printed Index To Map Panels.

Coastal base flood elevations shown on this map include the effects of wave action.

Coastal base flood elevations apply only landward of 0.0 NGVD.

Construction equipment will be stored on the MDC land on Palermo Street. In order to access the site, a path approximately 20 feet wide by 200 feet must be cut through the shrub/sapling vegetation just south of the condominiums on Leverett Street. This type of vegetation is expected to re-establish in the area following the completion of construction.

During construction, the vegetation in the footprint of the channels will be removed and replaced by non-vegetated substrate. Areas adjacent to the channels, where construction equipment will operate and timber mats will be placed, will be trampled. These areas are expected to revegetate following the completion of construction. Soil compaction will likely occur, but is not expected to preclude revegetation.

2. Projected Species Composition

The restoration of tidal flooding to Area A is expected to reduce the cover of Phragmites and to increase the cover of salt marsh species, in particular, salt meadow grass and black grass. (Increases in spike grass and short salt marsh cordgrass are also likely.) This result has been reported where similar alterations have restored tidal flooding (Sinicrope et. al., 1990; Bongiorno et. al., 1984; Roman et. al., 1984; Niering and Warren, 1980). A study of a former salt marsh with constricted drainage in Connecticut where tidal flooding was restored led Bongiorno et. al. (1984) to conclude that restoration of degraded tidal wetlands can be accomplished with relative ease where full tidal flow can be achieved. They reported the results of restoring a 4.5 foot tide range that had been reduced by 9 inches during normal high tides and 18 inches during spring tides. Phragmites density declined dramatically following the first year of reintroducted flooding from 1,643 plants/145m^2 to 482 plants/145m^2 and Phragmites height declined from 182 cm to 140 cm. The density and height continued to decline in the following years, although stunted Phragmites was still present 3 years after tidal flooding was restored.

The studies referenced document the results of a greater level of tidal flooding than can be achieved at the Belle Isle Marsh site without grading. In the case of Belle Isle Marsh, full tidal flow will not be achieved because of elevation changes due to the previous disposal of dredged material. Consequently, the decline in the density of Phragmites is expected to occur at a lower rate at the project site and the ultimate reduction in density is expected to be less significant. However, conditions following the restoration effort are expected to be similar to those which exist in other areas behind the berm where the tidal connection exists. This prediction is based on the assumption that the density and height of Phragmites on-site is stable in relation to elevation and tidal flooding although a preliminary review of 1985 aerial photography suggests that the elevation-vegetation relationship may not be stable. A more comprehensive analysis would be required to describe the trend of Phragmites growth with certainty.

Elevation in relation to tidal regime affects the level of soil water salinity. According to Mitsch and Gosselink (1986), "Tidal action must be strong enough to maintain salinities above 5 ppt; otherwise, the salt marsh is replaced by reeds, rushes, and other freshwater aquatic plants." Odum et. al. (1984) showed a salinity range for Phragmites in Maryland between 0.2-10 ppt. Sinicrope et. al. (1990) reported that vigorous growth of Phragmites occurs at salinities of 20 ppt or less. Howard et. al. (1978) summarized results of studies which indicated that Phragmites can tolerate areas with salinities up to 12 ppt and invades marshes where salinity is just below 20 ppt. They also presented study results which indicated that Phragmites growth was good at salinities of 4.8 ppt and very poor above 12.5 ppt. They suggested that mature plants are limited to areas where soil salinity at 10 cm depth does not exceed 12 ppt.

Salinities behind the berm at the project site, measured on February 25, 1991, ranged from 5.8 ppt in high salt marsh vegetation to 0.4 ppt in a pure stand of tall Phragmites. These are one-time salinity measurements which fall within the range of Phragmites tolerance limits. Therefore, a definite prediction of the restoration, based on salinity levels, cannot be made. The likely results of the restoration effort are based mainly on the elevation relationships described below. Additional sampling would be required to predict the future salinity levels with greater certainty.

Tidally influenced portions of the bermed area support complete cover of salt marsh vegetation up to elevation 11.0 MLW and a mixture of stunted Phragmites and salt marsh vegetation between elevations 11.0 and 11.8 MLW. Based on these relationships the effects of restoring tidal flow to additional areas behind the berm have been predicted. Of the estimated 7.5 acres to be affected by tidal flooding, about 0.36 acre is expected to consist of a mixture of Phragmites, switchgrass (Panicum virgatum), and creeping bent grass (Agrostis stolonifera); 0.93 acre is expected to consist of stunted Phragmites, creeping bentgrass, black grass and salt meadow grass; 5.95 acres are expected to consist of stunted Phragmites, black grass, and salt meadow grass; and 0.40 acre is expected to be dominated by salt marsh vegetation and contain salt ponds. (These estimates do not include additional salt marsh vegetation which could vegetate the side slopes of the channels.) These vegetative types are expected to replace the 100% cover of Phragmites (excluding ponds) which presently exists in the area resulting in positive effects on the marsh system.

Because the proposed restoration site is at the margins of successful vegetative restoration through the restoration of tidal flooding alone, implementation of an additional control technique may be necessary in the future. Management techniques should be considered in the future if salt marsh vegetation has not colonized the site, but are not included in the present project. These techniques may include water management or mechanical removal of plants.

The depth of water presently existing in the area will be reduced from

approximately 6-8 inches to 0 inches during most of the month and will result in up to 10 inches of flooding during the highest spring tides. The depth of ponds would decrease from 43 to 33 inches in the deepest pond and from about 20-30 to 10-20 inches in the smaller ponds. Without the reintroduction of tidal flooding, the reduction in depth of these ponds would likely result in the fringes of these ponds being colonized by Phragmites. However, the reintroduction of tidal flooding should result in the portions of these ponds below elevation 11.0 MLW being colonized by high marsh vegetation, and the ponds that remain should become more saline.

3. Productivity

Salt marshes are credited with having immense productivity, rivaling that of the most productive agricultural lands (Teal and Teal, 1969). This productivity is generally greatest in the low marsh in New England, southern latitude marshes, and marshes with greater tidal amplitudes (Teal, 1962 in Nixon, 1982). The proposed restoration area is at the extremes of spring tides and will result in the creation of very little new low salt marsh, so the productivity will not be increased. The productivity of Phragmites marsh may be greater than that of the high salt marsh so the level of productivity in the area may actually decrease (Nixon, 1982). As stated previously, however, the productivity of salt marshes is more useful to the ecosystem than that of Phragmites marsh.

An important result of salt marsh production is the export of energy to the aquatic food web. The proposed restoration effort at Belle Isle Marsh would have a minimal positive contribution to this export. The value of high salt marshes is not considered as great in terms of productivity export (Nixon, 1982), and the tidal range of the restored marsh will be very small, further reducing its potential export value.

C. WILDLIFE

1. Construction Phase Effects

The effects of the construction phase on wildlife use will be temporary and result from the disturbance caused by the on-site operation of construction equipment. Construction is expected to occur during the spring of 1992 because of the constraints imposed by the funding source. (All funds must be spent by July 1992; see Section I.C. above.) This may coincide with the nesting or birthing season for wildlife, most notably black ducks, mallards, common terns and muskrats, all of which are known to breed at Belle Isle Marsh (ACEC Nomination Letter dated March 6, 1988). Common terns do not nest in the area behind the berm and would not be affected by construction (Scott Hecker, Massachusetts Audubon Society, pers. comm.).

Bellrose (1980) indicates that the nesting season for black ducks begins on March 19 in Maryland and April 12 in the Saint Lawrence Estuary. The start of the nesting season in Massachusetts would fall between these extremes at about April 1 and, according to Bellrose, lasts for 80 days. For mallards, Bellrose (1980) indicates that nesting begins between April 10 and April 30 with the peak of nest initiation occurring between May 5 and May 20. Since construction is presently expected to occur during this spring time-frame, one waterfowl nesting season will be negatively affected. However, waterfowl breeding has not been confirmed in the study area. The value of the habitat for waterfowl is expected to improve following completion of the project.

2. Projected Changes in Habitat Value

The habitat value of the marsh and surrounding ecosystem will change with the change of habitats within Area A from Phragmites dominated marsh to stunted Phragmites/high salt marsh mixture. The benefits of any habitat manipulation can be measured in terms of structural relationships and values of individual plant species and physical attributes. The changes in values will result from structural changes as well as the change in species composition. Structurally, the proposed change will result in small scale increases in the interspersion, juxtaposition, edge and layering qualities of the habitat and a decrease in the depth of fresh water on the site to be replaced by a periodic increase in tidal flooding.

The proposed restoration will change a deep Phragmites marsh (6"-3' water depth; Larson, 1976) to a high salt marsh/Phragmites marsh mixture with salt water flooding about 3 to 35 times per year (NOS, 1990), varying with the location and elevation in the marsh. This change may affect muskrats and mosquitoes as described below in Section 3.

The creation of a salt marsh/Phragmites habitat within an area dominated by Phragmites will improve the habitat qualities of interspersion, juxtaposition and edge by improving the food source (salt marsh vegetation) in proximity to cover. The alignment of the Phragmites against the high salt marsh improves the habitat by creating an ecotone, or transitional habitat type and providing an additional layer (i.e., low grasses) adjacent to robust persistent emergent vegetation (Phragmites).

The change in species composition is expected to result in the replacement of Phragmites with plant species which have greater wildlife value, while the unaffected Phragmites border will maintain the most important value of Phragmites, which is wildlife cover and nesting sites for birds (Howard et. al., 1978). The forage value of Phragmites for wildlife consists of food for muskrats, although of low quality, and support for insect production, which in turn serves as food for terrestrial and aquatic organisms (Howard et. al., 1978; North Atlantic Division, ACOE, 1977). In contrast, seeds of the high salt marsh dominants (salt meadow grass, black grass, and spike grass) which are expected to increase following the restoration project, provide food for

black ducks, Canada geese, and other waterfowl, marsh and shore birds, and small mammals. The shoots and rootstocks provide forage for muskrats, small mammals and waterfowl (Amos and Amos, 1985; NAD, ACOE, 1977; Niering, 1968). This brief comparison shows the greater food value for wildlife which will be realized with the change to salt marsh vegetation.

However, the total quantity of water within Area A will decrease with the project. Under existing conditions it appears that nearly all of the vegetated portion of the site is covered with 6 to 8 inches of water. The ponds range in depth from about 20 to 40 inches. Following the construction of channels the standing water on-site is expected to be reduced substantially. Only the ponds which are avoided by channel alignment are expected to remain. However, the juxtaposition of food in relation to the water and cover requirements and the value of the habitat should improve. The new habitat will have a surrounding border of Phragmites which will continue to provide cover. It will contain tidally influenced ponds which will provide an additional source of food and cover and brood rearing habitat. The high salt marsh vegetation will provide an additional food source proximate to the cover element.

3. Effects on Specific Species

Red-winged Blackbirds. Red-winged blackbirds (*Agelaius phoeniceus*) are one of the most noticeable birds in the project area. Redwings are widely distributed throughout North America wherever they can find suitable marshes in which to breed. The presence of water at or near the breeding site is essential, and the birds must have certain types of dense vegetation in which to conceal their nests. Sufficient height of the vegetation is apparently one of these factors (Bent, 1965).

The Phragmites in the project area has served this purpose, and has supported many redwing nests over the years. The proposed restoration of the project area is not expected to eradicate all of the Phragmites, but rather is expected to leave at least a border of tall Phragmites around the bermed area. Therefore, the value of the project area to breeding redwings should not be seriously affected, in spite of a decrease in the amount of Phragmites and an increase in the proportion of salt or brackish water.

Muskrats. Muskrats, the most obvious mammalian residents of the restoration area will be affected by the habitat change. The vegetation change to greater cover of salt marsh species, by itself, is not expected to negatively affect muskrat habitat. Muskrats inhabit freshwater, brackish, and salt marshes (Allen and Hoffman, 1984; Whitaker, 1980; Odum et. al., 1979). Odum et. al. (1978) reported results obtained by Palmisano (1972) who found that muskrats in Louisiana reached their highest densities in brackish marshes dominated by *Scirpus olneyi* and *Spartina patens*. *Spartina patens*, or salt meadow grass, will be present in Area A following restoration. *Scirpus olneyi* (now referred to as *Scirpus americanus*) inhabits salinity ranges of 3-10 parts per thousand (ppt)

(Odum et. al., 1984) and could occur in the restoration area with propagation. In addition, Allen and Hoffman (1984) indicate that wetlands with 0-10% occurrence of bulrush retain a low value as muskrat habitat. The projected change in habitat with the project will be from non-tidal freshwater marsh to tidal brackish/salt marsh. Palmisano (Odum et. al., 1979) indicated that average production of muskrats in tidal freshwater and brackish water areas was about the same. These findings suggest that, in terms of food value, the change from Phragmites covertype to salt marsh covertype will benefit the muskrat population, although a decrease in house building materials will occur.

The optimum vegetative canopy composition for muskrats is 50-80 % persistent emergent vegetation (Allen and Hoffman, 1984). With the project, the ratio of open-water to emergent vegetation will probably decrease, thereby slightly decreasing the value of the habitat for muskrats in terms of interspersion.

The decrease in water levels will reduce the area of deep marsh and the depth of ponds in the restoration area. Also, the change to a tidal system will increase the water level fluctuation. Muskrats inhabit water bodies that do not have large sudden fluctuations in depth (Godin, 1977), and Trippensee (1953) reported that areas with stable water levels had nearly six times as many muskrat lodges as those with fluctuating water levels. However, Allen and Hoffman (1984) indicate that suitable estuarine muskrat habitat is present where water levels fluctuate less than 35 inches per year. The tidal range of the restoration site will be less than 24 inches; therefore, impacts to muskrats from an increase in water level fluctuation are not expected to be severe. A small decrease in the quality of the habitat may occur with the reduction in depth of Area A and the permanent ponds, however.

The normal home range of muskrats is within 200 yards of their house and circular in shape in the center of marshes and strip shaped to several hundred feet along banks; and those muskrats living in smaller ponds are more likely to wander than those in larger ponds (Godin, 1977). This suggests that, because their range is not exceeded by the alignment of salt marsh to Phragmites marsh under existing site conditions, no significant improvement will occur with the projected change in habitat.

Although the proposed change may result in an overall decrease in the value of the habitat for muskrats, muskrats are expected to continue to inhabit the project site.

D. MOSQUITOES

Under the existing conditions the site contains Phragmites marsh with up to about a foot of standing water. This type of habitat is a breeding area for mosquitoes (J. Card, Essex County Mosquito Control Project, pers. comm. 3 April 1991). The proposed restoration of tidal flow should reduce

the total habitat available for mosquito production because standing fresh water will be removed. Deep ponds, connected to tidal flooding, will support fish which feed on mosquito larvae. Any shallow, temporarily flooded areas that form as a result of the project will create habitat for mosquito breeding. However, these sites can be addressed after they form and are identified (J. Card, Essex County Mosquito Control Project, pers. comm., 3 April 1991). Considering the reverse of the proposed project, Bongiorno et. al. (1984) claimed that mosquito breeding increased in a former tidal marsh in obstructed ditches when flow was restricted and the marsh became dominated by Phragmites. Therefore, the overall effect of the proposed project is expected to be a decrease in mosquito breeding.

E. RECREATION AND AESTHETICS

This section was prepared by the Metropolitan District Commission.

1. Construction Phase Effects

The construction phase of the channelization will entail a wider access of heavy equipment to both the Reservation and the Park. Access and storage of the equipment will take place on Reservation property at Palermo Street. The approximate 2,000 cy of material excavated in the construction of the conveyance channels will be used (if of acceptable quality) for park landscaping.

2. Long Term Effects

Presently, the project area is covered with dense stands of Phragmites which average 8-10 feet in height. The height and density of this vegetation restricts views and makes access through the area difficult. Due to the Phragmites, access, open space, and recreational opportunities in this area are extremely limited.

The restoration of the salt marsh will benefit both open space and recreational opportunities at Belle Isle. Usable open space will increase by the elimination of stands of Phragmites while acceptable excavated material will be used to re-landscape eroded areas of Belle Isle Park. Recreational and educational opportunities created by this project will include:

- Educational programs: The MDC has presented interpretive programs on the cultural and natural history of Belle Isle Marsh since 1986. The Friends of Belle Isle Marsh also present educational and recreational programs at Belle Isle Marsh Reservation. This project will offer an unique opportunity for school groups and the general public to closely study the restoration of salt marsh enviornment.

- Belle Isle Border Trail: The MDC is planning to develop a

destination trail to run the length of the Reservation. The project area would improve the species diversity along this trail, and thus make the trail more interesting for visitors and increase opportunities for interpretation.

- Birding: The project should create a 5-7 acre parcel of high salt marsh, preferred by a variety of bird species, ringed by a dense stand of Phragmites. These conditions should prove to be ideal for bird watching as the phragmites will act as a blind and enable birders to view wildlife without disturbing it.

- Re-landscaping: The use of the excavated material for re-landscaping will improve areas of the park which have been eroded from poor soil conditions and overuse.

