

RESTORATION PLAN FOR ARMY CREEK LANDFILL SETTLEMENT

NEW CASTLE COUNTY, DELAWARE

Prepared by

Army Creek Natural Resources Trustees

October 1995

State of Delaware,
Department of Natural Resources and Environmental Control

U.S. Department of Interior,
Fish and Wildlife Service

U.S. Department of Commerce,
National Oceanic and Atmospheric Administration



The Army Creek Natural Resource Trustees have approved this Restoration Plan and Environmental Assessment for public distribution and review.

State of Delaware
Department of Natural Resources
and Environmental Control

The Department of Interior,
U. S. Fish and Wildlife Service

U.S. Department of Commerce,
National Oceanic and Atmospheric Administration

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EXECUTIVE SUMMARY

Under the authority of the Comprehensive Response, Compensation and Liability Act of 1980, as amended (CERCLA), the designated Natural Resource Trustees (Trustees) are restoring natural resources which were injured by releases of hazardous substances from the Army Creek Landfill Superfund site in New Castle County, Delaware. The Trustees are the Delaware Department of Natural Resources and Environmental Control (DNREC), the U.S. Department of Commerce's National Oceanographic and Atmospheric Administration (NOAA), and the U.S. Department of the Interior. As part of a Consent Decree requiring remedial actions at the Army Creek site, the Trustees agreed to a monetary settlement with certain responsible parties for natural resource damages. The settlement of \$800,000 was designated for restoration, replacement, or acquisition of the equivalent natural resources injured, which included lost upland habitat, contaminated aquatic and wetland habitats, and lost use of groundwater. This document describes the plan which has been developed by the Trustees to restore the injured upland, aquatic and wetland habitats. In addition, to the above referenced amounts the State of Delaware settled a claim relating to loss or injury to groundwater resources. The groundwater issue is not included in this restoration plan.

The goal of the restoration plan (Plan) is to restore, replace, or acquire the equivalent quantity and quality of habitat and biodiversity of the upland and wetland (including aquatic) habitats within the Army Creek watershed. This goal will be achieved by the following two actions:

- 1) Restoration of tidal exchange to wetland habitats of Lower Army Creek in order to increase tidal flushing and tidal volume, which will improve exchange of inorganic and organic materials, access and use by biota, and the distribution and abundance of more desirable tidal marsh plant species; and
- 2) Acquisition and management of uplands within the Army Creek watershed to enhance ecological values, encourage wildlife use, and

provide a buffer between developed upland areas and Army Creek.

The proposed wetlands restoration project (i.e., #1 above) consists of two main elements: a water management plan and a vegetation management plan. The water management plan involves modification of an existing water control structure (at the confluence of Army Creek and the Delaware River) by adding automated tide gates which will allow rapid adjustments of direction, frequency and duration of tidal flows into and out of the Army Creek marsh. The enhanced tidal exchanges will allow ingress and egress of estuarine and anadromous fishes for spawning, feeding, and refuge, and will improve habitat quality and nutrient and detrital exchange. Automated control of water levels will help avoid flooding of adjacent property. The vegetation management plan includes suppression of phragmites colonization by a combination of herbiciding, burning and water level management to increase marsh plant diversity. Greater marsh plant diversity will result in improved habitats for waterfowl, wading birds, shorebirds, and aquatic mammals and will also provide aesthetic enhancement and improved recreational and educational opportunities. The wetlands restoration project also includes a plan for long-term operation and maintenance.

The proposed upland restoration project (i.e., #2 above) consists of acquisition and rehabilitation of approximately 60 acres of upland habitat, which the trustees consider to be appropriate compensation for the loss of similar upland acreage due to construction of an impermeable "cap" on the Army Creek landfill. Options available to the Trustees include a habitat restoration agreement, acquisition of property interests such as, easements and/or fee-simple acquisition. Candidate upland sites, both within and outside of the Army Creek watershed, have been identified according to screening criteria (including proximity to Army Creek, presence of wetlands, condition of the site, size/shape, degree of disturbance, potential management problems). A long-term maintenance plan will be developed upon acquisition of the properties. Final selection and acquisition of a parcel(s) will not take place until after public review/comment and subsequent finalization of this Plan.

INTRODUCTION

1.1 Authority

The Comprehensive Environmental Response, Compensation and Liability Act of 1980, as amended, (CERCLA) provides authority for the Environmental Protection Agency (EPA) to seek recovery for response costs from potentially responsible parties (PRPs) associated with the release of hazardous substances. Additionally, CERCLA provides the federal, state and tribal natural resource trustees with authority to seek damages for injury to, destruction of, or loss of natural resources resulting from releases of hazardous substances. The purpose of this provision is to authorize the Natural Resource Trustees (Trustees) to bring and resolve natural resource damage claims and to use recovered damages to compensate the public for losses by restoring, replacing, or acquiring the equivalent of the injured or destroyed resources.

Pursuant to Section 107 (f) (1) of CERCLA and Subpart G, 40 C.F.R. Part 300 of the National Contingency Plan (NCP), the Governor of the State of Delaware and the Secretaries of the United States Departments of Interior and Commerce are the designated natural resource trustees for among other resources the land, fish, wildlife, biota, air, water and groundwater associated with the Army Creek Superfund site. The Governor of the State of Delaware delegated his authority as natural resource trustee for the Army Creek Superfund site to the Secretary of the Delaware Department of Natural Resources and Environmental Control (DNREC) (March 4, 1993). For the purposes of development and implementation of this restoration plan (Plan), the Secretary of DNREC delegated his authority to the Director of the DNREC Division of Fish and Wildlife (March 29, 1993). The Secretary of Commerce's authority has been delegated to the Administrator of National Oceanic and Atmospheric Administration (NOAA) via Organizational Order No. 25-5A. Accordingly, the Trustees for the Army Creek Superfund site are the State of Delaware Division of Fish and Wildlife; U.S. Department of the Interior (DOI); and U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA). The natural resources of concern associated with the Army Creek Superfund site, which were identified by the Trustees according to their respective legal authorities, include migratory and other bird species; anadromous

and other fish species; the upland, aquatic and wetland habitats utilized by those species (Army Creek, pond and marsh and the existing landfill habitat); and groundwater.

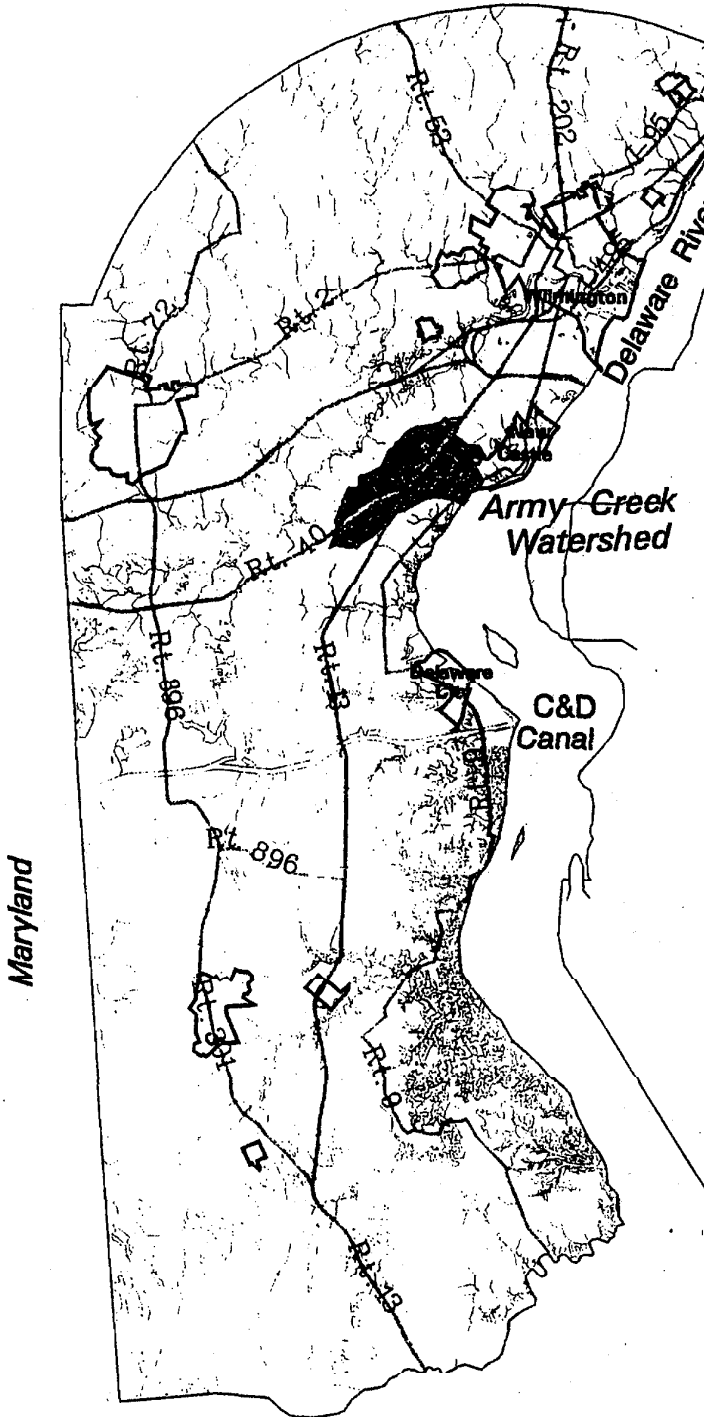
1.2 Purpose

The purpose of this Plan is to restore, rehabilitate, replace, or acquire the equivalent of those Trust natural resources and/or services injured as a result of impacts from the Army Creek Landfill. The terms restoration, rehabilitation, replacement, and acquisition of the equivalent all refer to acts of human intervention and will be collectively referred to in this plan as restoration. The injuries identified by the Trustees include the following: first, the landfill contaminated nearby groundwater resulting in the lost use of 2-3 million gallons per day which could have been used for the public water supply. Second, the contaminated groundwater was subsequently pumped to the surface and discharged to Army Creek where high concentrations of metals in the surface water and sediments of the creek and pond affected the food chain for migratory birds. The contamination of Army Creek was a factor in the State of Delaware's decision to not allow fish passage features in the tide gate when it was installed in 1987; thereby, excluding anadromous species from Lower Army Creek Marsh. Finally, injuries occurred when approximately 60 acres of upland habitat were destroyed during landfill capping. Cap design requirements significantly restricted habitat diversity.