F. HISTORIC AND ARCHAEOLOGICAL

Historic and archaeological resources are described in Appendix C. No adverse affects to significant historic resources are expected from the proposed project, since the unidentified pen-like wooden enclosure located to the east of the earthen berm would not be damaged or otherwise affected by the project.

VI. PERMIT REQUIREMENTS

The following permits and regulatory reviews may be required for the proposed project:

Filing of Environmental Notification Form and determination by the Secretary of EOEA that the Project complies with MEPA.

Order of Conditions from the Boston Conservation Commission.

Chapter 91 Waterways License from the Department of Environmental Protection (DEP) Division of Wetlands and Waterways.

Water Quality Certification from the DEP, Division of Water Pollution Control.

Section 10 and/or Section 404 Permit from the Army Corps of Engineers.

Coastal Zone Management (CZM) Consistency Determination.

VII. WORKING GROUP COMPOSITION AND INVOLVEMENT

A working group, consisting of representatives of EPA, Region I; Massachusetts Coastal Zone Management Office; the Massachusetts Environmental Trust; the Metropolitan District Commission; and the Friends of Belle Isle Marsh, was appointed to oversee and prioritize the work effort. The working group provided technical review and decision-making input at decision points throughout the process. The Massachusetts Environmental Trust acted as the program manager. As custodian of the project site the MDC is the project proponent and applicant. The New England Division of the Corps of Engineers provided project management, engineering evaluations and design, and ecological evaluations.

Baseline studies of the vegetation, benthos, fish, and birds of the marsh in the vicinity of the project area were conducted by the Massachusetts Audubon Society, North Shore. The results of these studies are provided in Section II.B of this report. Mass. Audubon also provided input to the project formulation process through the working group meetings, reports, and other coordination. The Friends of Belle Isle Marsh provided the section on the effects on red-winged blackbirds. MDC prepared the Recreation and Aesthetics and Historic and Archaeological sections.

VIII. CONCLUSIONS

The conclusions in this report (Section IV, B, 2) are limited by the level of study which is possible under the budget established by the Federal court order. In most cases predictions cannot be made with absolute certainty. However, the expected result of the project is a decrease in the coverage of Phragmites and a partial restoration of salt marsh vegetation in about 7 acres of former salt marsh. Overall, this would result in positive ecological benefits to the Belle Isle Marsh system.

The alternative recommended for implementation based on expected effectiveness within the budget constraints consists of the construction of hydraulic conveyance channels to restore tidal flow to Phragmites dominated Area A, the portion of the marsh adjacent to Bennington Street. A system of 2,000 feet of channels would be constructed to convey tidal water within approximately 100 feet of areas at or below elevation 11.8 MLW. Based on tide levels from the National Ocean Service tide tables, construction of these channels would result in 10 flooding tides during 1989, 11 during 1990, and 4 during 1991. The channels would link to an existing salt marsh ditch on the exterior side of the berm. This ditch is expected to be subject to erosion until its size equalizes with that of the newly constructed conveyance channels.

As stated in the report, Phragmites is a relatively low value species ecologically, primarily due to its low food value for wildlife and its tendency to exclude all other species of vegetation from an area. Because of its agressive growth characteristics, where the conditions are suitable, Phragmites dominates entire marsh systems. This has occurred at the proposed project site on Belle Isle Marsh and has occurred at numerous sites along the Atlantic coast. In contrast the quantity of salt marsh continues to decline. Invasion of previously diverse marshes by Phragmites results in low plant species diversity and correspondingly low fish and wildlife values. The proposed project at Belle Isle Marsh will improve the ecological value of the marsh by increasing the species diversity and increasing the value of the species composing the vegetation at the project site.

In cases where full restoration of the pre-existing tidal regime can be accomplished the beneficial results are clear. Over time Phragmites is reduced in height and density as salt marsh species reclaim the site. At the project site, the elevations are at the extremes of tidal flooding; this reduces the potential impact of the proposed restoration. Rather than complete restoration of salt marsh vegetation, a mixture of stunted Phragmites, influenced by increased salinity levels, and salt marsh vegetation is expected to dominate. Due to the lower level of tidal flushing that will occur at the project site, the change in species composition is expected to be slower than would occur with a higher level of tidal restoration. Even with complete restoration of tidal flooding the change to salt marsh species requires a number of years.

The ultimate level of recolonization by salt marsh species cannot be predicted with absolute certainty because of the elevation change that has occurred at the site. The extent of change should be monitored so that additional management measures can be applied in the future to reduce the level of Phragmites dominance if necessary. These measures could include direct control of Phragmites through cutting or mowing or may consist of water management. Two options for water management include temporary, extended storage of water during tidal flooding events through the use of a water control structure at the outlet or perimeter ditching to channel freshwater from the site. A water budget for the site could be developed to evaluate the significance of freshwater input on the marsh salinity regime prior to constructing a perimeter ditch system.

The vegetation change from the project will result in changes in the habitat value for certain species. In particular, effects on muskrats, waterfowl, and red-winged blackbirds were considered in the report. Based on the evaluations in this report, effects on these species would not be severe. In addition, concern has been raised about effects on black-crowned night heron roosting. Effects on these species have been considered light of beneficial effects on typical salt marsh species such as sharp-tailed sparrows.

TABLE 5. SUMMARY OF EFFECTS OF THE PROPOSED PROJECT

	SHORT TERM	LONG TERM
UPLAND FLOODING	NA	Any increase is expected to be minimal, although the level of study was not sufficient to predict with certainty.
VEGETATION	Vegetation on the marsh, in the staging area, and in the access area will be disturbed during construction.	Phragmites dominance would decrease. An increase in the diversity of vegetation would occur with the increase in salt marsh species abundance.
WILDLIFE HABITAT VALUE	Short term disturbance due to construction activity and temporary loss of vegetation would occur.	Habitat value would increase as salt marsh species replace low-value Phragmites.
RED-WINGED BLACKBIRDS	Short term disturbance due to construction activity.	Minor effect.
MUSKRATS	Short term disturbance due to construction activity.	Negative effect due to decreased water levels may be somewhat balanced by increased food value of the vegetation.
MOSQUITOES	NA	Potential decrease in mosquito populations.
RECREATION	Short term disturbance due to construction activity.	Positive effect due to increased non-consumptive use value.
AESTHETICS	Short term effect on visual resources and noise due to construction.	Positive effect due to increased visibility at the project site.
HISTORIC AND ARCHAEOLOGICAL	No adverse effect.	No adverse effect.

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APPENDIX A
RESULTS OF BASELINE STUDIES ON THE BIOTA OF BELLE ISLE CARRIED OUT BY THE MASSACHUSETTS AUDUBON SOCIETY: NORTH SHORE

RESULTS OF BASELINE STUDIES ON THE BIOTA OF BELLE ISLE CARRIED OUT BY THE MASSACHUSETTS AUDUBON SOCIETY: NORTH SHORE AS OF MAY 20, 1991

I. BELLE ISLE MARSH BENTHIC SURVEY

Introduction and Methods

Benthic samples were taken from ten stations in Belle Isle Marsh in August 1990. The sampling regime was selected to provide an initial inventory of the intertidal benthic fauna of the marsh, and to provide a comparison of the benthic fauna within and outside of the berm.

Stations A1 and A2 were located in the main channel and Stations B1, B2 and B3 were situated in mosquito ditches that cut through the marsh towards the berm (Fig. 1). Samples were collected at low tide and represented sites that were flooded throughout most of the tidal cycle.

Stations I1 and I2 were taken from the edge of standing pools (salt pans) inside the berm area, while stations O1 and O2 were in a similiar habitat outside the berm. Station M was in an algae mat within the berm area.

At each Station 3, replicate 0.003 m^2 cores were collected. All samples were sieved through a 0.3 mm mesh screen, stained with rose bengal, preserved in 10% formalin, and sorted and identified to species under a dissecting microscope.

The sediments at Station A, B, and M were all fine grained muds with most of the sediment washing through the 0.3mm mesh screen. Station A2 had slightly more sand than the others. All samples from Stations A and B contained broken shell material. Stations I and O contained fine grained muds with some fragments of plant material.

Results and Discussion

The composition of Stations A1&2 and B1 was very similiar (Table 1). In all cases Oligochaetes and the spionid polyschaete, Streblospio benedicitii, were the dominant taxa. Together the two types of worms accounted for between 89 and 93% of all individuals found at the five stations. The dominance of these two taxa is characteristic of the intertidal fauna of Boston Harbor, usually accounting for 50 to 90% of the animals found (New England Aquarium 1983, Keay 1988, Gallagher and Grassle 1988, M. Hall unpublished data). The other species found in the present study (Table 1) are typically minor components of the intertidal fauna in these studies.

The number of species (15) found at the five stations at Belle Isle Marsh was identical to the species number at the north side of the airport opposite to Belle Isle Inlet (New England Aquarium 1983). In contrast, more species (23 to 30) and less dominance by Oligiochaetes and Streblospio benedictii is characteristic of the intertidal fauna of Savin Hill Cove (Keay 1988, Gallagher and Grassle 1988) and the Marina Bay area in Quincy (M. Hall- unpublished data).

The density of animals found at the six Belle Isle stations (22,900 to 63,400 m^2) is similar to

that occuring off Logan Airport (New England Aquarium 1983) and Marina Bay but is an order of magnitude less than what has been found at Savin Hill Cove (Keay 1988, Gallagher and Grassle 1988). The higher densities at Savin Hill reflect the increase in nutrient availability due to the proximity of the Cove to the Fox Point Combined Sewer Overflow.

The interdal benthic community found at Stations A1&A2 and B1-3 appears to be the typical intertidal fauna of Boston Harbor. Extension of the ditches into the bermed area will presumably create favorable habitat for this community and lead to an increase in faunal diversity behind the berm.

Stations I and O were sampled in order to compare similar habitats (salt pannes) within and outside the berm. The low numbers of species and individuals found at these stations were not totally unexpected, since the habitat was far from ideal for traditional benthic communities. Quantitatively, Station I1 and I2 differed little form Station O1 and O2,. however, the types of species found at the stations differed. Calliopius laeviusculus, a pelagic-benthic amphipod, was only found in the O Stations. This species is a prey item for small fish. Interestingly, fish were observed in the salt pannes from which O samples were taken. Neither fish nor amphipods were observe in the I salt pannes during the late summer and fall.

Station M was in an occasionally flooded algal mat behind the berm. Only two worms were found. Benthic invertebrates apparently do reside in very low densities in these mats. Any increase in the frequency of tidal flooding in these habitats will increase the probability of colonization by invertebrates and provide more suitable conditions for their long-term survival. The cyanobacteria and diatoms of this mat are discussed later.

II. BELLE ISLE MARSH VEGETATION ANALYSIS

Introduction

The goal of the vegetation analysis is to describe the condition of the existing plant community in the study area and to set up a series of permanent transects so that changes in vegetation resulting from any habitat restoration activities can be monitored over time.

Methods

1. Community analysis

Vegetation analysis of the study area has been carried out using the line intercept method. The location of the three transects are indicated on the map. These transects have been selected to represent areas dominated by salt marsh vegetation, and areas transitional between salt marsh and Phragmites. Transects have been marked at each end with PVC pipe tipped with red paint. Flags have been placed every 5 m, except in places of obvious human traffic.

Veg. #1: In the northeast corner of the study area and running in a line 104-284 degrees off magnetic north. The line starts 20 m seaward of the berm, running through the first break in the berm after you enter the area from the old drive-in movie section, and into the Phragmites area,

roughly in a line with a large obvious cottonwood. The line extends 100 m landward of the berm.

Veg. #2: This is perpendicular to the southwestern border of the study area, near a breach in the berm. The line begins 20 m seaward of the berm, runs over the berm, and continues 100 m landward of the berm, roughly in a line with an obvious willow. Angle of the line in relation to magnetic north is 43-221 degrees.

Veg. #3: Our third transect begins west of the area of actual salt marsh landward of the berm in very thick Phragmites in a slight upland. There is a small staghorn sumac in the "understory" of the Phragmites. The line runs NW to SE at 140-320 degrees for 100 meters. The line passes over a salt panne (usually dry) and through a Phragmites island before ending in another panne (usually wet) not far from the end of veg. #2.

Each transect is divided into 5 m intervals. In September 1990, data collected for each interval included the linear distance covered by each species present and the maximum height of the tallest and second tallest species. Data analysis for 1990 included plant species present, relative frequencies, relative cover, and relative importance (importance = frequency+cover) for each species.

2. Vegetation height in relation to tidal inundation

On December 3, 1990, an extremely high spring tide (12.3 ft) resulted in extensive tidal inundation of the study area. We used this opportunity to measure the relative height of the water above the marsh surface along each transect line. Since the tide was dropping while we were making these measurement, elevation comparisons inferred from these results are only valid within one transect.

3. Biomass comparison

The effect of the berm on aboveground biomass was analyzed by comparing 20 quadrats ($0.1 m^2$) of pure Spartina patens within the berm to 20 randomly selected quadrats outside the berm but within a short distance of the berm (ca. 20 m). The quadrats inside the berm were selected by running a 100 m transect line through a patch of pure S. patens roughly parallel and about 20 m within the southwest border of the study area. This was the only patch of S. patens within the berm that was relatively free of other salt marsh vegetation, hence differences in biomass would not be confounded by differences in species composition. All aboveground biomass was collected within a 0.1 m^2 quadrat sampler placed down at 5 m intervals along the transect line. The quadrats outside the berm were selected by looking for patches of pure S. patens within 20 m of the berm. Since pure patches were generally less than 10 m in diameter and were not contiguous, we sampled by randomly throwing our quadrat sampler into a patch. For several patches larger than 20 m, we ran a short transect through the middle of the patch and sampled at 5 m intervals. The maximum number of quadrats collected from any patch outside the berm was three.

Results

Salt marsh vegetation typical of New England marshes, i.e. the cordgrasses Spartina alterniflora and S. patens, dominates an area of roughly four acres in the southeast corner of the study area (Table 2). The only salt marsh species that occurred outside the berm, but was not

located within the study area was Triglochin maritima. Continued vigilance in the spring may lead to the discovery of this plant in the study area.

To the northwest of this salt marsh zone is an area (ca. 3 acres) transitional between salt marsh and Phragmites australis. P. australis forms the "canopy" of this area and is the most visually obvious plant, however salt marsh species, especially S. patens and Juncus gerardi, dominate in terms of cover (see Figs. 1a-1c). Another typical "understory" plant in this area is seaside goldenrod, Solidago sempervirens. Within this area, we collected a specimen of Calamagrostis epigeios, a grass native to the Caspian Sea area that was previously unknown in the Boston area. The identification of this plant, which is similar in appearance to a stunted P. australis was done by Bruce Sorrie, Botanist with the Massachusetts Natural Heritage and Endangered Species Program.

The remainder of the study area is dominated by P. australis. Scattered patches of shrubs such as bayberry, Myrica pennsylvanica, and staghorn sumac, Rhus typhina, occur in drier areas. This P. australis area was not well characterized in our surveys, since only a small part of vegetation transect #3 included it. The wetter parts are very difficult to access.

All three transects included some pannes. Some were more or less permanently inundated, others were flooded only at extremely high spring tides (greater than 12 ft) and contained stunted S. alterniflora, Salicornia europaea, Sa. bigelovii, or an algal mat.

Vegetation height along transects was greatest on the berm itself and in the area of mixed P. australis and salt marsh (Fig. 2a-2c). This is obviously related to the height of P. australis. The 1990 data on heights will be valuable for future, post-alteration comparisons, since we expect greater tidal flushing to result in greater stunting of P. australis. The only place where Sp. alterniflora was greater than one meter tall, indicative of relatively good tidal flushing, was in the part of transect one that was seaward of the berm.

Importance values of plants along the three transects differed (Table 3). Transect 1 is dominated by Sp. patens, J. gerardi, and P. australis, transect 2 by Sp. alterniflora, Sp. patens. and D. spicata, and transect 3 by P. australis, J. gerardi, and D. spicata. These differences are likely related to differences in elevation, transect 2 being relatively "wet" and transect 3 relatively "dry" compared to the others. Importance values will provide useful baseline information if greater tidal flushing is allowed into the study area.

The biomass of Sp. patens was greater outside the berm than within the study area (Table 4). This suggests that the some characteristic of the study area, such as less tidal flushing or differences in elevation results in lower aboveground production within the study area. The end of season biomass values (600-800 $g\text{-}m^{-2}$) of S. patens both within and outside the study area are fairly typical productivity values for New England high salt marshes (Nixon, S. 1982, The ecology of New England high salt marshes: A community profile, USFWS/OBS-81/55).

Discussion and Recommendations

Phragmites typically grows in salinities between 15-25 ppt. Since we have no present data on ground water salinities in the study area, nor the extent of sheet flow of ground water, it will be very difficult to predict what percent of the study area will be restored to salt marsh

vegetation with enhanced tidal inundation. We also do not know the overall dynamics of the salt marsh/Phragmites boundary, i.e. is the Phragmites zone expanding, decreasing, or static.

Increasing tidal inundation by creating more breaches in the berm and digging a channel to the back area of the Phragmites zone is a necessary step toward increasing the area of salt marsh in the study area. Enhanced tidal inundation alone will not likely get rid of Phragmites except immediately adjacent to any channels that are installed, because the Phragmites is already well established and the groundwater salinities are not likely to be much higher than 20-25 ppt. The salinities of the tidal water entering the marsh from Belle Isle Inlet average around 30 ppt, based on data from Massachusetts Audubon's Boston Harbor Monitoring Program, thus freshwater dilution through groundwater or overland runoff might bring salinities down to a range still tolerated by Phragmites. A long term program of active Phragmites management, such as burning or mowing, will also likely be necessary after greater tidal inundation is established. Another possible management tool for reducing Phragmites could be channeling freshwater away from the Phragmites area to reduce the dilution of the saltwater entering through the proposed channel.

III. BELLE ISLE BIRD DATA

Introduction

Birds are the most obvious wildlife in the study area, and are largely the reason the area is attractive to naturalists. Due to their value as environmental indicators of habitat changes, we collected data on birds from a number of sources. We wanted to assess how restoration efforts might impact bird numbers in the area. Our intention is to continue sampling birds in the study area over the next year and to sample the study area intensely in the spring for nesting birds.

The information collected by birders and cited in an earlier study of Belle Isle Marsh (Gard 1984) is not specific to the study area. They focus on areas where birds tend to be abundant on the marsh. They provide baseline information on what the overall habitat supports for comparison our specific study area.

METHODS

We collected three types of data:

1. Historical data based on discussions with two well-respected bird watchers who have frequented Belle Isle Marsh, Soheil Zendeh and Leo Rogers.
2. Routine observations of birds as we worked in the study area, using binoculars. As with the vegetation data, most of these observations were carried out in the salt marsh and transitional areas between salt marsh and Phragmites. We also kept notes on birds we casually observed in other areas of the marsh, to get a sense of how the study area compared to the whole marsh.
3. An attempt at quantitative assessment by sampling along three bird transects. Transects are described below. An observer would walk along a transect line, stopping for a minimum of four minutes at 50 m intervals. Dates of our transect surveys were 28 Nov 90, 5 March 91, 14 May 91.

Bird sampling transects

Bird transects are marked at their ends with pvc pipe painted with yellow tips, except where the transects are congruent with the vegetation transects. Flags are placed every 50 m.

Bird #1: This is begins at the first break in the berm (see veg. #1) and is congruent with veg. #1 for its first 100 m. It extends for a total of 189 m toward the cottonwood (see veg #1). The yellow pvc pipe marking the upland end is located at the border of the marsh and Phragmites roughly 10 m E of the cottonwood.

Bird #2: This is congruent with veg. #3 and extends to the berm, where it is marked with a yellow pvc pipe.

Bird #3: This is parallel to the southwestern edge of the study area, roughly ten meters from the berm on that side. It runs at an angle of 148-328 degrees in relation to magnetic north and extends for 250 meters.

RESULTS AND DISCUSSION

The value of our attempts to quantify bird use of the study area by transect censusing was limited by the low number of birds we observed during two of the three censuses, November 90 and March 91 (Table 5). Our survey in May 1991 was timed to coordinate with the height of spring migration. The three most abundant birds observed in the study area during the May census were starlings, red wing blackbirds, and black-crowned night herons. We did Use of the study area by birds may be too sporadic to get reliable quantitative data without sampling much more often than is feasible.

Our overall qualitative assessment, based on observations made during our field visits to the study area, is that the study area is used by fewer birds than other parts of the marsh (Table 6). Typical marsh birds that were commonly observed along Belle Isle Inlet or in Rosie's Pond but were rarely observed in the study area include snowy egrets, black-bellied plover, greater and lesser yellowlegs, and gulls. Mallards and black ducks were occasionally observed in the study area, but were more common in other areas of Belle Isle.

Nonetheless, some bird species may be more common in the study area than in other areas of the marsh. In late summer and fall 1990 and winter 90-91, these included sharp-tailed sparrows, American bittern (a state listed "species of concern"), black-crowned night herons (a number of which roost during the day around a pond in the Phragmites according to Leo Rogers and our own observations), and a short-eared owl (state listed endangered species). The Phragmites area is also the major area of the entire Belle Isle Marsh for nesting of red wings (L. Rogers, pers. comm. and our own observations).

Phragmites marshes are not considered valuable bird habitats in the eastern United States and are not associated with the breeding of any species in Massachusetts (W. Peterson, Mass Audubon Society Staff Ornithologist, pers. comm.). The Phragmites part of the study area at Belle Isle Marsh is not, however, without value to birds and other wildlife. In addition to the species mentioned above, black ducks have been observed in the small freshwater ponds in the Phragmites area, where the tall growth of this reed apparently provides good cover. At least four muskrat houses also occur within the Phragmites zone and nowhere else at Belle Isle (L. Oliver, pers. comm.). The Phragmites provides an aesthetic buffer from the activities and traffic of

Bennington Street, a buffer that might also be important in reducing disturbance to wildlife. Scrubby upland areas created by dredge spoils within the Phragmites may provide nesting areas for a number of birds that forage on the marsh but need drier habitats for nests. Based on the bird list for Belle Isle (Zendeh 1988) these might include song sparrows, American kestrel, and killdeer.

Waterlogged short Spartina alterniflora marshes are typical foraging habitats of sharp-tailed sparrows. The nest of this species is typically built on the ground, hidden within Spartina patens or Juncus gerardi zones of marshes (Hill, N.P. 1968. Eastern sharp-tailed sparrow. In Bent, A.C. 1968, Life history of North American cardinals, grosbeaks, buntings, towhees, finches, sparrows, and allies, Part Two, Dover Publ. New York, pp 795-912). Sharp-tailed and seaside sparrows are suspected nesters in the salt marsh within the study area (S. Zendeh, pers. comm.).

IV. BELLE ISLE FISH SURVEYS

Introduction

One of the major functions of salt marshes, as noted in the Massachusetts Wetlands Protection Regulations, is their connection to fisheries resources. Salt marshes are considered valuable for fisheries resources in that they serve as nursery areas for the juveniles of commercially important species. Species such as winter flounder, Pseudopleuronectes americanus, may inhabit salt marsh creeks and adjacent habitats for part of their life history. By feeding directly on the marsh surface during high tides, mummichogs, Fundulus heteroclitus, transform marsh productivity to marsh creeks and the nearshore community. Thus an examination of the fish populations within the study area and other parts of Belle Isle would provide an indication of the value of this area to fisheries resources.

Methods

On October 1, 1990, February 26, 1991, standard steel minnow traps were placed in creeks right at the point where there are breaches in the southeast and southwest borders of the study area. Two traps at each site was left in situ for 1.75 hr on Oct 1 and 1 trap at each site on Feb 26. Fish species and numbers were counted.

We seined a number of the creeks and mosquito ditches with a standard minnow seine (4 ft x 4 ft, mesh size 0.25 inch) on November 8, and 28, 1990 and February 26 and March 26, 1991. One person walked along each side of the creek, dragging the bottom of the seine lightly along the bottom of creek. Approximate distance seined was noted for later quantification. Voucher specimens were collected and are preserved at the Norman's Woe Marine Studies Center.

On November 8, we seined in Belle Isle Inlet in the vicinity of benthic station A2 (near the mussel bed). We used a minnow seine (20 ft x 4 ft, mesh size 0.25 inch). We seined in the Inlet near the water pumping station on Bennington Street on March 26.

Results and Discussion

More mummichogs were caught in our minnow traps in October than in February (Table 7). The numbers caught in 1.75 hr at the breach of the SE creek were roughly comparable to numbers we have caught in a "pristine" salt marsh creek in Ipswich in 24 hr. Thus our impression is that the creeks leading up to the study area and the breaches within the study area support high populations of mummichogs.

The low numbers of mummichogs in February suggest that mummichogs avoid these relatively shallow mosquito ditches in colder weather. Alternatively, populations may be lower because of the absence of recruitment into the population through reproduction.

Fish were sporadically present in the salt pannes within the study area. We failed to catch any mummichogs on November 8, but caught about one hundred on March 26. We also caught a pregnant nine-spined stickleback and a three-spined stickleback in a panne within the study area at this time. This panne may be too shallow to support fish between spring tides. Increasing the tidal flushing into this area will likely increase its ability to support mummichogs and other salt marsh fish on a more regular basis.

Species lists derived from seining indicate that the most abundant fish in the mosquito ditches and salt pannes seaward of the berm were mummichogs (Table 8). We caught an occasional nine-spined stickleback. In samples collected by seining and dip netting salt pannes and mosquito ditches outside the study area during the summer, Gard (1984) reported three and four spined sticklebacks (Gasterosteus aculeatus and Apeltes quadracus), striped killifish Fundulus majalis, and juvenile eels Anguilla rostrata. We caught three spined sticklebacks in one of the pannes outside the berm in March. We have also regularly caught two shrimp, Paleomonetes pugio (abundant) and Crangon septemspinosus (occasional), in the mosquito ditches.

Seining within Belle Isle Inlet itself was difficult due to the softness of the substratum. In November, we caught several silversides, Menidia menidia, and a shrimp, Paleomonetes pugio, in the Inlet near the mussel beds. Menidia probably spawns in the nearby Saugus/Pines Estuary (USACOE 1989 Saugus River and Tributaries Flood Damage Reduction Study) and may also spawn in Belle Isle Inlet. In March we caught two juvenile eels (Anguilla rostrata), including one glass eel, in the Inlet near the water control station.

Winter flounder are commonly caught by recreational fishermen in the Inlet (Gard 1984). This species spawns in nearby Saugus/Pines estuary in March and April and juveniles occur there through the summer (USACOE 1989). This fish may also spawn in Belle Isle Inlet.

TABLE 1: BELLE ISLE MARSH BENTHIC STUDY - AUGUST 1990
STATION TOTALS

SPECIES	STATION A1	A2	B1	B2	B3
Annelids					
Capitella spp.	2		3	7	
Eteone heteropods*	4	11	5	5	13
Hediste diversicolor	1		11	1	1
Leitoscoloplos fragilis	4	4			7
Nereis succinea			2		
Polydora cornuta (ligni)	4	7	9	5	7
Spio setosa		4	1		
Streblospio benedictii*	235	172	431	188	314
Oligochaetes	102	104	49	23	270
Crustaceans					
Ampelisca abdita	4	1			
Calliopius laeviusculus*					
Corophium insidiosum			4		
Molluscs					
Ilyanassa obsoletus	3	3	1		6
Macoma balthica	2				5
Mya arenaria	1	3			9
Mytilus edulis		1			
# of individuals (per 0.01m^2)	362	310	516	229	634
# of species	11	10	10	6	10

* Stations with only a few individuals are listed below:

I1 - 1 Streblospio benedictii
I2 - nothing
M1 - 1 Streblospio benedictii
1 Eteone heteropoda
O1 - 1 Streblospio benedictii
3 Calliopius laeviusculus
O2 - 3 Calliopius laeviusculus

MAS BELLE ISLE PROJECT
TABLE 2: WORKING LIST OF PLANT SPECIES FOUND WITHIN THE BERM AT BELLE ISLE MARSH, March 11, 1991

Grasses, sedges, rushes
Spartina alterniflora
Spartina patens
Phragmites australis
Agropyron repens
Distichlis spicata
Juncus gerardii
Agrostis stolonifera var palustris
Puccinellia maritima
Poa pratensis
Calamagrostis epigeios
Panicum virgatum
freshwater grasses??

Forbs
Atriplex patula
Salicornia europaea
Salicornia bigelovii
Suaeda linearis
Limonium carolinianum
Solidago sempervirens
Spergularia marina
unknown herb #1
Aster subulatus
Calystegia sepia
Lythrum salicaria
Onoclea sensibilis
Equisetum sp.

Upland trees and shrubs
Betula occidentalis
Rhus typhina
Myrica pennsylvanica
Populus deltoides
Populus tremuloides
Spiraea tomentosa
Rosa sp.
Lonicera sp.
Prunus serotina
Pyrus malus
Amelanchier sp.
Salix sp.

SPECIES FOUND AT BELLE ISLE, BUT NOT WITHIN THE BERM - *Triglochin maritima*

Thanks to Bruce Sorrie of Mass Natural Heritage and Endangered Species Program for aid and confirmation of plant identifications.

MAS BELLE ISLE PROJECT: Robert Buchsbaum

TABLE 3: RELATIVE IMPORTANCE VALUES OF PLANT SPECIES FOUND WITHIN THE BERM AT BELLE ISLE MARSH, FALL 1990 SAMPLING

Grasses, sedges. rushes	Transect 1	Transect 2	Transect3
Spartina alterniflora	8	37	10
Spartina patens	26	19	7
Phragmites australis	16	6	24
Agropyron repens	1	1	0
Distichlis spicata	11	13	12
Juncus gerardii	20	2	17
Puccinellia maritima		1	
Calamagrostis epigeios	?		?
Forbs			
Atriplex patula	1	0	0
Salicornia europaea	2	8	3
Salicornia bigelovii	2	1	2
Suaeda linearis	1	1	0
Limonium carolinianum	4	1	1
Solidago sempervirens	5	4	9
Calystegia sepia	0	0	1
Trees and shrubs			
Rhus typhina	0	0	1

MAS BELLE ISLE PROJECT:

TABLE 4: ABOVEGROUND BIOMASS OF SPARTINA PATENS WITHIN AND JUST OUTSIDE THE BERMOCT 1990

Site	n	biomass (g/m^2 ±SE)
inside	20	69 ±51
outside	20	8 1 ±42

MAS BELLE ISLE PROJECT:

TABLE 5: BIRDS OBSERVED DURING THREE TRANSECT SURVEYS WITHIN THE BERM AT BELLE ISLE MARSH

SPECIES	NOV. 28, 1990	MAR 5, 1990	MAY 14, 1990
WADERS:			
black-crowned night heron			14
green backed heron			2
SHOREBIRDS			
least sandpipers			5
lesser yellowlegs			2
greater yellowlegs	1		
DUCKS			
mallard		2	
black duck		1	
GALLINACEOUS BIRDS			
ring-necked pheasant		1	
PASSERINES			
barn swallow			3
crow		2	
starling		13	73
goldfinch			2
house finch		1	
song sparrow		2	4
red wings		14	14
common grackle			1
robin			1

MAS BELLE ISLE PROJECT:

TABLE 6: WORKING LIST OF BIRDS OBSERVED WITHIN THE BERM AT BELLE ISLE MARSH

as of May 20, 1991, total of 16 field trips.

WADERS:	
black-crowned night heron	Nycticorax nycticorax
American bittern	Botaurus lentiginosus
green-backed heron	Butorides striatus
SHOREBIRDS	
least sandpipers	Erolia minutilla
spotted sandpiper	Actitus macularia
greater yellowlegs	Totanus melanoleucus
lesser yellowlegs	Totanus flavipes
DUCKS	
mallard	Anas platyrhynchos
black duck	Anas rubripes
GULLS AND TERNS	
herring gull	Larus argentatus
RAPTORS	
kestrel	Falco sparverius
merlin	Falco columbarius
red-tailed hawk	Buteo jamaicensus
short eared owl	Asio flammeus
GALLINACEOUS BIRDS	
ring-necked pheasant	Phasianus colchicus
PIGEONS AND DOVES	
mourning dove	Zenaidura macroura
PASSERINES	
barn swallow	Hirundo rustica
tree swallow	Iridoprocne bicolor
crow	Corvus brachyrhynchos
starling	Sturnus vulgaris
goldfinch	Spinus tristis
house finch	Carpodacus mexicanus
song sparrow	Melospiza melodia
savannah sparrow	Passerculus sandwichensis
sharp-tailed sparrow	Ammospiza caudacuta
cedar waxwing	Bombycilla cedrorum
northern shrike	Lanius excubitor
red wings	Agelaius phoeniceus
common grackle	Quiscalus quiscula
robin	Turdus migratorius

MAS BELLE ISLE PROJECT:

TABLE 7: NUMBERS OF MUMMICHOGS CAUGHT AT SE AND SW BREACHES OF THE BERM

Site	Date	Fish caught/hr
SE breach 1	1 Oct 90	57
SE breach 2	"	157
SW breach 1	"	4
SW breach 2	"	15
SE breach	26 Feb 91	0
SW breach	"	2

MAS BELLE ISLE PROJECT:

TABLE 8: LIST OF FISH AND MACROINVERTEBRATES CAUGHT AT BELLE ISLE MARSH as of December 31,1990, total of 3 field trips with seine.