The goal of this Plan is to restore the injuries identified above (with the exception of groundwater) by increasing the quality and quantity of wetland and upland habitat within the Army Creek watershed. This Plan includes the following objectives:

- Objective 1: Restore tidal exchange to Lower Army Creek to:
- A) increase tidal flushing to improve exchange of inorganic and organic materials and access and use by biota (including anadromous fish species such as striped bass, blueback herring, alewife, and shad); and
 - B) increase tidal volume and marsh water levels to improve the distribution and abundance of more desirable tidal marsh plant

Pennsylvania



New Castle County, Delaware

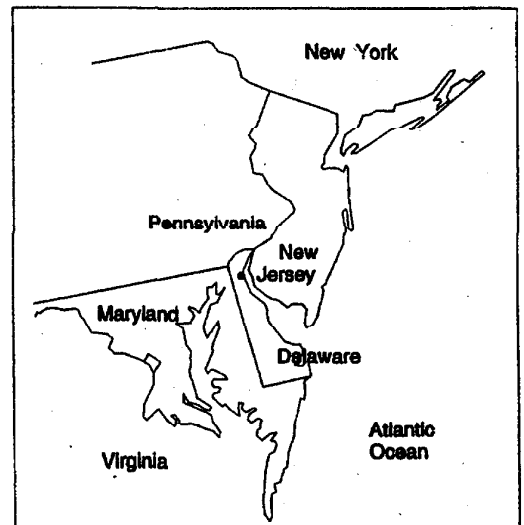


Figure 1. Army Creek site location

species without causing adverse secondary impacts such as, flooding of adjacent property.

Objective 2: Acquire and manage uplands within the Army Creek watershed to:

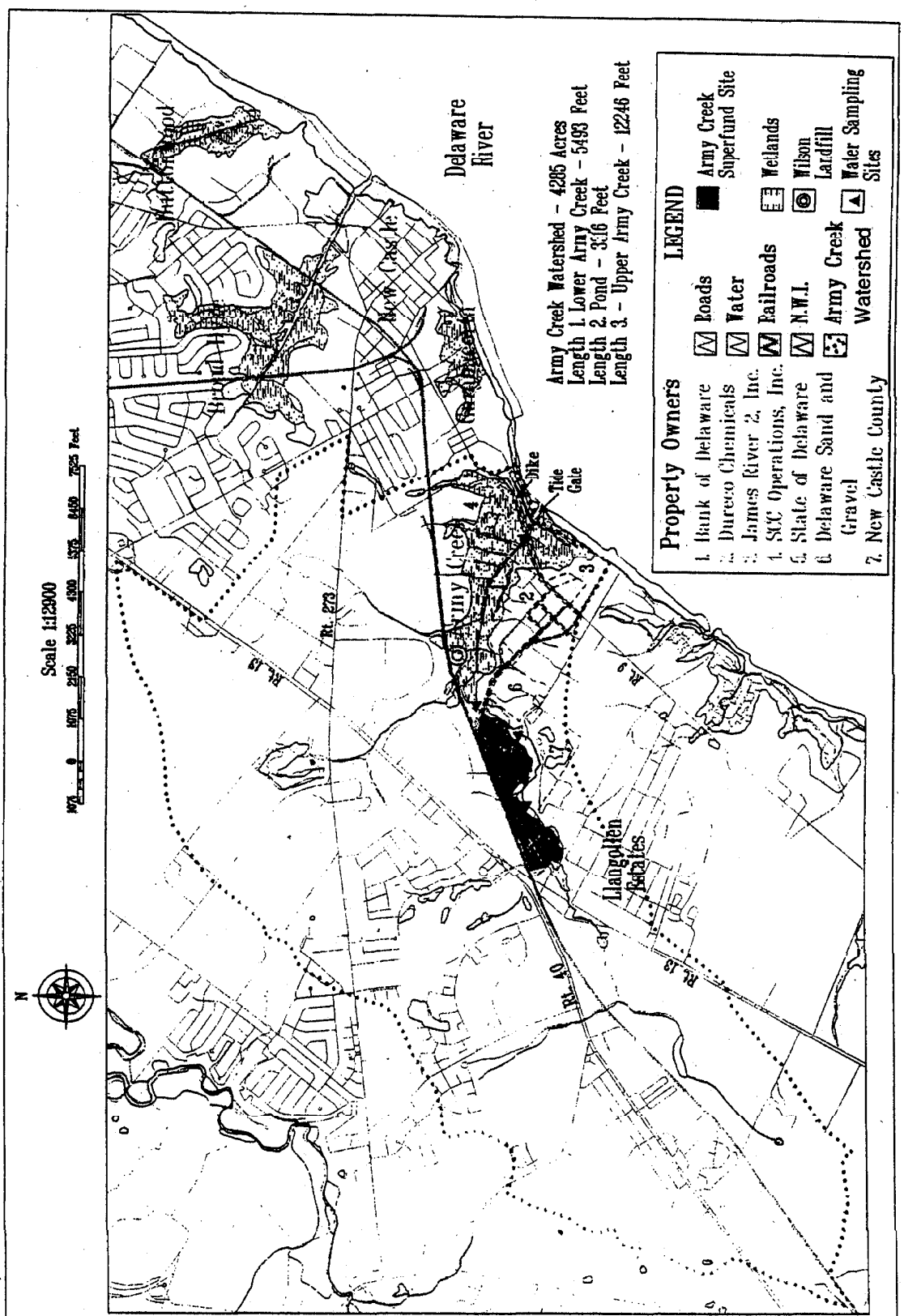
- A) enhance ecological values,
- B) encourage wildlife use, and
- C) provide a buffer between developed upland areas and Army Creek.

Specifically, these objectives include the following activities: 1) the restoration of partial tidal flow to Lower Army Creek via modification of a tidal gate located at the mouth of the Creek to provide fish passage for anadromous species (striped bass, blueback herring, alewife, and shad); 2) improvement of habitat quality (i.e., Phragmites control and tidal circulation) and quantity (i.e., approximately 225 acres of restored wetlands); 3) acquisition and potential rehabilitation of uplands to benefit wildlife and improve water quality for aquatic species; and 4) long-term operations, maintenance, and protection of the area following restoration.

1.3 Background

The Army Creek Superfund site is located in New Castle County, Delaware (Figure 1). The 60 acre site was a former sand and gravel pit which was operated during the 1960s by New Castle County as a landfill for municipal and industrial wastes. Contaminants leaching from the landfill were discovered in nearby private drinking water wells in 1972. In 1973, the County installed a recovery well system which effectively prevented the contaminated groundwater from migrating to nearby public water supply wells. This removed the immediate threat to human health presented by the site. However, the recovered groundwater was discharged, without treatment, directly into Army Creek which forms the lower limits of the landfill area (Figure 2).

Army Creek, a tributary of the Delaware River, is about 3.9 miles long



Scale 1:12500
 0 400 800 1200 1600 2000 2400 2625 Feet



Army Creek Watershed - 4285 Acres
 Length 1 - Lower Army Creek - 5493 Feet
 Length 2 - Pond - 316 Feet
 Length 3 - Upper Army Creek - 12246 Feet

LEGEND	
	Property Owners
	Roads
	Water
	Railroads
	N.W.I.
	Army Creek Watershed
	Wetlands
	Wilson Lardfill
	Army Creek Superfund Site
	Water Sampling Sits

Figure 2. Army Creek Watershed

(Figure 2). Its drainage area is approximately 6.7 square miles. The upper 2.9 miles of the Creek, including a three acre pond, contains freshwater. The salinity of the lower one mile of the Creek, including a 225 acre emergent wetland, ranges from fresh to slightly oligohaline. A tidegate at the mouth of Army Creek limits exchange of water and biota from the Delaware River.

The landfill was placed on the National Priorities List in 1983. A remedial investigation/feasibility study (RI/FS) was completed in 1985 and a Record of Decision (ROD) was issued by EPA in 1986. The remedy selected in the ROD consisted of covering the landfill with an impermeable membrane/soil cap system to prevent precipitation from leaching through the waste and into the groundwater, plus continued operation of the recovery well system. A second RI/FS and ROD in 1989 determined that treatment was required for the recovery well discharges primarily because iron concentrations were greater than the criterion for the protection of aquatic life. The landfill cap was completed in December 1993, and the water treatment facility was completed in January 1994.

In February 1990, representatives of EPA, the State of Delaware and the settling PRPs reached an agreement with regard to the PRPs liability for response costs at the Army Creek Superfund Site. The PRPs requested that the Trustees grant a covenant not to sue for natural resource damages associated with the Army Creek site. At that time the Trustees entered into negotiations. Based upon a review of the litigation risks associated with the Trustees' claims, EPA's proposed remedial activities at the Army Creek site, a review of the resulting past and residual injuries associated with these resources and a review of the loss of these resources, the Trustees agreed to a monetary settlement. The proposal provided for on-site restoration actions, off-site habitat development and a monetary settlement for injuries associated with groundwater as reasonable compensation for losses to public trust resources.

On September 18, 1990, 18 PRPs entered into a Consent Decree to implement clean-up actions and reimburse the EPA for past response costs. The Consent Decree also required the PRPs to deposit \$800,000 into a trust fund of which \$200,000 was to be used solely by the State of Delaware for groundwater protection and restoration and \$600,000 was to

be used for habitat restoration by the Trustees. This restoration plan addresses habitat restoration only.

Upon approval of the Consent Decree by the court, it became the responsibility of the Trustees to plan and implement restoration actions, using the settlement funds. Army Creek was one of the first natural resource damage settlements requiring joint implementation of a restoration plan by three government entities. To implement the settlement the Trustees executed a Memorandum of Agreement (MOA) on October 22, 1991.