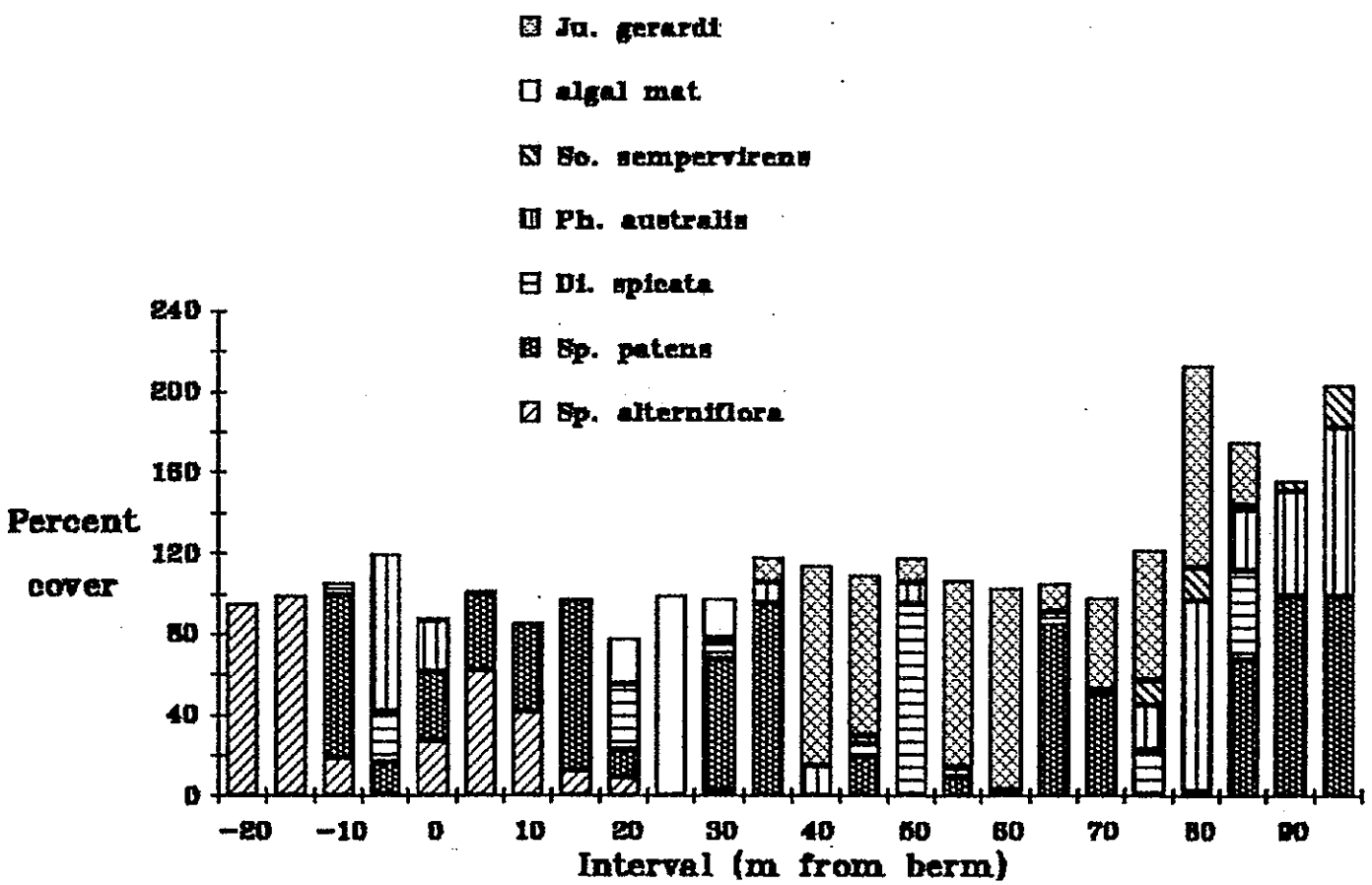
FISH

mummichog	***Fundulus heteroclitus***
nine-spined stickleback	***Pungitius pungitius***
three-spined stickleback	***Gasterosteus aculeatus***
American eel	***Anguilla rostrata***
silversides	***Menidia menidia***

INVERTEBRATES

grass shrimp	***Palaemonetes pugio***
shore shrimp	***Crangon septemspinosa***
amphipods (various)	

Relative cover at different intervals: Transect 1



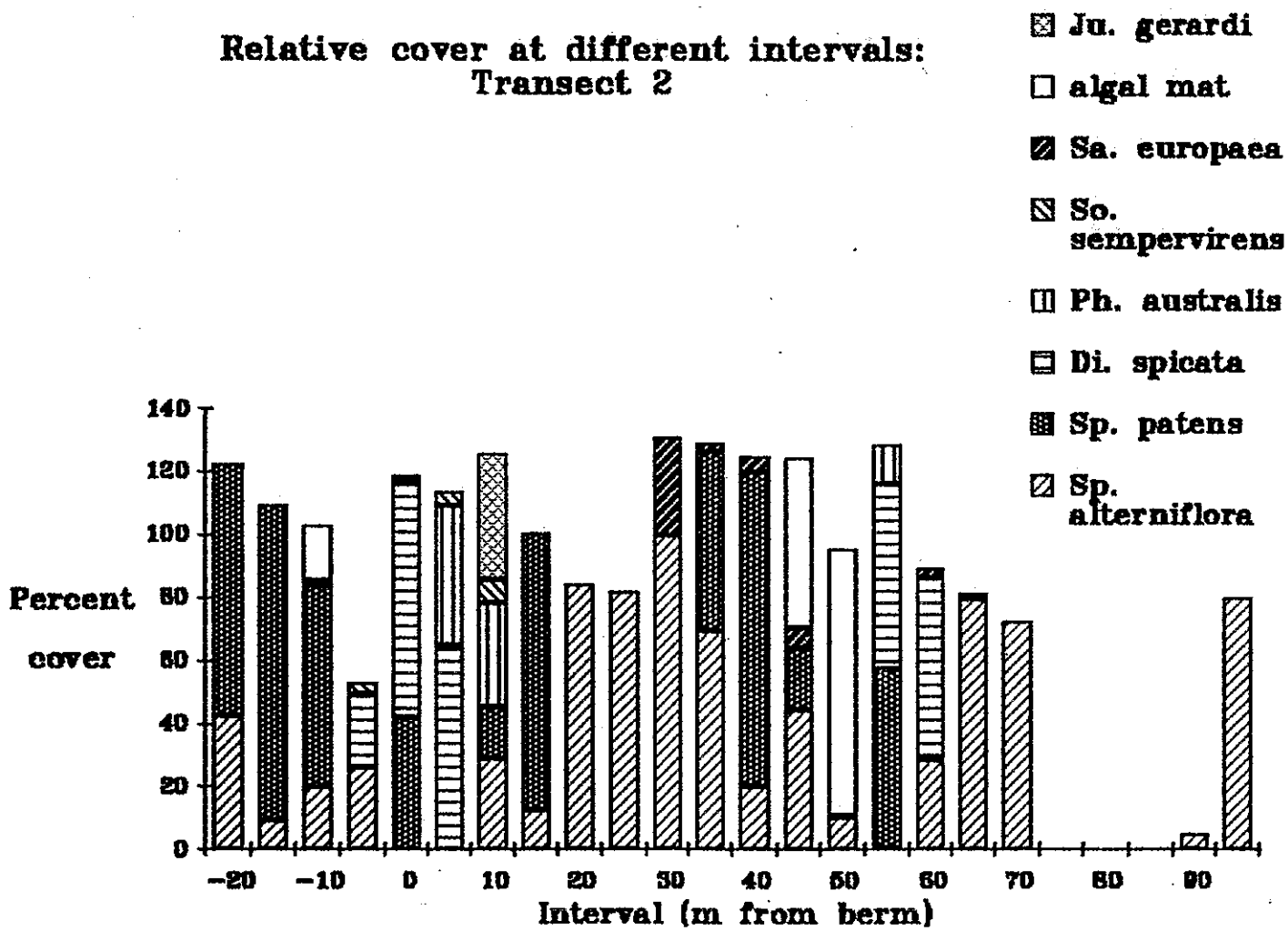

Relative cover at different intervals:
Transect 2
Ju. gerardi
algal mat
Sa. europaea
So. sempervirens
Ph. australis
Di. spicata
Sp. patens
Sp. alterniflora
Percent cover
140
120
100
80
60
40
20
0
-20
-10
0
10
20
30
40
50
60
70
80
90
Interval (m from berm)

FIG 1C

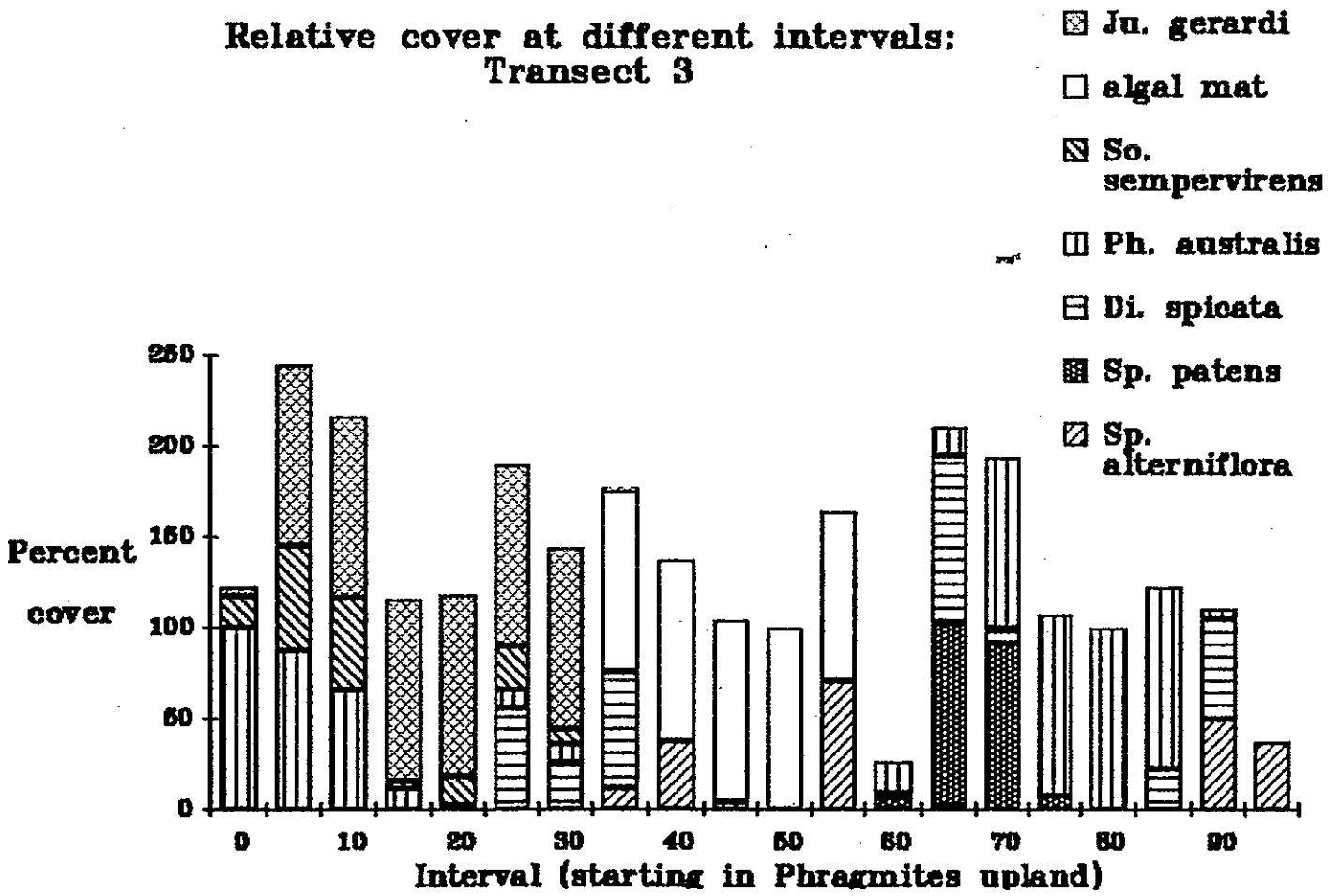
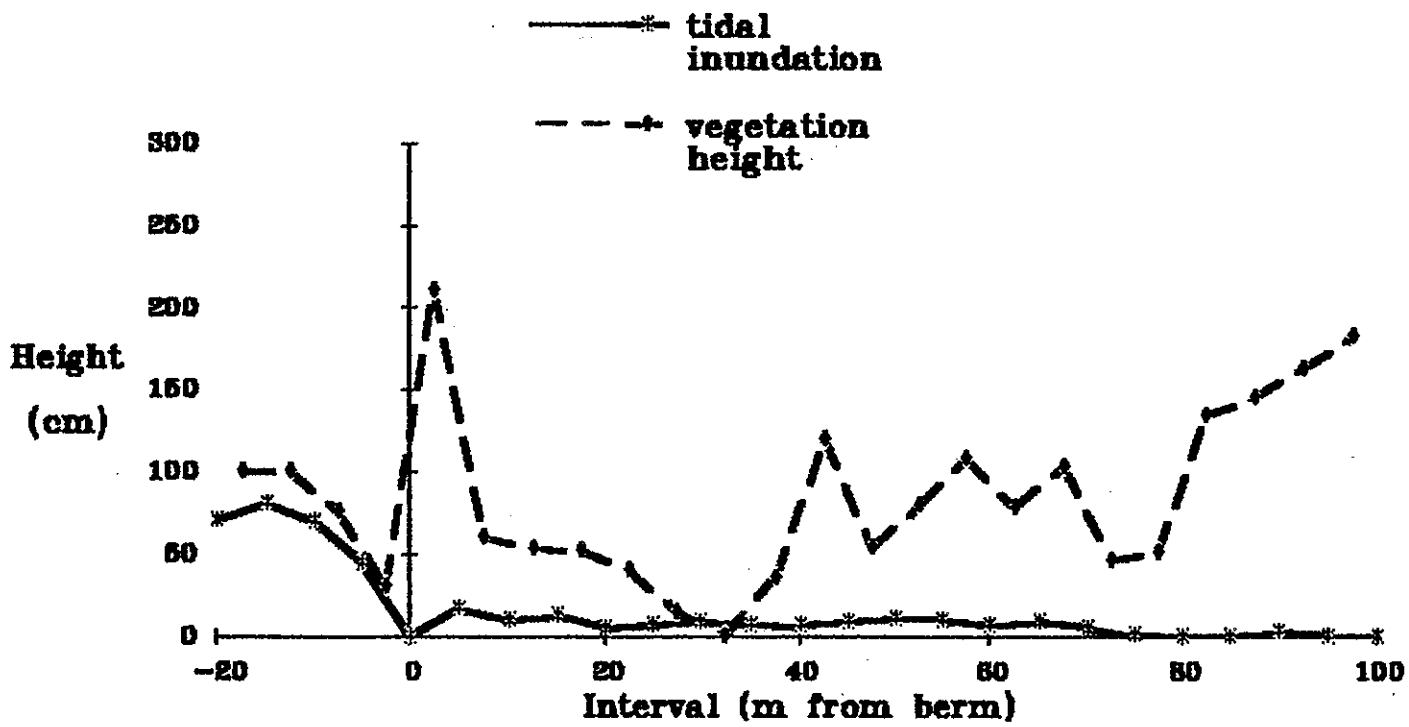
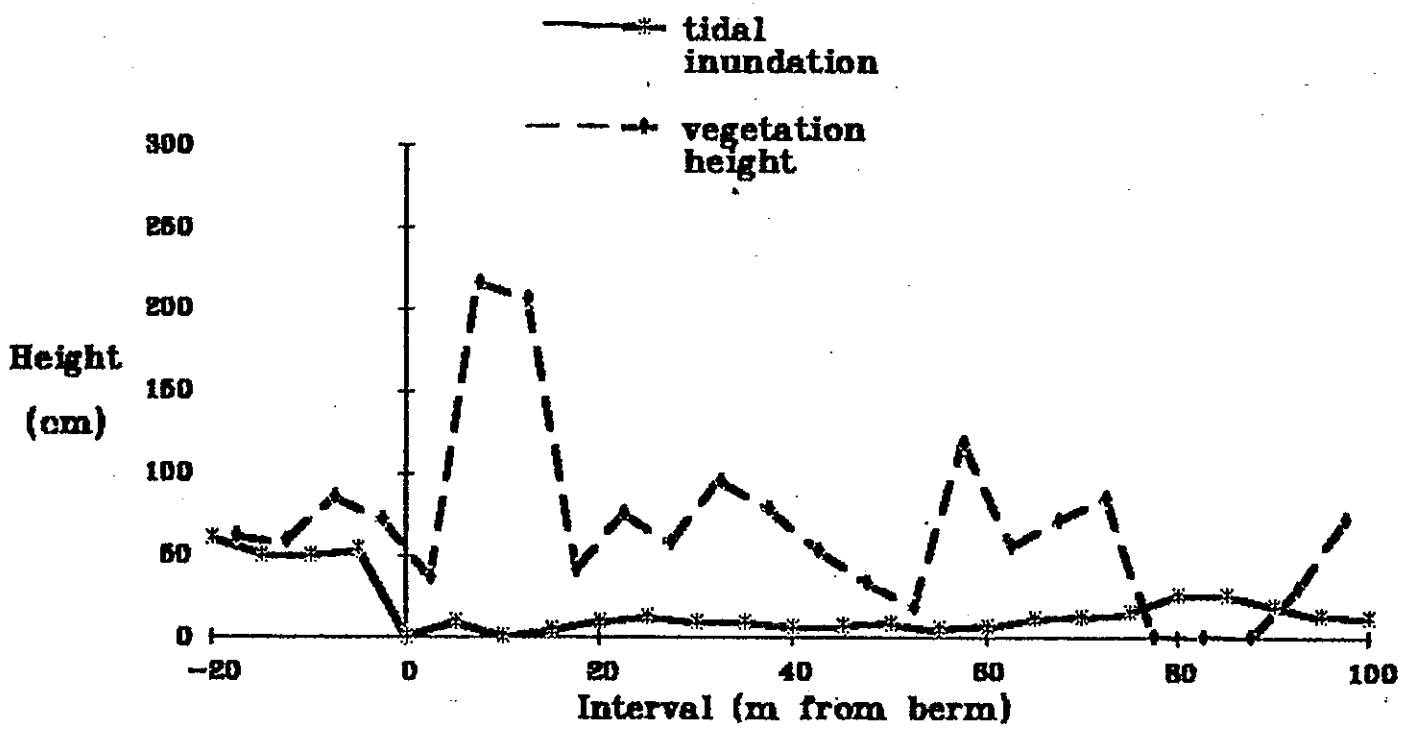

Relative cover at different intervals:
Transect 3
Ju. gerardi
algal mat
So. sempervirens
Ph. australis
Di. spicata
Sp. patens
Sp. alterniflora
Percent cover
250
200
150
100
50
0
0
10
20
30
40
50
60
70
80
90
Interval (starting in Phragmites upland)

FIG 2A

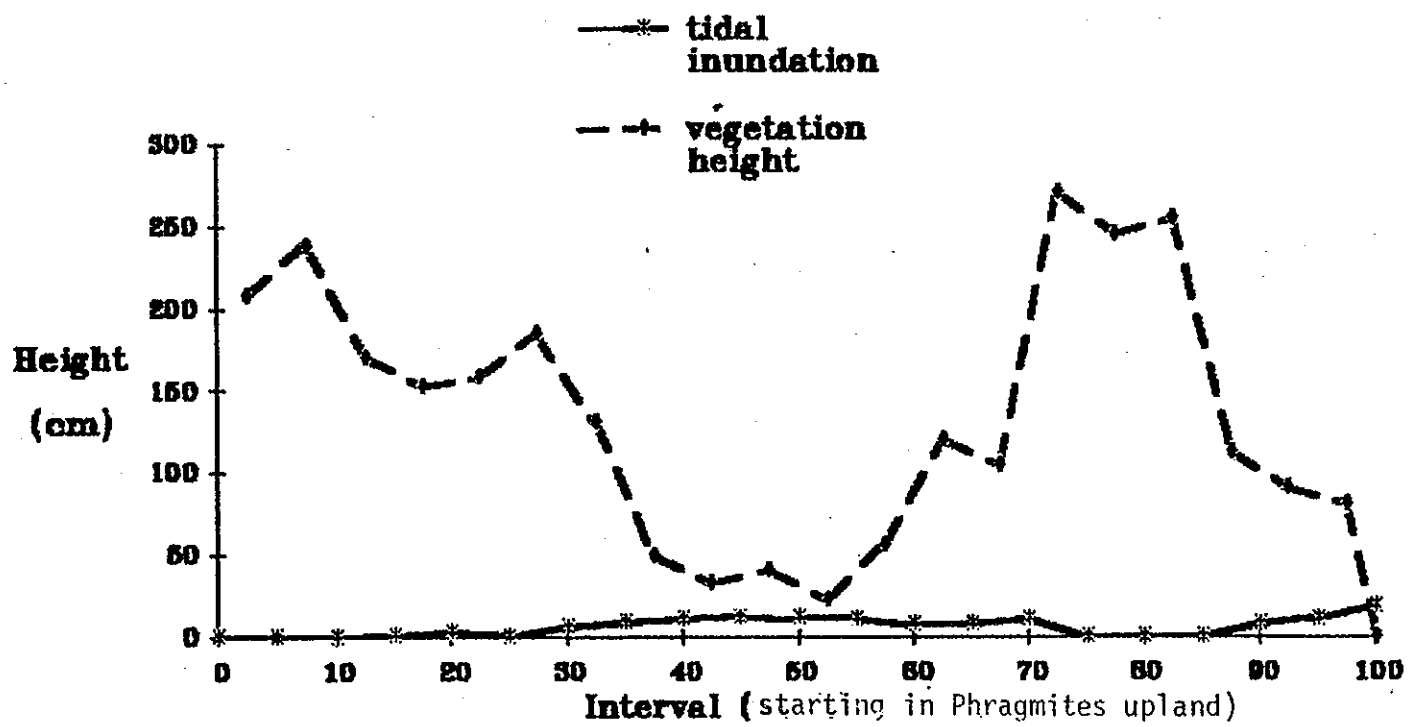
Vegetation height vs tidal inundation
Transect 1



Vegetation height vs tidal inundation
Transect 2



Vegetation height vs tidal inundation
Transect 3



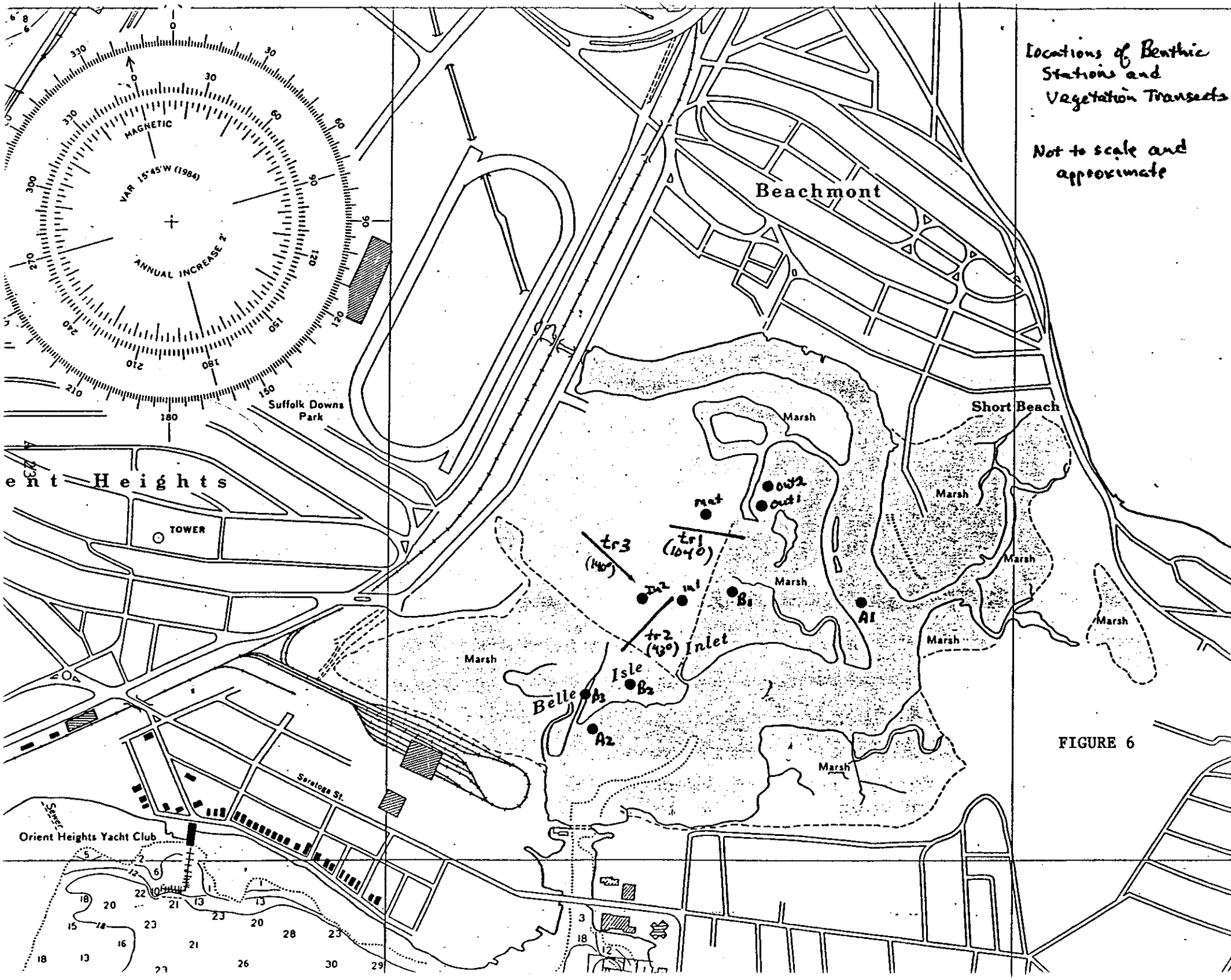

Locations of Benthic Stations and Vegetation Transects
Not to scale and approximate
Beachmont
Short Beach
Marsh
Suffolk Downs Park
ent Heights
TOWER
MAGNETIC
VAR 15°45'W (1984)
ANNUAL INCREASE 2'
out2
out1
mat
tr1 (104°)
tr3 (140°)
in2
in1
B1
A1
tr2 (43°)
Inlet
Isle
Belle
B2
B3
A2
Saratoga St.
Sewer
Orient Heights Yacht Club

FIGURE 6

MAS BELLE ISLE PROJECT:

APPENDIX 1: BENTHOS

RAW DATA

STATION A1

SPECIES	REPLICATE 1	2	3
Annelids			
Capitella spp.		2	
Eteone heteropoda		2	2
Hediste diversicolor			1
Leitoscoloplos fragilis	1	3	
Polydora cornuta (ligni)		1	3
Streblospio benedictii	51	57	127
Oligochaetes	33	12	57
Crustaceans			
Ampelisca abdita		2	2
Molluscs			
Ilyanassa obsoletus	2		1
Macoma baltica			2
Mya arenaria		1	
# individuals (per 0.003m)	87	80	195
# of species	4	8	8

STATION A2

SPECIES	REPLICATE 1	2	3
Annelids			
Eteone heteropoda	8	2	1
Leitoscoloplos fragilis		1	3
Polydora cornuta (ligni)	1		6
Spio setosa	2	2	
Streblospio benedictii	31	49	92
Oligochaetes	41	39	24
Crustaceans			
Ampelisca abdita		1	
Molluscs			
Ilyanassa obsoletus		3	
Mya arenaria	1	1	1
Mytilus edulis		1	
# individuals (per 0.003m)	84	99	127
# of species	6	9	6

STATION B1

SPECIES	REPLICATE 1	2	3
Annelids			
Capitella spp.		1	2
Eteone heteropoda	2	3	
Hediste diversicolor		1	10
Nereis succinea	1	1	
Polydora cornuta (ligni)	4	4	1
Spio setosa		1	
Streblospio benedictii	183	207	41
Oligochaetes	18	20	11
Crustaceans			
Corophium insidiosum			4
Molluscs			
Ilyanassa obsoletus		1	
# individuals (per 0.003m)	208	239	69
# of species	5	9	6

STATION B2

SPECIES	REPLICATE 1	2	3
Annelids			
Capitella spp.	2	4	1
Eteone heteropoda	2	1	2
Hediste diversicolor	1		
Polydora cornuta (ligni)		5	
Streblospio benedictii	63	101	24
Oligochaetes	4	17	2
# individuals (per 0.003m)	72	128	29
# of species	5	5	4

STATION B3

SPECIES	REPLICATE 1	2	3
Annelids			
Eteone heteropoda	4	7	2
Hediste diversicolor		1	
Leitoscoloplos fragilis	1	5	1
Nereis succinea		2	
Polydora cornuta (ligni)	1	4	2
Streblospio benedictii	38	196	80
Oligochaetes	90	115	65
Molluscs			
Ilyanassa obsoletus	3	3	
Macoma baltica	4	1	
Mya arenaria	3	2	4
# individuals (per 0.003m)	144	336	154
# of species	8	10	6

STATION I1

SPECIES	REPLICATE 1	2	3
Annelids			
Streblospio benedictii			1

STATION I2

SPECIES	REPLICATE 1	2	3
NOTHING FOUND			

STATION M1

SPECIES	REPLICATE 1	2	3
Annelids			
Eteone heteropoda		1	
Streblospio benedictii	1		

STATION 01

SPECIES	REPLICATE 1	REPLICATE 2	REPLICATE 3
Annelids			
Streblospio benedictii		1	
Crustaceans			
Calliopius laeviusculus	1		

STATION 02

SPECIES	REPLICATE 1	REPLICATE 2	REPLICATE 3
Crustaceans			
Calliopius laeviusculus		3	

APPENDIX B
RESULTS OF SOIL ANALYSES

Analytical Data Report

BELLE ISLE MARSH

U.S. Army Corps of Engineers
New England Division
Environmental Laboratory
Hubbardston, MA 01542

Date: 2 July 1991

William A. Saner
Acting Chief, Environmental Laboratory

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1. Case Summary

2. Sample Listing

3. Laboratory Data

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5. Chain of Custody

6. Cooler Receipt Form

7. Quality Assurance Review

1. CASE SUMMARY

BELLE ISLE MARSH

1. Six sediment samples were received for the above subject project on March 20, 1991. Standard USEPA methods were employed for sample preservation. Copies of the custody sheets are enclosed for your reference, along with a list of the samples collected.

2. The following analyses were performed in-house:

Analysis	EPA Method
Total Petroleum Hydrocarbons	9070/418.1
TOC	9060

3. Our validated contracted laboratory performed the following analyses:

Analysis	EPA Method
Pesticides/PCBs	8080
Antimony	EPA SW-846/6010
Arsenic	EPA SW-846/7060
Beryllium	EPA SW-846/6010
Cadmium	EPA SW-846/6010
Chromium	EPA SW-846/6010
Copper	EPA SW-846/6010
Cyanide	335.2 CLP-M
Lead	EPA SW-846/7421
Mercury	EPA SW-846/7471
Nickel	EPA SW-846/6010
Selenium	EPA SW-846/7740
Silver	EPA SW-846/6010
Thallium	EPA SW-846/7841
Zinc	EPA SW-846/6010

2. SAMPLE LISTING

BELLE ISLE MARSH

ENV. NO.	DATE/TIME	FIELD DESCRIPTION	MATRIX
12567	3/13/91	A-1 30"-32",A-2 36"-39"	SEDIMENT
12568	3/13/91	A-1 32"-38"	SEDIMENT
12569	3/13/91	A-1 6"-30"	SEDIMENT
12570	3/13/91	A-2 21"-36"	SEDIMENT
12571	3/13/91	A-3 11"-18"	SEDIMENT
12572	3/13/91	A-3 18"-40"	SEDIMENT

3. LABORATORY DATA

NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON 07/11/91
15:31

BELLE ISLE MARSH - TPH AND TOC

METHOD 9070/418.1 (TPH)
METHOD 9060 (TOC)

ENV NO	FIELD DESCRIPTION	TPH (ppm)	TOC (%)
12567	A-1 30"-32", A-2 36"-39"	38	0.27
12568	A-1 32"-38"	62	1.20
12569	A-1 6"-30"	10	0.17
12570	A-2 21"-36"	< 10	0.09
12571	A-3 11"-18"	10	0.23
12572	A-3 18"-40"	44	0.71
	METHOD BLANK	< 6	0.01

NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON 06/28/91
13:46

BELLE ISLE MARSH - CYANIDE, TOTAL

ENV NO	FIELD DESCRIPTION	CYANIDE (mg/kg)
12567	A-1 30"-32", A-2 36"-39"	< 1.81 *
12568	A-1 32"-38"	< 3.11 *
12569	A-1 6"-30"	< 1.59 *
12570	A-2 21"-36"	< 1.58 *
12571	A-3 11"-18"	< 1.67 *
12572	A-3 18"-40"	< 1.99 *

* - Results expressed as mg/kg (dry weight basis).

NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON 07/11/91
15:31

BELLE ISLE MARSH - CYANIDE, TOTAL

METHOD 335.2 CLP-M

ENV NO	FIELD DESCRIPTION	CYANIDE (mg/kg)
12567	A-1 30"-32", A-2 36"-39"	< 1.81 *
12568	A-1 32"-38"	< 3.11 *
12569	A-1 6"-30"	< 1.59 *
12570	A-2 21"-36"	< 1.58 *
12571	A-3 11"-18"	< 1.67 *
12572	A-3 18"-40"	< 1.99 *

* - Results expressed as mg/kg (dry weight basis).

NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON 05/21/91
13:11

BELLE ISLE MARSH

METHOD 8080: PESTICIDES - SEDIMENT (ug/kg)

PARAMETER	12573 Belle Isle Sediment	12573 Repeat Sediment	Method Blank Sediment
Alpha-BHC	< 1	< 1	< 1
Gamma-BHC (Lindane)	< 1	< 1	< 1
Beta-BHC	< 1	< 1	< 1
Heptachlor	< 1	< 1	< 1
Delta-BHC	< 1	< 1	< 1
Aldrin	J 0.43	< 1	< 1
Heptachlor epoxide	J 1.3	J 0.49	< 1
Endosulfan I	< 1	< 1	< 1
4,4'-DDE	2.7	J 1.2	< 1
Dieldrin	< 1	< 1	< 1
Endrin	< 1	< 1	< 1
4,4'-DDD	2.6	J 1.6	< 1
Endosulfan II	< 1	< 1	< 1
4,4'-DDT	J 0.72	J 0.51	< 1
Endrin aldehyde	J 0.39	J 0.17	< 1
Endosulfan sulfate	< 1	< 1	< 1
Chlordane	< 5	< 5	< 5
Toxaphene	< 10	< 10	< 10
PCB-1016	< 10	< 10	< 10
PCB-1221	< 10	< 10	< 10
PCB-1232	< 10	< 10	< 10
PCB-1242	< 10	< 10	< 10
PCB-1248	< 10	< 10	< 10
PCB-1254	< 10	< 10	< 10
PCB-1260	< 10	< 10	< 10
Surrogate Recovery (%)			
TCMX	30%	30.8%	32%

SAMPLE DATE:	3/13/91	3/13/91	
DATE EXTRACTED:	4/4/91	4/4/91	4/4/91
DATE ANALYZED:	5/6/91	5/6/91	5/6/91

Notes:
J: Estimated result. Concentration below quanititation limit.

NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON 07/02/91
08:21

BELLE ISLE MARSH

PRIORITY POLLUTANT METALS (mg/kg)

PARAMETER	12567 A-1,"30-"32"A-2,'A-1,32"-38" Sediment	12568 Sediment	12569 A-1,6"-30" Sediment	12570 A-2,21-36" Sediment	12571 A-3,11-"18" Sediment
Cadmium	< 0.69	< 1.4	< 0.65	< 0.67	< 0.64
Chromium	19	26	12	11	14
Silver	< 0.69	< 1.4	< 0.65	< 0.67	< 0.64
Beryllium	< 0.69	< 1.4	< 0.65	< 0.67	< 0.64
Copper	21	29	5.4	4.5	40
Nickel	9.7	13.1	8.6	6.4	11
Zinc	51	49	20	18	40
Antimony	< 6.9	< 14	< 6.5	< 6.7	< 6.4
Mercury	0.21	0.29	< 0.063	0.064	< 0.063
Arsenic	4.6	4.8	< 2.3	< 2.1	16
Selenium	< 1.1	< 2.3	< 1.1	< 1.1	< 1.2
Lead	33	107	4.7	2.2	17
Thallium	< 2.2	< 4.7	< 2.3	< 2.1	< 2.5
SAMPLE DATE:	3/13/91	3/13/91	3/13/91	3/13/91	3/13/91
DATE RECEIVED:	3/20/91	3/20/91	3/20/91	3/20/91	3/20/91
DATE ANALYZED:	5/29/91	5/29/91	5/29/91	5/29/91	5/29/91

Note: All soil values are reported on a dry weight basis.
Method EPA SW-846/6010 - Cadmium, Chromium, Silver, Beryllium, Copper, Nickel, Zinc, Antimony.
Method EPA SW-846/7060 - Arsenic.
Method EPA SW-846/7740 - Selenium.
Method EPA SW-846/7421 - Lead.
Method EPA SW-846/7841 - Thallium.
Method EPA SW-846/7471 - Mercury.

NEW ENGLAND DIVISION, ENVIRONMENTAL LABORATORY

PRODUCED ON 07/02/91
11:11

BELLE ISLE MARSH

PRIORITY POLLUTANT METALS (mg/kg)

PARAMETER	12572 A3,18"-40" Sediment	Method Blank Sediment
Cadmium	< 0.88	< 0.5
Chromium	46	< 0.5
Silver	< 0.88	< 0.5
Beryllium	< 0.88	< 0.5
Copper	40	< 1.0
Nickel	22	< 1.0
Zinc	107	< 0.5
Antimony	< 8.8	< 4.5
Mercury	0.518	< 0.05
Arsenic	11.8	< 2.0
Selenium	< 1.3	< 1.0
Lead	63	< 0.6
Thallium	< 2.6	< 2.0

SAMPLE DATE:	3/13/91	3/13/91
DATE RECEIVED:	3/20/91	3/20/91
DATE ANALYZED:	5/29/91	5/29/91

Note: All soil values are reported on a dry weight basis.
Method EPA SW-846/6010 - Cadmium, Chromium, Silver, Beryllium, Copper, Nickel, Zinc, Antimony.
Method EPA SW-846/7060 - Arsenic.
Method EPA SW-846/7740 - Selenium.
Method EPA SW-846/7421 - Lead.
Method EPA SW-846/7841 - Thallium.
Method EPA SW-846/7471 - Mercury.

4. QUALITY ASSURANCE DATA

PESTICIDE MATRIX SPIKE DUPLICATE ACCURACY

SPIKING COMPOUND	MATRIX SPIKE RECOVERY (%)	ACCEPTABLE RANGE	IN OR OUT OF QC LIMITS
Lindane	76	56 - 123	IN
Heptachlor	45	40 - 131	IN
Aldrin	34	40 - 120	OUT
Dieldrin	19	52 - 126	OUT
Endrin	68	56 - 121	IN
DDT	26	38 - 127	OUT

TRACE METALS
REPLICATE SAMPLE ANALYSIS
PRECISION

PARAMETER	RELATIVE PERCENT DEVIATION (RPD)	RPD MAXIMUM	IN OR OUT OF QC LIMITS
Arsenic	2.2	30	IN
Selenium	ND	30	---
Lead	7.6	30	IN
Thallium	ND	30	---

ND = Not detected, no analyte detected in sample/duplicate.

TRACE METAL ANALYSIS
MATRIX SPIKE/MATRIX SPIKE DUPLICATES
PRECISION

PARAMETER	MATRIX SPIKE RESULT	MATRIX SPIKE DUPLICATE RESULT	RELATIVE PERCENT DEVIATION (RPD)	RPD MAXIMUM	IN OR OUT OF QC LIMITS
Cadmium	98.3	98.9	0.6	30	IN
Chromium	77.6	110	34.5	30	OUT
Silver	71.8	64.8	10.2	30	IN
Beryllium	99.9	100	0.1	30	IN
Copper	42.3	108	87.4	30	OUT
Nickel	84.8	98.1	14.5	30	IN
Zinc	NC	NC	NC	30	---
Antimony	31.5	37.7	17.9	30	IN
Mercury	81.9	90	9.4	30	IN

NC = Not calculated, sample concentration much greater than spiking level.

TRACE METAL SPIKE RECOVERY
MATRIX SPIKE/MATRIX SPIKE DUPLICATES
ACCURACY

PARAMETER	MATRIX SPIKE RESULT	CONTROL LIMITS REC	IN OR OUT OF QC LIMITS
Cadmium	98.3	75 -125	IN
Chromium	77.6	75 -125	IN
Silver	71.8	75 -125	IN
Beryllium	99.9	75 -125	IN
Copper	42.3	75 -125	OUT
Nickel	84.8	75 -125	IN
Zinc	NC	75 -125	---
Antimony	31.5	75 -125	OUT
Mercury	81.9	75 -125	IN
Arsenic	98	75 -125	IN
Selenium	93	75 -125	IN
Lead	NC	75 -125	---
Thallium	115	75 -125	IN

NC = Not calculated, sample concentration much greater than spiking level.

5. CHAIN OF CUSTODY

U.S. ARMY CORPS OF ENGINEERS

CHAIN OF CUSTODY RECORD

PROJ. NO.

PROJECT NAME: Belle Isle Marsh

SAMPLERS: (Signature) Forrest E Knowles

ENV ~~STA. NO.~~ #18	DATE	TIME	COMP.	~~CORE~~	STATION LOCATION	NO. OF CONTAINERS	Metals	TOC	TPH	CN	PCB+Pesticides		REMARKS
12567	3/13/91		✓		A-1, 30"-32" A-2, 36"-39" Comb	1	✓	✓	✓	✓	✗		① Mix Thoroughly
12568	3/13/91			✓	A-1, 32"-38"	1	✓	✓	✓	✓	✗		before taking
12569	3/13/91			✓	A-1, 6"-30"	1	✓	✓	✓	✓	✗		Analysis
12570	3/13/91			✓	A-2, 9"-36"	1	✓	✓	✓	✓	✗		
12571	3/13/91			✓	A-3, 11"-18"	1	✓	✓	✓	✓	✗		
12572	3/13/91			✓	A-3, 18"-40"	1	✓	✓	✓	✓	✗		② Prepare before
					Composite of 12567, 12569-12572	1					✓		3/27/91

→ The correct depth on this is 21-36" (sample container labelled correctly) per telecon w. F. Knowles 3/21/91

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Forrest E Knowles	3/19/91 2:55	Monique Yandell	Monique Yandell	3/20/91 755	Patricia Jamalle
Patricia Jamalle	3/20/91 1255	Ralph L. [illegible] 3/20/91 1255			

Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature)	Date / Time	Remarks

Distribution: Original Accompanies Shipment; Copy 1 to Sample Custodian; Copy 2 to Coordinator Field Files

0503

U.S. ARMY CORPS OF ENGINEERS

CHAIN OF CUSTODY RECORD

PROJ. NO.	PROJECT NAME
	Belle Isle Marsh

SAMPLERS: *(Signature)* Materials Lab

ENV STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	13 Priority Pollutant Metals						REMARKS
12567	3/13/91		✓		A-1 / A-2; 30-32" / 36-39"	1	✓						
12568				✓	A-1; 32-38"	1	✓						
12569				✓	A-1; 6-30"	1	✓						
12570				✓	A-2; 21-36"	1	✓						
12571				✓	A-3; 11-18"	1	✓						
12572				✓	A-3; 18-40"	1	✓						

Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*
[signature]	3/22/91 0730	Patricia Jamache	Patricia Jamache		UPS TRACKING # 1004-2877-941
Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date / Time	Received by: *(Signature)*

Relinquished by: *(Signature)*	Date / Time	Received for Laboratory by: *(Signature)*	Date / Time	Remarks
				Sent to EAL

Distribution: Original Accompanies Shipment; Copy 1 to Sample Custodian; Copy 2 to Coordinator Field Files

Belle Isle PCB and Pesticides

12567
Composite
A-1, 30"-32"
A-2, 36"-38"

12569
A-1, 6"-30"

12570
A-2, 21"-36"

12571
A-3, 11"-18"

12572
A-3, 18"-40"

Prepare enough Composite from equal portions of these samples to run PCB and pesticides with 2 QC

6. COOLER RECEIPT FORM

COOLER RECEIPT FORM

PROJECT: BELLE ISLE MARSH
Cooler received on 3/20/91 and opened on 3/20/91 by Ralph Lundquist
(signature)

1) Were custody seals on outside of ~~cooler~~? No Cooler Budget-plastic — Yes No
If Yes, how many and location(s) 3, around edge of lid

2) Were date and signature on seal(s) correct? — Yes No

3) Were custody papers taped to lid inside ~~cooler~~? Hand carried — Yes No

4) Were custody papers properly filled out (ink, signed, etc.) — Yes No

5) Did you sign custody papers in appropriate place? — Yes No

6) Did you attach shipper's packing form to this form? Hand Carried — Yes No

7) What kind of packing material was used? Beads - Styrofoam

8) Was sufficient ice used? Cold water - packs. — Yes No

9) Were all bottles sealed in separate plastic bags? — Yes No

10) Did all bottles arrive in good condition? — Yes No

11) Were all bottle labels complete? (No., date, analysis, preservative, sign., etc.) — Yes No

12) Did all bottle labels agree with custody papers? — Yes No

13) * Were correct bottles used for tests indicated? — Yes No

14) Were VOA vials checked for absence if air/headspace and noted if found? — N/A Yes No

15) Was sufficient amount of sample sent in each bottle? — Yes No

16) Were air volumes noted for air samples? — N/A Yes No

17) Were initial weights noted for pre-weighed filters? — N/A Yes No

Explain any discrepancies: *Sample Jar A2-21"-36 was entered on Custody Forms as Sample A-2 9"-36.

per telecon - sample container is labelled correctly. per F. Knowles

Forrest Knowles was contacted on 3/21/91 by [illegible] to resolve discrepancies.

7. QUALITY ASSURANCE REVIEW

Quality Assurance Review

Project: Belle Isle Marsh Dredging Project

Date: 31 July 1991

A. Sample Handling

The samples were collected using procedures conforming to the EPA/CE regional sediment sampling and testing protocol. Appropriate containers and preservation techniques were used. Proper chain-of-custody procedures were followed.

B. Laboratory Analysis

1. The maximum holding times for metals, cyanide, TOC, and TPH were met. The 14 day maximum holding time before extraction for PCBs and pesticides was exceeded by eight days. This is not considered significant.

2. The method blanks for TPH, PCB, and metals were free from contamination. Slight contamination was found for TOC but too low to be of concern. No blank data is available for the cyanide analysis.

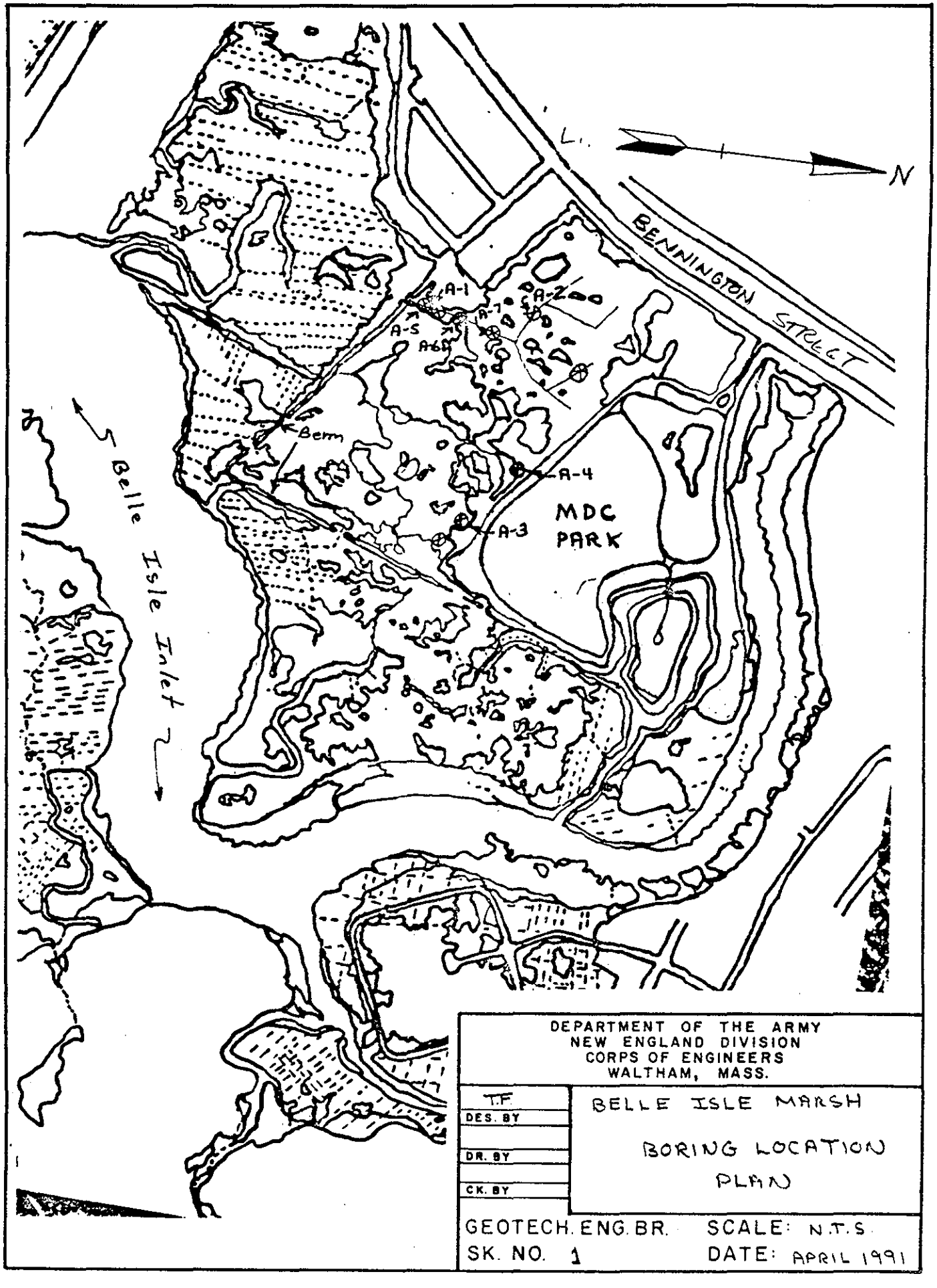
3. Standard EPA procedures were used for all analyses except in the case of PCBs and pesticides where the procedures described by the Tetratech Company publication were used per request of the project manager.