The MOA established among other things: 1) the division of settlement monies among the three government entities, 2) a repository for the settlement monies until spent, and 3) the Army Creek Site Natural Resources Trustee Committee (Trustee Committee) to serve as the decision making body for issues relating to the restoration of joint Trustee resources. Each government entity designated one voting member and an alternate to the Trustee Committee. The MOA requires consensus decision making by the Trustee Committee.

Public participation in the development of this restoration plan has been facilitated in three ways. First, pursuant to Delaware law, all restoration planning meetings conducted by the Trustee Committee were declared open to the public and advertised in the local newspapers. Second, the procedure established by the National Environmental Policy Act (NEPA) (See Appendices A and B), was followed in developing the Plan. NEPA requires a notice and comment period to allow the public to have input into the development of the restoration plan. Third, an administrative record, consisting of the restoration plan and documents relating to its development, has been compiled and is available for review at the DNREC New Castle Office.

1.4 Natural Resource Trustee Committee Actions

In 1992, the Trustee Committee established a Technical Advisory Committee (TAC) to investigate the level of contamination within Army Creek to determine if restoration could be undertaken on-site. A Report of

the TAC on Army Creek Contaminant Issues (November 1994) recommended on-site resource restoration of Lower Army Creek, below the Pond, (Figure 2) because contaminant levels there were below those thought to cause adverse biological effects. The report also recommended delaying any decision regarding restoration of the Pond and Upper Creek until after completion of EPA's periodic review. To evaluate the anticipated environmental effects associated with on-site restoration and to comply with the NEPA, DOI, with the assistance of NOAA, drafted an Environmental Assessment (EA) which was released for public review and comment in January 1995. No comments were received. A Finding-of-No-Significant-Impact was made.

The EA reviews alternative restoration plans and explains reasons for the selection of the preferred alternative. The alternatives considered were: 1) No Action, 2) Restoration of natural resources at a site(e) outside of the Army Creek watershed which are equivalent to those which were injured or destroyed on-site, and 3) On-site restoration of injured or destroyed natural resources in the Army Creek watershed. The preferred alternative of on-site restoration within the Army Creek watershed was selected.

1.5 PLAN ORGANIZATION AND COMPLIANCE

In addition to the introduction, this report consists of five major sections and four appendices as follows:

Section 2.0 contains the wetlands and upland restoration plans. These plans address the restoration objectives presented in section 1.2.

Section 3.0 provides the monitoring plans for Lower Army Creek wetlands and upland sites. These plans describe how the sites will be monitored for mid-point correction and determination of a successful end-point.

Section 4.0 specifies how the restored sites will be operated and maintained and designates responsibilities for such.

Section 5.0 presents budgetary allocations of the settlement monies.

Appendix A contains the Environmental Assessment (EA) and two attachments--Upland Selection Criteria and Report of the Technical Advisory Committee on Army Creek Contaminant Issues. The EA considers whether or not restoration should occur on-site (i.e., within the Army Creek watershed) or off-site, and if on-site over what portion of the watershed.

Appendix B addresses compliance with the National Environment Policy Act (NEPA) concerning wetland and upland restoration projects and their long-term operations and maintenance.

Appendix C details the existing and proposed water control structure. The costs and schedule for this new structure are elaborated in this appendix.

Appendix D contains the proposed treatment process for phragmites control along with treatment costs.

Appendix E contains an abbreviated Wetland Monitoring Plan

2.0 Army Creek Restoration Project

2.1 Wetlands Restoration (Lower Army Creek)

2.1.1 Water Management Plan

The objective of this water management plan is restore tidal exchange to Lower Army Creek to increase tidal flushing and volume (See Figures C-1 and C-2 in Appendix C). Greater tidal flushing between Army Creek and the Delaware River will result in the following benefits:

- * Improved water quality in Lower Army Creek and adjacent marsh;
- * Flushing of nutrients, detritus, and sediments;
- * Increased filtering and nutrient uptake by wetlands;
- * Access to spawning, nursery, feeding and/or refuge habitats for diadromous and estuarine species
- * Improved wetlands habitats for waterfowl, wading birds, shorebirds, and aquatic mammals;
- * Increased structural complexity of shallow-water habitat;
- * Suppressed growth and reinvasion of Phragmites;
- * Reduced areal extent of mosquito breeding habitats;
- * Increased predation on mosquitoes by larvivorous fishes (i.e. mosquito-larvae-consuming fishes); and
- * Aesthetic enhancement and improved recreational and educational opportunities.

I. Scope of water management problem in Army Creek

The existing water control structure at Army Creek Marsh consists of five one-way flapgates that only allow outflow discharges of accumulated upland runoff water from the marsh. No tidal inflows into what should be a tidal marsh are permitted to occur (although some might occasionally happen if one or more of the flapgates becomes accidentally obstructed in an open position during rising tides). The history of water management at Army Creek is similar to several other formerly tidal freshwater or brackish marshes along the lower Delaware River in Delaware (and at many other locations in the mid-Atlantic region). For purposes of flood prevention and development uses of low-lying areas for residences, businesses, industry or agriculture, marsh-adjacent upland areas (that were occasionally subject to tidal flooding during unusually

high tides or storm surges) were "protected" by excluding all tidal inflows into the marshes, thereby eliminating a major cause of undesirable flooding. At many sites, this tidal inflow exclusion has gone on for decades if not centuries. Of course, this practice has led to the disruption of many important ecological and environmental processes involved in marsh-estuarine interactions, and has also caused degradations to ecological structure and biotic communities within the marsh.

In areas where upstream "leaky" landfills or other sites having contaminant release problems present potentially significant threats to water quality of the Delaware River, exclusion of tidal inflows and associated tidal exchanges becomes somewhat desirable, and is partially responsible for some of the current water management practices at some of these locations (e.g. Army Creek Marsh, Red Lion Creek Marsh). The recent refurbishing in 1987 of Army Creek's water control structure has an engineering design that both prevents flooding by riverine tidal waters of developed areas (the primary concern is for Rt. 9), and which also prevents penetration of tidal waters into Army Creek Pond or upstream Army Creek, where Superfund-site contaminants are most problematic. Until the causes of such contamination are remediated, for the health of estuarine systems it's often not desirable to have tidal exchanges in these contaminant-affected watersheds. Thus, restoring ecological structure and function to tidally-excluded marshes that are also in the same basins where significant upstream contaminant problems occur should involve not only the physical reintroduction of tides, but also abatement or remediation of the substantive upstream contaminants.

The primary problem of lack of tidal water in Army Creek Marsh is further exacerbated by a diminution of upstream runoff waters, through extractions or diversions of surface waters in Army Creek's developed upper watershed, and by a lowering of groundwater inputs by both upstream well extractions and groundwater pumping associated with contaminant containment and remediation at the Army Creek Superfund site. In aggregate, exclusion of tidal inflows, and to a lesser extent upstream water withdrawals or diversions, have essentially led to Lower Army Creek Marsh being a "water deficit" or "dry" wetlands, relative to what should be the marsh's natural hydroperiod as a riverine tidal freshwater/brackish marsh.

Army Creek Marsh's relative lack of water, in terms of frequencies, durations and areal extent of tidal inundations and heights of marsh water levels, has caused many ecological and environmental problems -- e.g. elimination of marsh-estuarine interactions for water quality effects and sediment budgets; elimination of spawning, nursery, foraging and refugia for estuarine and anadromous fishes; severe encroachment of robust, thick monotypic stands of phragmites over 90% of the lower marsh, lowering wetlands wildlife habitat values and decreasing the marsh's aesthetic appeal; diminution of permanent shallow water habitats in the marsh, lowering habitat values for waterfowl, aquatic furbearers, fishes and aquatic invertebrates; and enhanced mosquito production following rainfalls, necessitating more chemical insecticide use. Many of the restoration goals and objectives of the Restoration Plan are dependent upon implementing new hydrologic management practices within the marsh; if we can get the hydrology "right," many restoration goals and practices will fall into place.

Even though Army Creek Marsh can best be described as a "dry" wetland relative to what it should be, there are still occasional problems with flooding of developed property within the marsh, essentially limited to flooding of Rt. 9's surface which traverses the lower marsh, particularly on the north side of the Rt. 9 bridge. The relatively low elevation of Army Creek's marsh surface in relation to tidal datums in the adjacent Delaware River (i.e. most of Army Creek Marsh's surface is below mean sea level, 0.0 ft NGVD) limits the duration when water levels in the Delaware River are low enough to permit water discharges from the marsh (gravitational outflows can only occur about 4 hours out of each 12.5-hour tidal cycle). This limitation on discharge durations, combined with the numbers and sizes of the flapgates, sometimes causes accumulated upland runoff in the lower marsh to back-up, not being able to be discharged fast enough into the river to avoid flooding problems for Rt. 9. The heavier the rainfall, the faster the runoff enters the lower marsh basin, and the longer that storm conditions prolong elevated river heights preventing or limiting marsh outflows, the worse the flooding problems become for Rt. 9, in terms of both height and duration of flooding. Elaborations upon the scope of this flooding problem for Rt. 9, and how it might be resolved, are discussed elsewhere in the Restoration Plan.

II. Alternatives Considered and the Proposed Action

Achievement of the environmental objective, listed in Section 1.2, will depend upon successful management of marsh basin waters, both tidal (from Delaware River) and upland runoff. To assess the best water management strategy to achieve this objective, four alternative water management practices were examined. They are:

1. No action,
2. Uncontrolled (unmanaged) tidal flood-and-ebb,
3. Maximize marsh surface inundation, and the
4. PROPOSED ACTION -- Controlled (managed) tidal exchanges and marsh water level heights.

Each alternative is described in more detail below.

1) NO ACTION.

a) Description -- Make no modifications to the existing water control structure, which consists of 5 one-way flapgates which exclude almost all tidal flooding from the Delaware River, and discharge any upland runoff accumulated in the marsh from the marsh to the Delaware River twice per day. The prevention of tidal floodings and the rapid discharges of upland runoff keeps much of the marsh surface of lower Army Creek Marsh relatively dry, which minimizes concerns about floodings of developed property. The no action alternative is to continue with this water management strategy.

b) Consequences -- To meet the objectives, we cannot continue to maintain an abnormally dry marsh. An isolated marsh will have little benefit as spawning, nursery or feeding areas for estuarine or anadromous fishes. Shallow pool habitats beneficial to juvenile fishes, aquatic invertebrates, and foraging waterbirds are limited. The excessively dry conditions were a major factor in the extensive spread of dense phragmites cover over the marsh basin. The dry conditions are a major

factor in perpetuating phragmites cover, lowering values of the marsh for wildlife habitat and estuarine detrital food webs, while decreasing aesthetic appeal of the wetlands. Perpetuating exclusion of almost all tidal exchanges between the Delaware River and marsh eliminates biogeochemical interactions and processes that normally occur between tidal wetlands and the open estuary. An excessively dry marsh creates mosquito-breeding problems following a rainfall event, when surface depressions isolated from access by larvivorous fishes become breeding pockets. Concerns with flooding of developed property would continue to be minimized.

2) UNCONTROLLED TIDAL EXCHANGES.

a) Description -- Remove the one-way flapgates from the existing water control structure and let Delaware River tidal waters flood-and-ebb into Army Creek basin in uncontrolled (unmanaged) fashion. The marsh's hydroperiod (flooding frequency, duration, height) would be determined solely by the varying tidal water level heights in the Delaware River in relation to surface elevations in the marsh and upland runoff conditions, with no hydroperiod management performed.

b) Consequences -- Although there will be benefits derived from this alternative, the overwhelming prohibition against this option will be flooding of Rt. 9 and surrounding private property. Flooding of developed property, particularly the roadbed and surfaces of Rt. 9, will create a serious transportation nuisance and safety problems at almost every high tide and major storm.

3) MAXIMUM POOL LEVELS.

a) Description -- Manage tidal exchanges and upland runoff to create and maintain extensive marsh surface inundations, maximizing the durations of surface floodings, with water depths ranging from relatively shallow (e.g. several inches) to relatively deep (e.g. several feet). This alternative produces a large, permanent, standing water pond controlled by a tidegate. A modified water control structure would restrict ebb tide discharges except during times of heavy upland runoff to prevent flooding.

b) Consequences -- Would provide good habitat for migratory waterfowl at certain times of the year, but at the expense of foraging habitat for wading birds and shorebirds. Limiting tidal exchanges will restrict access to the marsh by estuarine and anadromous fishes. Even this limited tidal exchange scenario would be an improvement over the current water management scheme. More permanent, deeper water areas will benefit aquatic invertebrates, but be detrimental to some wetland-estuarine biogeochemical interactions and processes. Limited tidal water exchanges will also cause some water quality problems, particularly regarding dissolved oxygen levels during summer nocturnal periods.

Prolonged inundation will cause a loss of emergent wetlands vegetation and reduce structural habitat diversity. Managing the lower marsh basin as a permanently flooded pool decreases mosquito egg-laying sites and provides the best non-chemical control strategy for mosquito abatement. Long-term phragmites suppression following initial eradications is best achieved with a maximum pool strategy, in that new phragmites would not reestablish from seed, nor would seedling survival be high.

Maintaining a relatively stable, albeit high, marsh water level will not present flooding problems for developed property, as long as good control can be maintained over upper threshold heights. Many people would find a large expanse of shallow open water, with fringes and sparse patches of emergent wetlands vegetation, to be aesthetically pleasing.

4) PROPOSED ACTION -- CONTROLLED (MANAGED) TIDAL EXCHANGES AND VARIABLE MARSH WATER LEVELS.

a) Description -- Manage marsh water levels while preventing excessive flooding by controlling tidal exchange between Lower Army Creek Marsh and the Delaware River. The existing water control structure will be modified by adding automated tidegates which respond to various water level cues on both the marsh and Delaware River sides of the structure. These modifications should permit rapid adjustments of the direction, frequency and duration of tidal flows into and out of the marsh, and rapid adjustments in marsh water level heights.

This modified structure will be operated according to a water management schedule that optimizes functions and values of natural resources within the marsh without flooding Rt. 9 and private property.

The manner in which tidal exchanges and marsh water levels are managed may vary greatly on a seasonal or more frequent basis. Detailed descriptions of the actions needed to modify the water control structure and details for water management schedule (over an annual cycle) are presented in Appendix C.

b) Consequences -- The proposed action will achieve the widest range of environmental benefits of any of the four alternatives considered. The proposed action's enhanced tidal exchanges will allow ingress and egress of estuarine and anadromous fishes to the marsh for spawning, nursery, feeding and refuge, and enhance habitat quality. Also, it reestablishes biogeochemical interactions and nutrient and detrital exchange processes between the marsh and open estuary.

This alternative will increase shallow water habitat diversity, improving habitat quality for aquatic invertebrates, fishes, and waterbirds. Because average marsh water levels will be higher (ca. 0.5 ft. higher) than existing conditions, diverse submerged aquatic communities will be established in the marsh's shallow ponds and surface depressions. Being able to elevate or maintain higher marsh water levels will promote non-insecticide control of mosquitoes and non-herbicide suppression of phragmites. Continuous inundation in areas of the restored marsh will most effectively control mosquito production and phragmites growth.

In order to ensure shallow-water habitat diversity within Lower Army Creek Marsh, and to promote biological control of mosquitoes by larvivorous fishes, it may be necessary to excavate shallow ponds and ditches, disposing the excavated spoil as a temporary, thin slurry over adjacent marsh surfaces (see Lower Army Creek Marsh -- Vegetation Management Plan). The excavated ponds will serve as reservoirs of permanent water during marsh drawdown periods, which will help to maintain submerged aquatic vegetation within the marsh while providing refuge for aquatic invertebrates and fishes; the excavated ditches will provide access for larvivorous fishes to isolated mosquito-breeding sites. The need to install any ponds or ditches will be determined after the tidal water management plan is initiated. If it is determined that such modifications are needed or desirable, the Trustees will contract with DNREC's Division of Fish and Wildlife (Mosquito Control Section) to selectively install the ponds and ditches.

Using water management practices to control recolonization by

phragmites in areas where marsh surfaces are subject to alternate flooding and exposure will probably be most effective during times of seed germination or young seedling growth. Continuous flooding of these areas for several weeks during critical growth periods (e.g. mid-spring) will suppress phragmites recolonization. Suppressing phragmites recolonization by a combination of herbiciding, burning (see Vegetation Management Plan), and management of water levels will increase the diversity of marsh plant species to include pickerelweed, arrow-arum, smartweeds, three-squares, rushes, sedges, cattails and mallows. Being able to control maximum marsh water levels will help avoid flooding of developed property except during unusual circumstances.

Flooding

The existing tidegated water control structure built in 1987 excludes tidal inflow into Army Creek Marsh, as did previous water control structures at Army Creek. Most of Lower Army Creek's marsh surface elevations are below mean sea level (i.e. below 0.0 ft NGVD), which limits discharging Army Creek's marsh waters into the Delaware River to less than one-half the duration of each tidal cycle. We estimate that whenever Lower Army Creek Marsh now comes to "flood stage" or 100% "full pool" level (i.e. almost all marsh surfaces are inundated with shallow water), as is occasionally caused by upland runoff events following storms, the Delaware River's water levels are low enough to allow marsh water outflows for only about 4 hours out of each 12.5-hour tidal cycle. This condition often leads to shallow flooding of Rt. 9's road surface, especially on the north side of the bridge where the roadbed was not elevated during the bridge's recent repair. During severe storm events, such as a 100-year storm, water levels within the lower marsh will rise and flood Rt. 9, with water backing up to also flood Army Creek Pond and portions of upper Army Creek. Fortunately, there are no homes, businesses or other developed structures of consequence located at elevations lower than the 10-foot NGVD contour line (FEMA's floodline demarcation for 100-year storm events), so the only concern with flooding for almost all storm events will be impacts to Rt. 9.

According to DELDOT engineers, the existing five-flapgated water control structure was designed to reduce flooding problems within the

marsh in comparison to past conditions, by discharging upland runoff through larger diameter pipes than used in previous versions of the control structure, while still excluding tidal inflows. The proposed modified structure will have retrofitted automated vertical lift gates that will allow controlled or managed tidal inflows of Delaware River water into the marsh. These tidal inflows by themselves will never be permitted to raise marsh water levels above a desired shallow, 100% "full pool" level in Lower Army Creek Marsh. In terms of basin discharge capacity following storm events and upland runoff, the structure's proposed modifications will have little to no effect on marsh water discharge rates or discharge times in comparison to the existing structure, so concerns with potential flooding of developed property should not increase beyond current concerns (which are fairly minimal with exception of Rt. 9's road surface). DELDOT proposes to elevate the 2000-foot section of Rt. 9 north of the bridge that still readily floods, increasing roadbed height by approximately 2 feet. When done, this will permit full implementation of the Restoration Plan's proposed hydrographic regime without flooding the roadbed. Following completion of this roadbed work, it's anticipated that the major effect of the proposed restoration water management plan on "flooding" will be more frequent high water-level events in the lower marsh after storm runoffs, because "normal" lower marsh water levels in the restored marsh will be purposely kept somewhat higher and for longer durations than present conditions. However, this should not affect the frequency, duration or severity of flooding problems for developed property beyond what currently exists, and with Rt. 9's eventual elevation, flooding problems in the basin should actually lessen.