4. Surrogate recoveries for PCBs and pesticides were all in control.

5. The metals QA/QC data were outside control limits in 2 cases out of 13 for both accuracy and precision. This indicates good laboratory technique as the sample matrix is an actual sediment sample. The pesticide matrix spike duplicate for accuracy exceeded the control limits in three cases out of six. This is most likely due to the sample matrix rather than laboratory technique. No QA/QC data are available for PCBs, TOC, TPH, cyanide and pesticide precision.

6. The data all appear reasonable and internally consistent.

Forrest E. Knowles, Jr.
Quality Assurance Officer


N
BENNINGTON STREET
A-1
A-2
A-5
A-6B
A-7
Berm
A-4
A-3
MDC
PARK
Belle Isle Inlet
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
T.F.
DES. BY
DR. BY
CK. BY
BELLE ISLE MARSH
BORING LOCATION
PLAN
GEOTECH. ENG. BR.
SCALE: N.T.S.
SK. NO. 1
DATE: APRIL 1991

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

PAGE 1

SUBJECT Belle Isle Marsh Restoration Project
COMPUTATION Hand Auger boring Logs
COMPUTED BY T.F GED CHECKED BY DATE 3/13/91

Hand Auger Boring Logs 13 March 1991:
(Corrected w/ Lab test results where applicable)

Boring A-1

0		
6"		silty f. SAND, Mostly marsh veg. & roots
	SM	Gr. loose silty (34) m-f. SAND
	CH	Gr. soft CLAY
32" 30"		
38"	Pt	Dk. Gr. and Blk. peat

▽ water level at ground surface

* Chemical sample tube driven to 30"

Boring A-2

0		
9"		water and marsh veg.
21"		Marsh veg. & roots (No sample)
	SM	Gr. loose silty (25-35) m-f SAND w/ organic fibres and shells
36"		Gr. soft CLAY w/ organic fibres and trace gravel
39"	CH	

Refusal at 39"

▽ water level 9" above boring

* chemical sample tube driven to 36"

Boring A-3

0		
11"		Marsh veg. w/ roots and glass fragments (No sample)
18"	ML	Gr. loose SILT w/ m-f sand (28) w/ Trace peat
	CH	Dk. Gr. soft CLAY w/ m-f sand (13) and trace peat
40"		

▽ water level at ground surface

* chemical sample tube driven to 53"

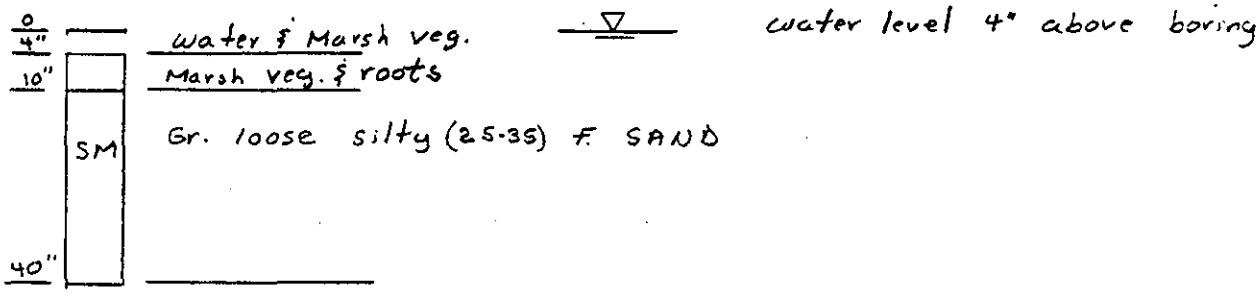
NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U S ARMY

PAGE 2

SUBJECT Belle Isle Marsh Restoration Project
COMPUTATION Hand Augre Borings
COMPUTED BY T.F. GED CHECKED BY DATE 3/13/91

Boring A-4



NOTE: samples classified in accordance with ASTM D 2488-84, Description and Indentification of soils (Visual-Manual Procedure)

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U S ARMY

SUBJECT Belle Isle Marsh Restoration Project
COMPUTATION Hand Auger Boring Logs
COMPUTED BY T.F. GED CHECKED BY DATE 2/26/91

Hand Auger Boring Logs 26 February 1991:

Boring A-5

0		
4"		Silty F. SAND, Mostly Marsh veg. & roots
	SM	Gr. loose silty (25-35) m-f SAND
30"		
	SM	DK. Gr. silty (25-35) m-f SAND w/ Trace peat
42"		

▽ water level 2" below ground surface

Boring A-6

0		
6" 4"		Ice and water
		Marsh veg. & roots
	SM	DK. Gr. loose silty (25-35) m-f SAND w/ little peat
42"		

▽ water level at surface

Boring A-7

0		
		Silty F. SAND, Mostly Marsh veg. & Roots
12"		
	ML	Gr. loose SILT w/ F. SAND (20-30) w/ trace organics
24"		
	SM	Gr. loose silty (25-35) F. SAND
48"		

▽ water level 2" below surface

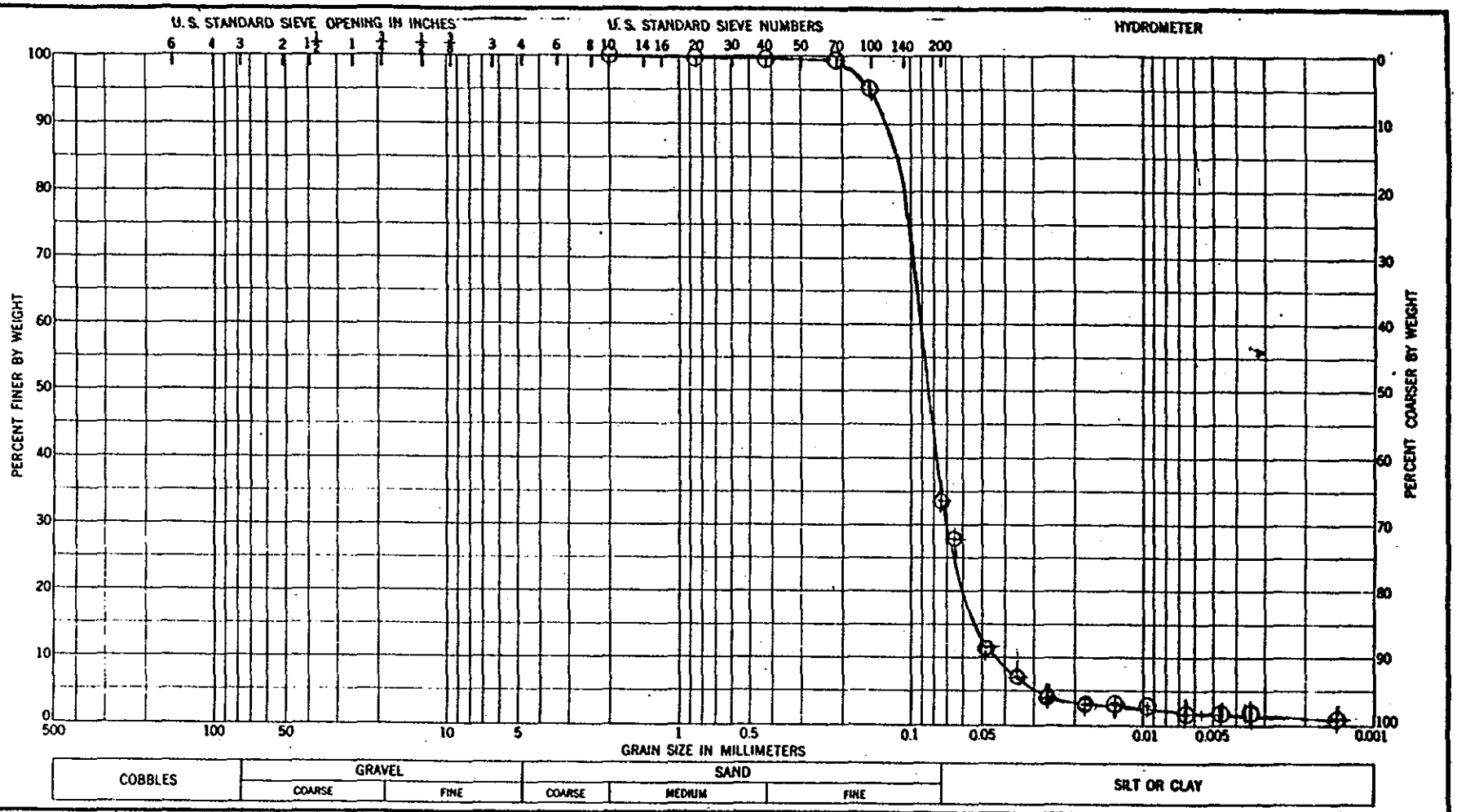
NOTE: Borings performed with 2" I.D. hand auger

BOTTOM SEDIMENT SAMPLE TEST RESULTS - PHYSICAL TESTING

91VW813 BELLE ISLE MARSH YEAR - 1991 STATE - MA TIDAL SYS - MES
QUAD - LYNN

LAB SERIAL NO.		100-540-1A		100-540-7A		100-540-7B
EXPLORATION NO.		A-1		A-3		A-3
SAMPLE NO.		1		1		2
SAMPLE DEPTH (FT)		0.5-2.5		0.92-1.5		1.5-3.33
DATE		3/13/91		3/13/91		3/13/91
VISUAL CLASSIFICATION BY LABORATORY		Light Brown and Grey Silty Sand (SM) with Some Roots and Micaceous Material		Grey Silt (ML) with Sand, Fibrous Material and Trace Micaceous Material		Grey Clay (CH) with Some Sand and Trace Micaceous Material
SOIL CLASS/DOMIN		SM		ML		CH
GRAIN SIZE CURVE-MED		0.0850		0.0550		0.0130
GRAIN SIZE CURVE-Q1		0.1000		0.0750		0.0400
GRAIN SIZE CURVE-Q3		0.0650		0.0350		0.0017
GR SIZE CURVE-% FINE		34		72		87
NORMAL/BIMODAL		N		N		N
LIQUID LIMIT						52
PLASTIC LIMIT						25
PLASTIC INDEX						27
SPEC GRAV SOLIDS						2.69
PERCENT SOLIDS		79.2		76.6		62.8
% VOL SOLIDS-EPA		0.68		1.15		4.20
% VOL SOLIDS-NED		0.32		0.76		2.94
% COARSE MAT'L (PASS >#10 US STD SIEVE)	LT	1	LT	1	LT	1
% MEDIUM SAND (PASS #10 SIEVE RETAINED #40)	LT	1		1	LT	1
% FINE SAND (PASS #40 SIEVE RETAINED #200 US STD SIEVE)		66		27		13

LT - LESS THAN



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	6"-30"	SILTY SAND (SM)				
		LIGHT BROWN & GRAY				
		SOME ROOTS & micaceous				
		material				
		Exploration A-1				

Project BELLE ISLE MARSH

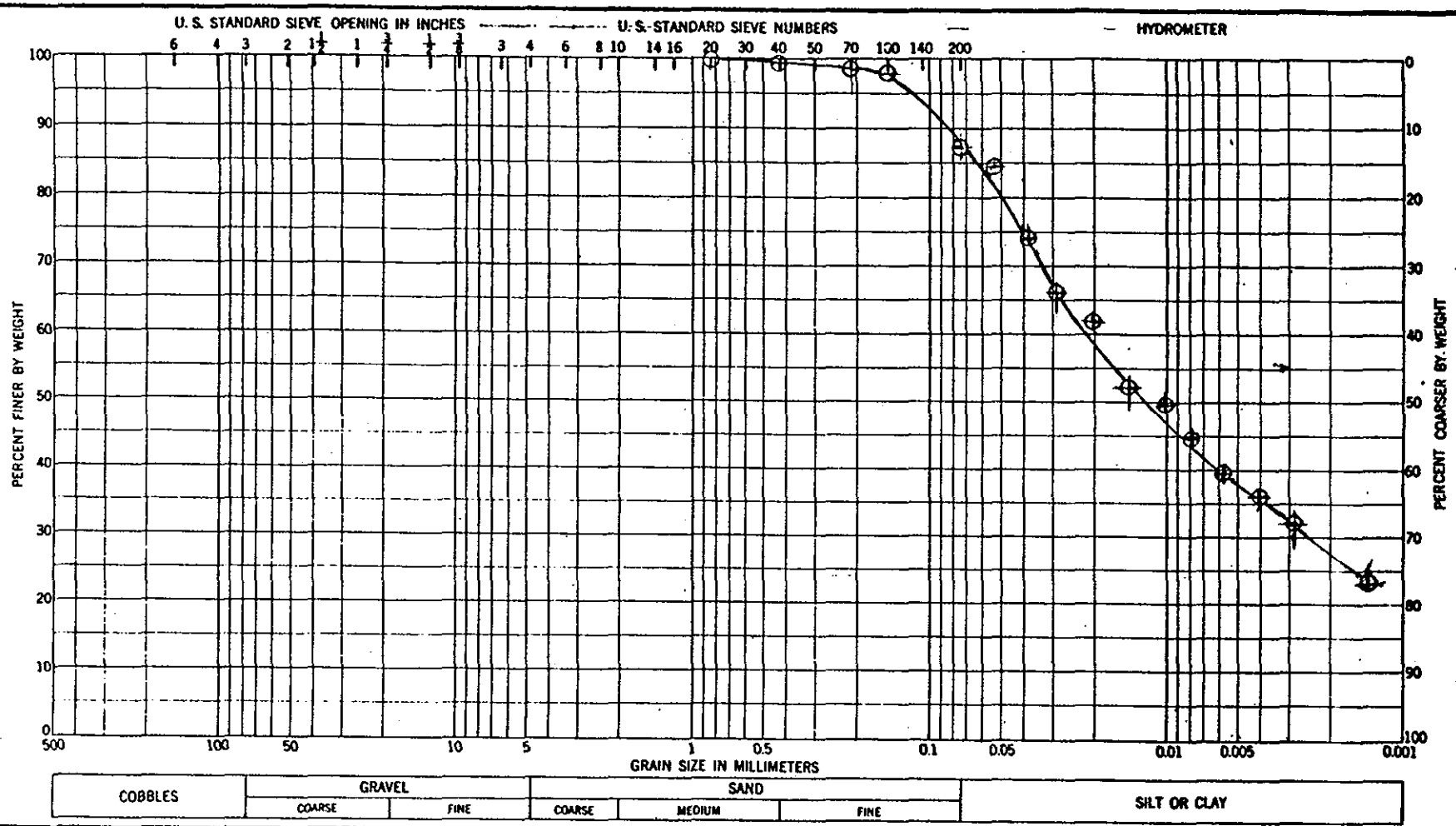
Area LAB 100-540-1A

Boring No.

Date 4/1/91

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	1.5'-3.25'	CLAY (CH) GRAY				
		Trace Sand - Trace		52	25	27
		Micaceous Matl				
		Exploration A-3				

Project: BELLE ISLE MARSH

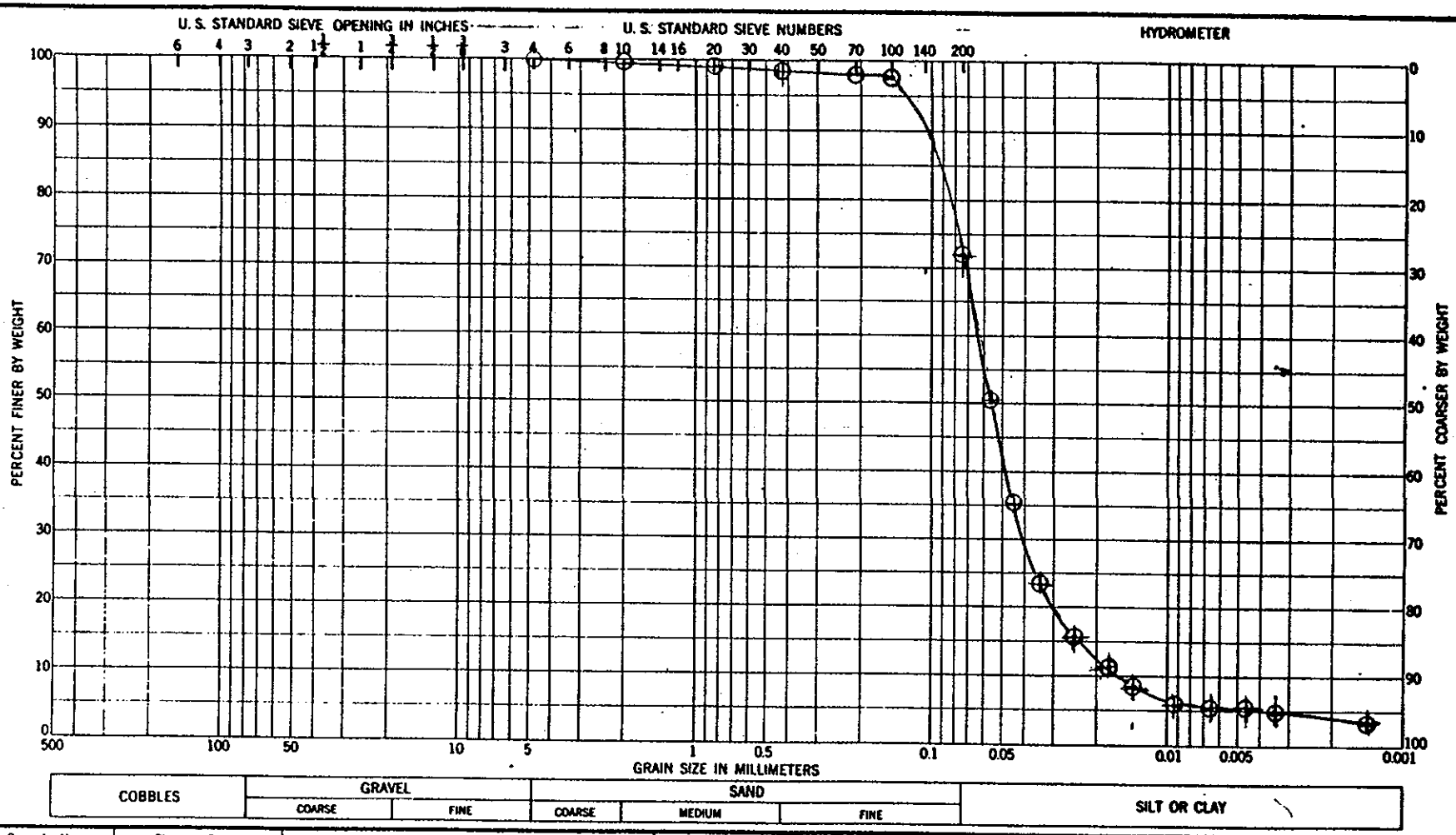
Area: LAR # 100-510-73

Boring No.