In modifying the structure and operation of the existing water control structure, there may be undesirable consequences to not being able to manipulate marsh water levels in event of failure of the structure to operate as designed or modified. The proposed automated vertical lift gates retrofitted to the existing structure will be designed to work in all types of weather, including ice conditions in the river or marsh. Design features will consider what do in the case of a mechanical failure or a physical obstruction to the gates' operating performance (e.g. a log stuck in one of the gates). If the structure's new gates are electrically operated, contingencies will be built in to the design or operation of the

gates to deal with electric power loss. The structure will be designed, protected (hardened), secured, checked and operated in a manner that minimizes vandalism problems to the extent practicable. There will be manual override features that will allow the gates to be manually manipulated in event of a gate's loss of its primary mechanical mode of operation, or in event of a power loss if electrically operated. A primary safety design feature will be to be able to close the gates manually under any type of field condition in order to stop incoming tidal flood waters, yet still have the gates be able to discharge accumulated marsh waters as rapidly as possible whenever the river becomes low enough to permit gravitational outflows. These last design features are essentially the current conditions at the structure, so that we'll always be able to return to existing conditions (for better or worse) if so desired.

Benefits

The proposed action will achieve a mosaic of shallow open water interspersed with numerous stands or expanses of emergent vegetation and will create good foraging areas for wading bird and shorebirds. Being able to manage a marsh for these multiple resource objectives, while satisfactorily accommodating some socioeconomic concerns, should create a demonstration area for environmental education purposes.

Permits

c) Regulatory Permits -- It is probable that three types of wetlands permits will be needed to implement the water management plan, for both modification of the water control structure and management of tidal exchanges and marsh water levels.

- 1) Section 404 wetlands permit (federal) -- if an Environmental Assessment is required for this permit, it is probable that sections of the Restoration Plan fulfill this need.
- 2) State of Delaware wetlands permit -- Type I or II.
- 3) Section 401 water quality certification (State-issued) -- needed prior to issuance of the Section 404 permit.

The Trustees will work cooperatively with all wetlands regulatory authorities to ensure that all regulatory requirements are met. At the same time, the Trustees hope that the large amount of information contained in the Restoration Plan will serve to expedite all permitting needs.

d) Landowner permission/cooperation -- In undertaking new tidal water management practices affecting privately-owned marshlands in Lower Army Creek Marsh, it will be necessary to have the permission and cooperation of the landowners. This permission or cooperation can be obtained via a water management easement, property donation, or similar device. Since the marsh landowners in Lower Army Creek Marsh are all corporations, and since preliminary contacts have indicated a willingness to cooperate in some manner in the environmental restoration, the Trustees do not anticipate serious landowner problems in implementing the water management plan. The actions that the Trustees are planning to take should increase the values of these wetlands as wetlands. The general status of landowner permission or cooperation for marsh properties affected by the water management plan is reviewed in another section of the Restoration Plan.

III. Other Water Management Needs

1) Nonpoint-Source (NPS) Pollution -- In order to address other issues that may be affecting water quality in Army Creek's wetlands, in addition to Superfund-site contaminants and lack of tidal exchanges, it is necessary to at least examine the extent and magnitude of NPS pollution problems in Army Creek's watershed. The origins of diffuse, NPS pollution may be from road runoff, urban stormwater discharges, agricultural drainage, etc. The Trustees will work with DNREC's Division of Water Resources to examine and promote the clean-up of road runoff contaminants associated with the passages of Rts. 9 and 13 over Army Creek. The Division is currently in the process of developing a NPDES

permit (Section 402), giving requirements for New Castle County and DELDOT to follow to alleviate road runoff contaminants. The details for how this evolving NPDES program might apply to reducing road runoff problems on Rt. 9 or Rt. 13 crossings, in terms of problem identification and implementing voluntary or enforceable preventive or remedial actions, cannot yet be stated; however, the Trustees express a desire that these two road crossovers be a focus (if possible) for future implementation of the new NPDES pollution reduction program. For other NPS pollutants, the Trustees will contract (for about \$10,000) with the New Castle Conservation District (NCCD) to perform an NPS pollution assessment of the Army Creek watershed, identifying the most serious NPS pollution issues within the basin, and recommending site-specific actions that should be undertaken to reduce or eliminate the major problems. Implementation of preventive or remedial actions to lessen NPS pollution could then be undertaken through various State or State-directed federal programs -- e.g. focused applications of Delaware's Erosion and Sediment Control Act (sediment and stormwater regulations); implementation of voluntary or enforceable actions associated with the Section 319 (federal Clean Water Act) or Section 6217 (federal Coastal Zone Management Act) NPS programs; or implementation of Best Management Practices through auspices of the New Castle Conservation District. The Trustees will not spend Natural Resources Damages monies to actually remediate these NPS pollution problems, but will use the NCCD's study results to encourage NPS clean-up via appropriate authorities or processes.

2) Rt. 9 Roadbed -- To fully implement the proposed water management plan for Lower Army Creek Marsh, particularly in regard to managing water levels at or near maximum proposed heights, it may be necessary to await future elevation by DELDOT of the Rt. 9 roadbed. The Rt. 9 bridge and its southside roadbed were elevated by the end of spring 1993, to heights where the proposed marsh water management will not cause transportation problems. However, the relatively low, northside roadbed may still be somewhat problematic at full pool levels (not in terms of road surface flooding, but perhaps in terms of roadbed stresses). According to DELDOT, the northside roadbed is also planned for elevation within the next 2-3 years, awaiting the appropriate funding cycle. The Trustees will work closely with DELDOT in seeing this highway project pursued to completion, and in managing marsh water levels on an interim

basis until the northside roadbed is eventually raised. It is important that DELDOT recognizes the need for this roadwork in order for the Trustees to eventually fully achieve the goals for many aspects of the marsh's restoration, and that DELDOT makes this project a high priority in their planning and implementation.

2.1.2 Vegetation Management Plan

The objective of this vegetation management plan is to restore the distribution and abundance of more desirable tidal marsh species which will result in the following benefits:

- * Decreased abundance of phragmites;
- * Increased species diversity of marsh plants;
- * Improved wetlands habitats for waterfowl, wading birds, shorebirds, and aquatic mammals; and
- * Aesthetic enhancement and improved recreational and educational opportunities;

I. Scope of phragmites problem in Army Creek.

About 210 acres of Lower Army Creek's 225 acres of wetlands are monotypic stands of phragmites. These stands have supplanted other wetland plant species more desirable as food and cover. Like many areas of coastal New Castle and Kent Counties in Delaware, Army Creek Marsh had relatively little phragmites cover as recently as 20-30 years ago. The Delaware General Assembly has declared phragmites to be a nuisance species and therefore may be controlled or eradicated. The Trustees propose to eradicate, to the extent practicable, the existing phragmites cover over approximately 200 acres. More desirable wetland plants will naturally volunteer (from dormant seedbeds, aerial seed dispersal, or vegetative outgrowth) after phragmites eradication, and might include species such as pickereelweed, arrow-arum, smartweeds, three-squares, rushes, sedges, cattails and mallows. The types of species to become established will depend in part upon the effects of the proposed water management plan. Not all phragmites cover will be attempted to be eradicated. In areas where phragmites is helping to stabilize and

maintain levees or dikes, no eradication will be done. In marsh basin peripheral streams or upstream areas where phragmites is growing in the channels, helping to filter nutrients and sediments, no eradication will be done unless there is a drainage blockage problem. Leaving phragmites initially untreated along levees or in peripheral drainage ditches might serve as a source for some future recolonizations of phragmites into the open marsh (particularly via vegetative outgrowths); however, wherever this might be observed and determined to be undesirably excessive, localized control methods ("spot treatments") could be used.

II. Alternatives considered and the proposed action.

In order to try to eradicate phragmites from much of Lower Army Creek Marsh, there are only a few management techniques available for practical consideration:

1. No action -- Take no steps to directly control phragmites; let the phragmites respond to whatever water management practices are implemented for other purposes.
2. Flooding -- Use water management to raise marsh water levels high enough and for long enough duration to try to "drown" the established phragmites stands.
3. Mowing -- Cut down the phragmites, and leave the mowed culms on the ground to decay, or physically remove the mowed culms from the marsh, or burn the mowed culms on-site.
4. Burning -- Perform a prescribed burn of the standing phragmites culms.
5. Physical removal (mow/burn) and shallow flooding -- physically remove aboveground portions of phragmites stands by mowing or prescribed burning, followed by prolonged surface flooding, to try to kill both aboveground and belowground portions of the stands.
6. Herbicide treatment -- Apply an appropriate herbicide to kill the phragmites stands.
7. PROPOSED ACTION -- Herbicide-and-burn treatment -- Apply an appropriate herbicide to kill the phragmites, and then follow with prescribed burning of the standing dead culms.

The seven alternatives considered are described in more detail below. Descriptions of the environments (socioeconomic, geology, hydrology, ecology, land use) potentially affected by the alternative actions are given in the Restoration Plan's Environmental Assessment.

1) NO ACTION.

a) Description -- Take no actions to directly or purposely control the existing phragmites cover. Let the phragmites stands respond to whatever water management practices are implemented in the marsh for other purposes.

b) Consequences -- This action will not eradicate the extensive phragmites cover, since there are no effective water management practices involving freshwater or low salinity tidal waters (such as what is found in the adjacent Delaware River, from 1-5 ppt).

These extensive stands of phragmites result in a poorer quality, less accessible source of detritus for estuarine food webs. The dense, tall phragmites has replaced shallow-water open habitats to the detriment of many fish and wildlife species.

2) FLOODING.

a) Description -- Purposely elevate marsh water levels for a long-enough duration to try to "drown" the existing phragmites stands. In order to kill phragmites, it is first necessary to kill the underground portions of the plant (roots, rhizomes); if only the aboveground portions of phragmites are killed or removed, the stand rapidly regenerates itself from underground parts. In order to kill a stand by prolonged flooding, it is first necessary to block the "snorkel" effect of aboveground stems of the plant, which serve as uptake sites and conduits for oxygen to belowground plant parts; in theory, this might be achieved by total submergence of all aboveground stems for prolonged durations.

Primary sources of water to potentially elevate marsh water levels in Army Creek Marsh would come from Delaware River tidal inflows and/or retention of upland runoff. Allowing Delaware River tidal waters to flood into Army Creek Marsh will introduce slightly higher salinity waters (from 1-5 ppt) than what are usually found in the marsh (from 0-2

ppt). In order to achieve and maintain the desired volumes and depths for prolonged surface inundations, most of the water volume would have to come from Delaware River tidal waters captured during a flood tide(s) and retained at appropriate depths during all ebb tides. Reliance upon retention alone of upland runoff waters to provide adequate inundation depths across the marsh surface (in an attempt to "drown" the phragmites) might be adequate during seasons or periods of high rainfall and runoff, but would be unsatisfactory during seasons or periods of average rainfall or droughts.

b) Consequences -- To "drown" established, mature stands of phragmites, it would be necessary to raise water levels in Army Creek Marsh perhaps 10-15 feet above existing marsh surface and maintain this elevated level for several weeks or months. However, this is NOT possible because of flooding and closure of Rt. 9 and flooding of other developed property around the basin. Such flooding would also cause severe disruptions to other aspects of marsh structure and function. The Delaware Game and Fish Commission attempted but failed to eradicate existing, mature phragmites stands via flooding in the 1950's, in which stands were flooded with oligohaline waters to depths of 4 feet deep for 6 months continuous duration. Laboratory and field tests by the University of Delaware demonstrated that flooding, following another eradication technique, could successfully control phragmites only in the seed set or seedling growth stages.

In some locations the introduction or reintroduction of high salinity estuarine waters can negatively effect but not totally eradicate phragmites. This occurs at salinities 15-30 ppt, higher than those in the Delaware River adjacent to Army Creek. Thus, the reintroduction or flooding of tidal riverine waters into Army Creek Marsh would not be expected to have any salinity-associated inhibitory effects on the site's phragmites cover or growth.

3) MOWING.

a) Description -- Using appropriate heavy machinery capable of working in wetlands (e.g. a flail mower), cut aboveground phragmites culms as close as possible to ground level, and then let the mowed culms decay in place, or physically remove the mowed culms from the marsh, or burn the mowed culms on-site.

b) Consequences -- Mowing yields only temporary control of phragmites, since belowground portions of the stands would not be killed, leading to rapid regrowth and pre-mowed conditions within a single growing season. Mowing activities will cause temporary population level effects on some marsh surface wildlife. Mowing will leave dead culms to decay in place and create severe dissolved oxygen problems for aquatic organisms in the marsh. Removing the mowed material from the area will be costly, labor intensive, and damaging to marsh surfaces. Trying to burn mowed culms decumbent on wet marsh surfaces will be difficult.

Additionally, the practical problems of trying to mow large acreages of marsh require the use of heavy machinery. Such machinery would have to generate very low ground pressures to be able to work over soft, unstable bottoms; the machinery should be able to float and be driven or propelled in order to cross larger channels and ditches. This alternative is expensive and does not permanently eradicate the phragmites.

4) PRESCRIBED BURNING.

a) Description -- Conduct a prescribed burn of the standing phragmites cover in Lower Army Creek Marsh, preferably in late winter or early spring when marsh conditions are dry, wind conditions can be used to advantage, and fresh, green regrowth has not yet started. The burn would be conducted by Delaware Division of Fish and Wildlife personnel in cooperation with local fire companies.

b) Consequences -- Burning temporarily controls aboveground portions of phragmites stands, leading to rapid regrowth and pre-burn phragmites conditions within a single growing season. Phragmites marsh burns are not "deep" burns, so belowground plant parts are not killed. Thus, burning will not be a satisfactory control method. Burning will have temporary population level effects on marsh surface wildlife by forcing some organisms to leave, some to seek refugia, and some to perish. Other minor problems with burning include temporary air pollution problems, the potential for inadvertent burning of developed property in the unlikely event a burn gets out of control, and a temporary disruption caused by smoke or flames to traffic traversing the marsh on Rt. 9.

5) PHYSICAL REMOVAL (MOW/BURN) AND SHALLOW FLOODING.

a) Description -- A combination of actions, involving mowing or burning the aboveground portions of a phragmites stand (alternative actions #3 or #4), followed by prolonged marsh surface flooding with shallow waters to try to kill ("drown") the belowground portions of the stand (alternative action #2). Because the aboveground portions of the stand would be first removed by mowing or burning, thereby removing as much as possible the "snorkel" mechanism for transfer of oxygen to belowground parts, it will not be necessary to flood and maintain marsh water levels at relatively deep depths in order to submerge any remaining aerial parts and cover the belowground biomasses. Rather, much shallower flooding (e.g., 1-2 feet) will cover any remaining aboveground biomass.

b) Consequences -- The consequences of physical removals via mowing or prescribed burning were previously discussed under alternative actions #3 and #4, and would also apply here. The consequences of flooding and prolonged inundations were previously discussed under alternative action #2, and would also apply here, with exception that the practical problems associated with maintaining marsh water levels at relatively deep depths would be avoided (e.g., potential flooding problems to Rt. 9 will be avoided).

The efficacy of these combined techniques in eradicating phragmites is unlikely. Even without the aboveground parts of the plant (e.g. if they were to be removed or shortened by mowing or burning), it is unknown for how long marsh surface inundations with overlying waters must be maintained before oxygen deprivations or build-ups of toxic metabolites might eventually kill the plant's root-and-rhizome system, which may constitute over half of the total biomass in a phragmites stand. Based upon some preliminary laboratory evidence (University of Delaware), it might take several months or more to kill a stand.

In order for "drowning" to be effective in killing belowground portions of a stand, any oxygen deprivation effects or toxic metabolite effects resulting from standing water conditions would have to occur during the growing season. Another problem in eradicating phragmites is its large underground reserves of nutrients. Any adverse effects of purposeful flooding will occur during the growing season, when

belowground portions of the plant rapidly produce aerial shoots. Thus, before a water depth of a few feet (e.g., 1-2 feet deep) might be able to cause any inhibitory effects on phragmites growth during the growing season, the belowground reserves will probably enable surface shoots to grow above the overlying waters.

Reliance upon prolonged inundations with shallow overlying waters to kill the belowground portions of a phragmites stand is tenuous. Thus, the use of shallow flooding with fresh or slightly brackish water for phragmites control will prevent establishment or recolonization of new stands that might occur from seed dispersal and seed set.

6) HERBICIDE APPLICATION.

a) Description -- Apply an appropriate systemic herbicide which will kill the roots and rhizomes of existing phragmites stands. Because of the large acreage and difficult access, any herbicide spraying of Lower Army Creek Marsh would be done by helicopter. Applications would be made at the appropriate time(s) of year to maximize treatment.

b) Consequences -- While there are herbicides that can kill much of an existing phragmites stand, one of the major problems with relying solely upon herbicide applications for control is that there are inhibitory shading effects of standing dead phragmites culms (following spray applications) on the growth of replacement plant species. For this reason it is undesirable to rely on herbicide applications alone.

7) PROPOSED ACTION -- HERBICIDE-AND-BURN TREATMENT.

a) Description -- This alternative involves the combination of a systemic herbicide application and subsequent prescribed burn, repeated annually over 2-3 consecutive years, in order to achieve successful eradication of robust phragmites stands. Detailed descriptions of this proposed treatment process are given in Appendix D. The Delaware Division of Fish and Wildlife has concluded that this approach is currently the best management strategy for phragmites control, in terms of treatment efficacy, environmental acceptability, and practicality. Treatment costs associated with this strategy are presented in Appendix D. Other vegetation management practices that may be desirable to do, in

conjunction with the primary proposed course of action, are given in Section IV. Herbicide-and-burn treatment may be improved when followed by water management practices designed to suppress new phragmites growth or inhibit recolonizations originating from seed set.

b) Consequences -- The environmental consequences of the possible effects on non-target organisms of herbicide use and prescribed burning are described in Section III, with a conclusion that any detrimental impacts from either spraying or burning are minimal or tolerable, particularly in light of the net environmental benefits to be gained from successful phragmites eradication. Implementation of the herbicide-and-burn control strategy should result in successful phragmites eradication.

III. Non-target impacts of proposed treatment process.

The formulation of systemic herbicide glyphosate approved by the EPA for use in tidal (estuarine) environments has a non-ionic surfactant, with water used as a carrier; the product's brand name is Rodeo, manufactured by the Monsanto Corporation. The product when used according to label instructions has not been observed to produce adverse effects on marine invertebrates, fishes, birds or mammals. However, glyphosate can be a broad spectrum herbicide in terms of plant effects, so care must be taken to limit its application to targeted areas. Using a helicopter to perform broadcast applications, versus fixed-wing aircraft, helps to keep the product on-target by minimizing target area misses and drift problems. Not all areas of a treated marsh require two or more broadcast applications of glyphosate. Only those areas where regrowth of phragmites is unacceptably excessive by the end of the first complete growing season (which follows the first spray done at the end of summer the year before) will be targeted for a second spray application. Once again, using a helicopter for these relatively smaller areas during second or subsequent sprayings keeps the product more on-target.

An unavoidable side-effect with repetitive, broadcast sprayings of glyphosate during the initial years of intensive phragmites treatment is that the spray applications also kill some or much of many other wetland plant species which have volunteered during each growing season (prior to the late summer herbicide applications). Many of these non-phragmites

species would have naturally senesced at the end of the growing season (particularly for annuals established via seed set), and as with the sprayed phragmites their aboveground parts are allowed to stand as dead matter throughout the winter, until the next spring's prescribed burn. The root and rhizome systems of non-phragmites perennial species which volunteered during the first complete growing season (following the initial glyphosate spraying toward the end of the previous summer) will also be affected by a second glyphosate spraying, with their aboveground dead structures also standing until the subsequent spring's prescribed burn.

Delaware-based research and operational observations indicate that colonizations of non-phragmites species are usually sparse during the first growing season following the initial glyphosate spray, but become much more extensive during the second growing season, which follows a second glyphosate application done toward the end of the first complete growing season. Ideally, no further broadcast glyphosate applications are needed after the second spraying. If third or even fourth-year broadcast sprays are needed, there will be some set-backs in establishing extensive covers of non-phragmites perennials, which cannot be avoided until after the need for all broadcast spraying ceases. If only two glyphosate broadcast applications are needed for the intensive treatment phase, non-phragmites cover should start to become extensive during the second complete growing season following start of the treatment program; if three broadcast sprays are needed, extensive non-phragmites cover would not be expected until the third complete growing season following start of the treatment program; in the unlikely event that a fourth consecutive broadcast spray is needed, extensive non-phragmites cover would not occur until the fourth complete growing season following start of the treatment program. Thus, during most of the initial intensive phragmites treatment period, the marsh surface is never colonized during any one year as thickly with non-phragmites cover as it could be, due to the usual necessity for at least one repeat glyphosate application in order to successfully eradicate a very tenacious target species.