Date: 4/1/91

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
#2	11" - 18'	SILT WITH SAND (PL)				
		[illegible] FIBROUS				
		[illegible] & TRACE				
		MICACEOUS MAT'L				
		Exploration A-3				

Project BELLE ISLE MARSH

Area LAB 100-540-7A

Boring No.

Date 4/1/91

GRADATION CURVES

ENG FORM 1 MAY 63 2087

APPENDIX C
HISTORIC AND ARCHAEOLOGICAL RESOURCES

BELLE ISLE MARSH RESERVATION
SALT MARSH RESTORATION

Based on a review of historic records at Belle Isle Marsh Reservation, the Metropolitan District Commission's Reservations & Historic Sites Headquarters in Boston, and the Massachusetts Historic Commission, the following assessment and recommendations are offered regarding the proposed Salt Marsh Restoration Project.

This assessment has been prepared by Thomas F. Mahlstedt, Chief Archaeologist, Metropolitan District Commission in accordance with the agency's mission to protect and preserve the cultural resources that exist, or may exist, within its jurisdiction. The assessment is meant to supplement the questions on page 4 of the ENF that relate to cultural resources. It is also meant to be sufficiently detailed so that all participants in the project, as well as project reviewers, will have sufficient information to make informed decisions regarding potential impacts and damage to cultural resources.

ENVIRONMENTAL NOTIFICATION FORM: Page 4

III. Assessment of Potential Adverse Environmental Impacts

B. Historic and Archaeological Resources

1. Affects to significant historic archaeological sites or buildings/structures.

No Adverse Affects to significant historic resources are expected, provided the unidentified pen-like wooden enclosure located to the east of the earthen berm is not damaged or otherwise affected by the project. Should it be necessary to affect this feature, additional research will be needed to determine its age, function and significance.

The principal reason for this assessment is that the impact area itself was not the locus of historic period development. Rather it remained a lowlying tidal marsh, with historic development occurring first on the hill to the west (present day Orient Heights) and later on Beachmont and Youngs Hill, to the north.

The first owner, John Gorges, granted a large track of land to Sir William Brereton in 1628. Included in the grant was an elliptically shaped drumlin, which stood 150 feet over the surrounding lowlying tidal marsh. Brereton named this landform ***Susanna Island***, after his daughter, but it quickly became known as ***Hog Island*** by the local settlers.

In 1678, Judge Sewall seized the property and built a wharf, planted trees and raised sheep on it. Joseph Russell, another early property owner, who is credited with giving it the name ***Belle Isle Marsh*** did not actually live there. The ***1796 Census*** listed Russell as the owner of ***Hog Island***, as it was still then known, but notes that no one lived on the island. It was valued at $1,100 at the time.

In 1813, Russell sold Belle Isle Marsh to John Breed, a wealthy Englishman, who purchased the land after the death of his fiancee. Breed built himself an impressive single story stone mansion, reputedly measuring 200 feet long (Sweeter 1888:128), with terraced gardens in front of it, at the foot of Hog Island, which is today Orient Heights, about a 1/2 mile west of the impact area.

Regionally, the rich salt marsh hay that grew in such environments, was prized by farmers, and Breed is credited with running a prosperous hay farm. It is assumed that the fall harvesting of the salt marsh hay continued at Belle Isle Marsh throughout the remainder of the 19th century, and it is probable that the marsh grasses that flourished in the calm waters of the estuaries provided summer pasture for cattle.

The only possible, although highly unlikely, historic period archaeological remains would be evidence of the hay harvesting activities. Remains of the wooden post structures known as ***staddles***, which held the marsh hay until the marsh and estuary froze enough to cart the hay to the local markets, may exist in the marshland or may have been buried by the landfill. Even if buried, they are likely to have been crushed by the weight of the overburden, so they would not retain a high degree of integrity. Importantly, numerous staddles survive to this day intact in the marshes of the Essex, Parker and Ipswich rivers in Essex County; thus the archaeological recovery of damaged structures is ***unlikely*** to be considered ***historically significant***. Other haying related equipment and tools that could be in an archaeological context are sunken and buried ***gundalows***, the shallow wooden boats used to unload the staddles, rakes, and crooks.

As noted above there is a large unidentified rectangular structure, which is defined by wooden planks and posts driven into the ground forming its three sides (east, south and north). The northern side, if it existed, was buried and presumably destroyed when the earthen berm was built, the date of which has yet to be determined. Conversely, if the wooden pen-like structure post dates the berm, the berm itself defines the western side. A preliminary history of the site failed to find documentation on this structure (Ogilvie 1987), and currently its age, function and significance are not known.

The second reason why significant historic resources are not expected to be impacted, relates less to the specifics of this project, since it will be confined to a roughly rectangular area northwest of the berm, instead of the upland part of Belle Isle Reservation known as ***Belle Isle Park***. However, since machinery and equipment must pass over the upland section to access the project area (i.e., area of primary impact); thus Belle Isle Park itself is considered an area of secondary impact.

Belle Isle Park has experienced multiple impacts in the 20th century, the most important of which is the fact that it is not a natural landscape or landform. A refuse dump was created in the vicinity in the 1920s when ***Breed's Isle***, as it was still called by some, was selected to relieve Boston's burgeoning waste problem. At that time the Coleman Brothers, who had the contract for the trash disposal, began to systematically fill the wetlands that bordered Belle Isle. Boring logs however indicate that the area that today comprises Belle Isle Park, may have been used as a dump for earthen fill, perhaps the spoil from nearby dredging, rather than for refuse.

Suffolk Downs Race Track was built in 1935 on the landfill. The MBTA Blue Line trolley and Bennington Street were also built on the land-fill south and east of the track. In the 1950s the Suffolk Downs Drive-In Theatre was built on the fill on the southeasterly side of Bennington Street, across from the race track. Closed in 1971, the former theater was neglected and abused as it became a general dumping ground.

Spurred on by the ***Friends of Belle Isle Marsh*** who advocated to save this remaining piece of undeveloped space, the Metropolitan District Commission purchased the 152 acre property. In 1986, with the formulation of management plans completed, extensive landscaping was performed at the site of the drive-in. Deep trenches were excavated through the fill creating the island-like configuration present today. The spoil from these excavations were placed over the drive-in and contoured and graded to create the rolling hilly meadow effect. The spoil was then capped with a membrane of impervious PVC plastic over which, loam was spread and graded. Benches, winding walkways, a small parking area, signs and an observation tower completed development of the park.

The movement of equipment and machinery over the landfill, i.e., Belle Isle Park, should have ***No Adverse Affect*** to historic resources.

2. Affects to archaeological (prehistoric) sites.

The presence or absence of prehistoric resources cannot be conclusively demonstrated from existing data. However, as the Boylston Street Fish Weir illustrates, the survival of prehistoric archaeological remains are known locally in a similar setting to Belle Isle.

No prehistoric sites are recorded in MHC or MDC archeological site files. These files however only relate to reported sites; there are many more archaeological sites which where encountered in early historic times, or more recently by relic collectors, who fail to report their finds to the appropriate agencies. Most importantly, these files do not relate to ***the potential existence*** of archaeological sites, although they are useful for establishing the ***sensitivity of an area for prehistoric settlement.***

Situated within an estuarine environment, places Belle Isle Marsh in one of the most biologically diverse and abundant ecological systems in the world. It is thus no accident that some of the highest prehistoric site densities in eastern New England are found in estuarine environments. From about 8,000 years ago, known archaeologically as the Middle Archaic Period, when sea levels had risen sufficiently after the retreat of the last glacier, and the migratory pattern of most fish and birds became established, until Europeans first came to these shores, estuaries were increasingly important to Native American subsistence and settlement patterns.

The attraction for Native Americans was the spring spawning runs of various ***anadromous fish,*** such as salmon, herring, alewives and shad. Additionally, the local estuaries typically were summer breeding grounds and nurseries for smelt, tom cod, winter flounder and sturgeon, and the tidal mud flats were rich in shellfish. The remains of these types of food resources have all been recovered archaeologically in Native American ***shell middens*** which dot coastal New England. During the fall and winter months families dispersed and moved into the surrounding uplands where nuts, berries and game became the primary focus of subsistence activities.

Although no sites are recorded at Belle Isle Marsh itself, two sites (19-SU-40 and 19-SU-3) lie between three quarters to one mile due south of the impact area near Ingleside Park in Winthrop Centre. Another site, 19-SU-2, was discovered 1 1/2 miles north at Crescent Beach in Revere. A fourth site, 19-SU-1, one of the most significant Native

American sites in the region, an early Contact Period grave, was also discovered at Revere Beach, about 3 miles north of Belle Isle Marsh, and 1 1/2 miles north of the Crescent Beach site.

During the 1880s 19-SU-3, a Contact Period (1500 - 1620) burial complex, consisting of ten graves containing quantities of Native and imported European grave goods, was encountered at the location of the now demolished railroad station in Winthrop Centre.

The exact location and circumstances under which 19-SU-40, known as the Herman Street Burials, was found is not known. However, Willoughby in his book ***Antiquities of the New England Indian*** (1935:240) describes and illustrates a knife made from a sheet of brass, set into a bone handle.

19-SU-2, located at Crescent Beach, toward the southern end of Revere Beach, is recorded merely as a ***human burial of unknown temporal/cultural association.*** There is no other information regarding the circumstances of the discovery or of the archaeological remains.

19-SU-1 was discovered in the 1870s by noted Lynn taxidermist Nathaniel Vickary in a ***sand hill at Revere-Chelsea Beach.*** While the exact location of the site is not well recorded, the richly accoutered grave itself is well documented. The site included two individuals apparently laid adjacent to one another. One was a nearly complete skeleton in an extended position with a large copper pot placed in an inverted position over the skull. The other individual from the description of the assorted bones sounds like a ***bundle burial*** (Hadlock 1949). Mortuary artifacts included a steatite tobacco pipe, sheet metal fragments, two strings of shell beads and sixty-one round glass beads of European origin, a miniature ceramic pot, pestles (including an anthropomorphic specimen), and shell Bosycon canaliculatum (Hadlock 1949: 66-70; Johnson and Mahlstedt 1982:28).

This cursory overview conclusively establishes Native American groups in the vicinity of Belle Isle Marsh during the Contact Period, and suggests that any elevated dry ground would have a high probability of settlement from that time back to the Middle Archaic Period about 8,000 years ago. In 1982 the Massachusetts Historical Commission's Survey Team, after studying prehistoric collections and site locations in Essex County concluded that one of the two principal habitats that exhibited high archaeological sensitivity was ***elevated areas adjacent to salt marshes and barrier beaches of the Essex County coast*** (Johnson and Mahlstedt 1982: 44). Sites located in such habitats may yield information on prehistoric exploitation of marine, estuarine and salt marsh resources, and how this exploitation changed through time.

However, boring logs indicate that the project area, contains a mantle of dredging materials. This suggests that the project area was not as elevated and well drained in historic and prehistoric times as it is today. Instead, the impact area was an active salt marsh, subject to the ebb and flow of the tide, and the many hills and coastline in the vicinity are where actual habitation would have occurred. Conversely, marshlands themselves would have been exploited for their natural resources, and as the ***Boylston Street Fish Weir*** illustrates, evidence of such activity can in fact survive relatively intact under enormous amounts of fill (Johnson 1942).

The estuarine settings of Belle Isle Marsh and Boylston Street were virtually identical, and the use and survival of wooden fish weirs, such as employed at Boylston Street sometime between 3,500 - 6,000 years ago, cannot be conclusively ruled out. Indeed, citing the Boylston Street Fish Weir, the Massachusetts Historical Commission itself has cautioned about the potential survival of archaeological in heavily developed areas (Bradley et al 1982:22).

RECOMMENDATION

Since the presence or absence of prehistoric archaeological resources cannot be conclusively demonstrated, the following course of action is recommended:

- The project will entail a minimum of earth movement, and the goal of ***increasing the flushing capacity*** of the marsh can be achieved by excavating narrow trenches. However, Boring Logs indicate that the anticipated depth of 2 to 4 feet of the excavations, will come close to, or possibly penetrate, original soil horizons. Therefore there is potential for ***Adverse Affects to prehistoric archaeological resources*** to occur.

- Provisions should be made for MDC archaeologists (as authorized by MHC General Archaeological Permit # 890), or archaeological consultants, to be on site to monitor work as maximum depths of the excavations, or original soil horizons, have been reached.

  Monitoring is a passive archaeological technique that does not rely on subsurface testing, but archaeologists must be on site to oversee the mechanized excavations. Monitoring may involve temporary work stoppage in order to record, document and evaluate archaeological remains if encountered. Should archaeological remains be determined to be sufficiently significant based on their form, type, configuration, size and integrity, arrangements must be made to mitigate the impacts by means of project redesign, or resource removal, in the form of ***Data Recovery*** in accordance with the Massachusetts Historical Commission's guidelines.

- The unidentified wooden structure to the east of the berm should be flagged or otherwise cordoned off, thus placing it outside of the impact area. Should it be necessary to alter this structure research must be undertaken to determine its age, function and significance. It must also be thoroughly recorded measured, mapped and photographed.

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APPENDIX D
TECHNICAL SPECIFICATIONS

DRAFT
Belle Isle Marsh Restoration Project
Technical Specifications

Scope

The work involves construction of a channel system to restore tidal flushing to a fresh water marsh at the Belle Isle Marsh Reservation as shown on the contract drawings. The channels shall be constructed with a minimum bottom width of three feet and side slopes of one vertical on three horizontal as shown on the typical cross sections.

Disposal of approximately 2,000 cubic yards of excavated material will be on park land in the Belle Isle Marsh Reservation as shown on the drawings.

Site Conditions

The project site currently consists of a fresh water marsh with reed grass of six feet or more in height. Soil conditions are as shown in the enclosed subsurface exploration summary. The majority of the site is covered by anywhere from six inches to one foot of standing water.

All potential bidders should visit the site before the opening of bids to verify the conditions and determine for themselves the type of construction equipment that will be required to accomplish the work.

Suggested Construction Procedures

The staging area is located alongside Leverett Street as shown on the contract drawings.

An access way to the work area must be cleared to allow the passage of construction equipment. The area to be cleared shall be no more than 20 feet wide over its entire length.

Excavation and removal of material shall be performed by low pressure construction equipment to minimize damage to existing substrate. The Contractor may elect to use a backhoe for excavation and a front end loader to transport excavated material to the staging area prior to transfer to the disposal area by truck.

It is recommended that the main channel from the existing drainage ditch through the berm to Station B shown on the drawings be constructed first to facilitate drainage of some of the standing water on the site.

Erosion Control

The Contractor shall prepare a Soil Erosion and Sediment Control Plan and submit it for approval to the Contracting Officer prior to starting any work. The Contractor shall furnish all labor, materials, equipment and incidentals necessary to install and maintain the erosion control facilities. As a minimum, staked hay bales shall be used at the downstream end of the channel system during construction. At the completion of construction, all sediments retained by the hay bales shall be removed and deposited in the authorized disposal area.

Upon completion of the work, the staging and access areas shall be restored to similar conditions as existed before the start of construction. The Contractor shall, to the maximum extent possible, use all appropriate measures necessary to minimize damage to the substrate.

The Contractor shall comply with all applicable permit conditions.