In the long-run, these unavoidable spray-associated set-backs in establishing non-phragmites cover are only temporary, ceasing to be problematic after completion of the intensive 2-4 year treatment period (with its repetitive broadcast sprayings). Also, the negative consequences accompanying the need for repeat sprayings are not

universally felt by all plant species, since not all wetland plants are equally affected by glyphosate exposure. For example, when some areas of saltmarsh cordgrass (Spartina alterniflora) have been sprayed with glyphosate, done inadvertently or in association with controlling recolonizing phragmites, the contact does not always have deleterious effects, perhaps due to the waxy surfaces of cordgrass leaves.

A potential problem of killing large biomasses of phragmites in a short period of time involves increases in biological oxygen demand within marsh waters, caused by enhanced microbial respiration in association with phragmites decomposition, potentially causing stress or death to aquatic organisms. Burning the dead phragmites culms helps to lessen biological oxygen demand problems by eliminating microbial substrates. The colder seasons prior to burning when the dead phragmites biomass is created and available for microbial decomposition (during fall, winter and early spring) also helps to lessen dissolved oxygen stresses.

The impacts of burning on the marsh are temporary in terms of vegetation recovery and effects on wildlife populations. The rapid and shallow nature of a marsh burn has little effect on muskrat lodges, and is done at a time of year when waterbird nesting is not affected. Prescribed burning of tidal marshes is a commonly-used tool by federal and state wildlife management agencies to promote vigorous new plant growth and retard undesirable successional stages (e.g. to limit shrub incursions), and is widely applied to cordgrass, three-square, and cattail marshes. However, there are undoubtedly at least temporarily adverse effects to some wildlife populations (e.g. voles), and great care must be taken in developed areas in order to avoid unintended fire damage to peripheral structures or property.

The occurrence of Torrey's rush (Juncus torreyi), an S1 State Plant Species of Special Concern (but not federally-listed as endangered or threatened), in a small stand along Rt. 9's roadside presents some concern for its protection when undertaking phragmites control actions. As described in the Restoration Plan's Environmental Assessment, this species has a widespread geographical distribution, extending over most of the eastern United States and Canada and throughout the American Southwest, but is relatively rare wherever it is found. In Delaware to date, Torrey's rush has been located at only two other sites (similar to Army Creek, these other two sites are also thought to be disturbed locations). The roadside stand of Torrey's rush in Lower Army Creek Marsh

could be adversely affected by increased water levels (flooding), mowing, burning, herbicide applications, or combinations of two or more of the above. The proposed action for phragmites control of herbiciding-and-burning could locally eradicate Torrey's rush from Lower Army Creek Marsh. Even though this species' occurrence in Lower Army Creek is probably due to the artificial habitat created by the Rt. 9 elevated roadbed traversing the marsh, and even though its habitat was probably grossly disturbed during the process of raising Rt. 9's road surface (done recently on the southside of Rt. 9's bridge), care should still be taken where practicable to try to ensure perpetuation of Torrey's rush during and following phragmites treatment. The portion of the roadbed where the rush is growing could be excluded from both herbicide spraying and burning, particularly since the phragmites cover is not overwhelmingly dominant at the rush's location. However, in conducting the widespread herbicide-and-burn treatments necessary to control the phragmites problem in Lower Army Creek, it may not be possible or practicable to purposely exclude the Torrey's rush site from treatment, or to avoid inadvertently treating the area. If this be the case, then consideration will be given to transplanting as much of the stand as possible to a nearby site not subject to herbiciding or burning, or to establishing a stand at such a protected site from seed or transplants. In event of eradication of the species at its existing location during phragmites treatment, it may be possible to reestablish it at the site from seeds or specimens collected at the site prior to phragmites treatment, or from seeds or transplants taken from other locations. However, the preferred alternative is to avoid if practicable spraying or burning Torrey's rush when the phragmites control efforts are conducted, as long as the success of the control effort is not seriously compromised.

IV. Other vegetation management practices.

While the focus of the Lower Army Creek Marsh vegetation management plan is on phragmites control, other vegetation management measures will be taken. Much of the remaining vegetation management will be undertaken and achieved in conjunction with the water management plan. Water levels and tidal exchanges will be managed to encourage the establishment and maintenance of a diverse,

brackish-water (oligohaline) tidal wetland community composed of naturally volunteering and occurring vegetation (e.g. submerged aquatic grasses, pondweeds, pickerelweed, arrow-arum, arrowheads, smartweeds, sedges, rushes, millets, cattails, hibiscus, shrubs, etc.). Achieving this goal will depend upon first eradicating the phragmites cover and then managing marsh water levels and tidal exchanges to establish and maintain the desired plant community. Managing for water levels that are higher than present conditions should help to suppress future phragmites recolonization. Additionally, enhanced tidal exchanges and a concomitant slight increase in salinity (from 0-2 ppt at present to 1-4 ppt after tidal restoration) should help to eliminate the potential for a purple loosestrife (Lythrum salicaria) invasion in Army Creek Marsh; purple loosestrife is an undesirable, pestiferous wetland plant that is rapidly colonizing many freshwater wetlands in New Castle County.

If it becomes desirable to increase wetland plant diversity beyond what occurs following the phragmites control effort and initiation of the water management plan, shallow ponds and ditches might be excavated to create the desired aquatic habitats, done to achieve a diverse mosaic of shallow water areas, mudflats, and emergent wetlands envisioned for the restored marsh. These shallow water habitats will also directly benefit aquatic invertebrates and fishes. The excavation of shallow ponds and ditches would most likely be done by the Delaware Mosquito Control Section, who have the excavation machinery to work in wetland areas; using this equipment, the excavated spoil is broadcast as a thin slurry over adjacent marsh surfaces, allowing for quick recovery of temporarily-covered vegetation. The excavation work might also be done in conjunction with reducing mosquito-breeding to acceptable levels, in order to decrease the need to apply chemical insecticides; the excavated shallow ponds and ditches serve as reservoirs for small, mosquito-consuming fishes (e.g. killifishes, mosquitofishes). If this work is to be done primarily for mosquito control purposes, increases in habitat diversity for wetland plants and aquatic organisms will still occur; however, the need for habitat diversity enhancement may or may not be the driving force for undertaking excavation work, depending upon how the marsh responds to phragmites control and initiation of the water management plan. If shallow water habitat and plant diversity are satisfactory, and mosquito-breeding acceptably low, then no excavation work may be necessary.

The estimated cost for creation of shallow ponds and ditches within Lower Army Creek Marsh, whether done to promote wetland plant diversity, fish habitat, mosquito control, or combinations of the three, is about \$15,000. This estimation is based upon what it would cost to install an Open Marsh Water Management (OMWM) system of ponds and ditches in about 25 acres of marsh, and to selectively reclean some canals or ditches for improved water circulation or increased aquatic habitat diversity. Whether this is a cost that the Trustees have to meet cannot yet be determined, but should be determinable within a few years after initiating the restoration work, as an outcome of the proposed monitoring work.

Food plots of wetland plants desirable as waterfowl foods, such as native millets or wild rice, might also be established by seedings or by plantings. The Trustees will set aside \$2000 to examine and perhaps initiate a waterfowl food plot project.

2.1.3 Landowner Cooperation

Cooperation and participation of affected landowners was considered essential to the implementation of this restoration plan. Contacts were made with the Army Creek marsh property owners early in the process because without their participation many of the marsh water and vegetation management efforts cannot be carried out. Potentially affected landowners were contacted by letter and invited to meet with representatives of the trustee group to discuss options for land access/acquisition and to get a preliminary commitment of willingness to participate. Options discussed included conservation easement water management agreement, donation to the State of Delaware, and outright purchase of both wetland areas and adjacent upland buffer zones. Preliminary commitments of cooperation have been received from each of the marsh property owners. After public comment on the restoration plan, agreements will be finalized based on an approach which is negotiated with each landowners.

2.2 UPLAND RESTORATION

2.2.1 BACKGROUND INFORMATION

The Army Creek Natural Resources Trustees (Trustees) selected the acquisition and rehabilitation of approximately 60 acres of upland habitat as appropriate compensation for the loss of similar acreage of upland habitat. To determine potential sites for acquisition and rehabilitation, a list of parcels with undeveloped acreage near Army Creek was prepared (TABLE 2-1). These parcels were subjected to a preliminary review under the "Acquisition Criteria for Site Selection" (See Attachment 1 of Appendix A). This review served to narrow the list of potential sites to 10 parcels. The parcels removed from consideration are reflected in Table 2-2.

Field inspection of the remaining sites were conducted. The parcels were ranked according to the "Acquisition Criteria for Site Selection" based in part upon these field inspections (TABLES 2-3 and 2-4). As parcels were only partly traversed, aerial photography (1992, 1988) was used to support field observations.

Landowner information was compiled from New Castle County tax maps (TRW-Redl Property Data Atlas, 1993). Zoning data was provided by the New Castle County Department of Planning. Soils data was compiled from New Castle County Soils Survey (USDA-Soil Conservation Service, 1970). Wetlands information was taken from the USFWS National Wetlands Inventory (1989).

In the event that conditions change so that it becomes infeasible to obtain any of the candidate upland sites described below, the Trustees shall identify alternative sites for acquisition. Selection of alternative upland sites, which do not affect proposed upland management options or other aspects of restoration, constitute a minor modification requiring no amendment to the overall plan. Additionally, alternative sites will be identified, ranked and selected using the criteria provided in appendix A, table I and II, which are those that were used to select the current candidate sites, to maintain consistency in the selection process.

TABLE 2-1: Potential Upland Acquisition Sites

<i>Tax Map #</i>	<i>Parcel Address</i>	<i>Acreage</i>	<i>Tax Map #</i>	<i>Parcel Address</i>	<i>Acreage</i>
10-023.00-010	Airport Rd.	91.36	10-036.00-008	Carroll Dr.	2.96
10-024.00-025	Christiana Rd.	58.45	10-040.00-022	S. DuPont Pkwy.	131.24
10-024.00-081	Churchmans Rd.	91.68	10-040.00-028	Federal La.	79.73
10-028.00-036	School Bell Rd.	74.00	10-041.00-001	River Rd.	75.70
10-030.00-076	River Rd.	2.27	10-041.00-002	River Rd.	25.45
10-031.00-003	River Rd.	165.16	10-041.00-004	River Rd.	69.81
10-034.00-067	Old State Rd.	11.65	10-045.00-007	Federal La.	316.61
10-034.00-069	Old State Rd.	13.00	10-045.00-011	River Rd.	42.99
10-034.00-070	S. DuPont Pkwy.	111.12	10-049.00-007	Bear Corbitt Rd.	1.30
10-034.00-077	S. DuPont Pkwy.	6.15	10-049.00-073	River Rd.	314.73
10-035.00-005	Grantham La.	29.56	10-050.00-006	River Rd.	86.36
10-035.00-006	Grantham La.	28.19	10-050.00-007	River Rd.	16.39
10-035.00-035	River Rd.	19.45	10-050.00-008	River Rd.	231.98
10-035.00-039	River Rd.	28.40	10-050.00-009	River Rd.	55.54
10-035.00-060	Grantham La.	11.82	10-050.00-011	River Rd.	42.20
10-035.00-061	Grantham La.	8.00	10-050.00-012	River Rd.	30.80
10-036.00-001	River Rd.	3.17	10-054.00-001	County Rd. 389	294.01
10-036.00-006	River Rd.	6.66	21-016.00-002	West 7th St.	5.29

TABLE 2-2: Upland Sites Eliminated from Consideration

Tax Map #	Reason for Elimination
10-023.00-010	Barriers to movement of species sources (Routes 13 & 273)
10-024.00-025	Barriers to movement of species sources (Routes 13 & 273)
10-024.00-081	Barriers to movement of species sources (Routes 13 & 273)
10-028.00-036	Barriers to movement of species sources (Routes 13 & rail line)
10-030.00-076	Condition of site (hazardous waste--asbestos--on site)
10-035.00-006	Condition of site (landfill)
10-035.00-039	Barriers to movement of species sources (Route 9)
10-035.00-060	Condition of site (industrial park)
10-035.00-061	Condition of site (industrial park)
10-036.00-001	Condition of site (industrial park)
10-036.00-006	Condition of site (industrial park)
10-036.00-008	Condition of site (industrial park)
10-040.00-022	Condition of site (recorded subdivision--Buena Vista Park)
10-041.00-001	Condition of site (recorded subdivision--Beaver Brook)
10-041.00-002	Condition of site (quarry)
10-041.00-004	Condition of site (recorded subdivision--River Edge Estate)
10-045.00-011	Parcel acquired by other governmental agency
10-049.00-007	Size (parcel is 1.30 acres +/-)
10-049.00-073	Distance to Army Creek (@ 2.5 miles +/-)
10-050.00-006	Condition of site (recorded subdivision--Stockton Dev. Co.)
10-050.00-007	Distance to Army Creek (@ 2.5 miles +/-); Size (parcel is 1.30 acres +/-)
10-050.00-008	Barriers to movement of species sources (Route 9) Distance to Army Creek (@ 2.5 miles +/-)
10-050.00-009	Barriers to movement of species sources (Route 9) Distance to Army Creek (@ 2.5 miles +/-)
10-050.00-011	Barriers to movement of species sources (Route 9) Distance to Army Creek (@ 2.5 miles +/-)
10-050.00-012	Barriers to movement of species sources (Route 9) Distance to Army Creek (@ 2.5 miles +/-)
10-054.00-001	Barriers to movement of species sources (Route 9) Distance to Army Creek (@ 2.5 miles +/-)

TABLE 2-3: Upland Sites within the Army Creek Watershed

Acquisition Criteria										
TAX MAP #	1. Distance - Species Sources	2. Disturbance	3. Size/ Shape	4. Proximity - Army Creek	5. Wetlands	6. Condition of Site	7. Side Effects	8. Endangered Species	9. Management	TOTAL
10-031.00-003	1	0	2	4	1	1	1	2	0	12
10-034.00-067	1	0	0	3	0	2	2	1	2	11
10-034.00-069	1	0	0	4	1	1	1	1	1	10
10-034.00-070	1	0	4	4	0	2	2	2	2	17
10-034.00-077	1	1	0	4	1	2	2	1	2	14
10-035.00-005	1	0	2	2	0	2	2	1	2	12

TABLE 2-4: Other Candidate Sites in the Vicinity of the Army Creek Watershed

Acquisition Criteria										
TAX MAP #	1. Distance - Species Sources	2. Disturbance	3. Size/ Shape	4. Proximity - Army Creek	5. Wetlands	6. Condition of Site	7. Side Effects	8. Endangered Species	9. Management	TOTAL
10-035.00-035	2	0	1	0	0	2	2	1	2	10
10-040.00-028	1	0	3	0	0	2	2	2	2	12
10-045.00-007	2	2	4	0	1	0	0	2	0	11
21-016.00-003	1	0	0	2	0	0	1	0	0	4

2.2.2 Candidate Upland Sites

Descriptions for these sites still under consideration are presented below. The parcels are listed in alphabetical order by Property Code. Property code refers to the alphabetical code, or letter, assigned to each parcel for map identification purposes on Map 2-1. This local area map, prepared by DNREC, Geographic Information System Section, was also used to supplement field observations. This map was prepared primarily for internal DNREC resource management purposes. The information is preliminary and subject to change or modification at any time. Use of this information by others is at their own risk and DNREC in no way guarantees the accuracy of the information. For ownership, soils and wetlands data, see TABLES 2-5 and 2-6.

Property Code A

Tax Map Number 10-030.00-046

Site Description This 35.98 acre parcel, is located in the Lower Army Creek marsh. Approximately 87 percent of this parcel is marsh, with a very small percentage in upland forest.

Site Problems This site exhibits signs of disturbance.

Acquisition Options/

Acquisition Methods The Bank of Delaware on behalf of their client has indicated that a fee simple acquisition at their latest appraisal would be acceptable.

Property Code B

Tax Map Number 10-031.00-003

Site Description This 165.16 acre parcel, zoned M-2 for light manufacturing, is located in the Lower Army Creek marsh. Approximately 67 acres of this parcel are upland. The upland areas are comprised primarily of meadow

habitat. Woodlands are present on the property as isolated stands or bordering the meadow areas.

Site Problems This parcel shows signs of significant human disturbance including arson, illegal hunting, and dumping of trash. The level of disturbance observed would seem to indicate that active management of the parcel would be required.

Acquisition Options/

Acquisition Methods The landowner has indicated that fee simple acquisition at full fair market value is the only option that will be considered.

Property Code C

Tax Map Number 10-034.00-067

Site Description This 11.65 parcel, zoned R-1-C, R-1-B for single-family residential use-clustered, is former farm with old fence rows and some outbuildings still evident. The undeveloped areas are comprised of old fields and woodlands.

Problems This site is located within a designated growth area in New Castle County's Five-Year Growth Plan. As this parcel is developed with a single family dwelling, less than 10 acres would be available for upland restoration.

Acquisition Options/

Acquisition Methods The landowners have indicated that they would be willing to discuss granting a limited interest, such as a conservation easement, on the undeveloped portions of the parcel.

Property Code D

Tax Map Number 10-034.00-069

Site Description This 13 acre parcel, zoned R-1-C, R-1-B for single-family residential use-clustered, is located along the upper reaches of Army Creek. The site is a mix of riparian wetlands and upland habitat. The upland appears equally divided between meadow and wooded areas.

Problems This site is located within a designated growth area in New Castle County's Five-Year Growth Plan. This parcel has been subject to dumping. Some material has been brought in as fill. The quality of the fill is difficult to discern. There has also been significant dumping of trash on site.

Acquisition Options/

Acquisition Methods No acquisition options or methods have been discussed.

Property Code E

Tax Map Number 10-034.00-070

Site Description This 111.12 acre parcel, zoned R-1-C for single-family residential use-clustered, is located along the upper reaches of Army Creek. The site is an active farm with approximately 50 acres currently being tilled. The remaining portion of the property is wooded.

Problems This site is located within a designated growth area in New Castle County's Five-Year Growth Plan. The site is adjacent to a subdivision including single family homes and town homes. The residents of the subdivision currently utilize the wooded portion of the site for passive recreation.

Acquisition Options/

Acquisition Methods This parcel is administered by a trustee who has indicated that his responsibility to the trust require that he consider only fee simple acquisition at full fair market value.

Property Code F

Tax Map Number 10-034.00-077

Site Description This 6.15 acre parcel, zoned C-2 for commercial use, is located along Army Creek in the vicinity of the Army Creek Landfill. The site contains wooded steep slopes, riparian wetlands and floodplain.

Problems No significant problems were observed during the field inspection.

Acquisition Options/

Acquisition Methods A bargain sale or donation of real property interest may be a possibility with this parcel because the natural features limit potential uses.

Property Code G

Tax Map Number 10-035.00-005

Site Description This 29.56 acre parcel, zoned M-1 for light manufacturing, is within or adjacent to the Army Creek watershed. The site is entirely wooded with a dense shrub layer.

Problems This site is located within a designated growth area in New Castle County's Five-Year Growth Plan.

Acquisition Options/

Acquisition Methods No acquisition options or methods have been discussed.

Property Code H

Tax Map Number 10-035.00-035

Site Description This 19.45 acre parcel, zoned R-1-B for single-family residential use-clustered, is not located within the Army Creek watershed. The site is entirely wooded with a dense canopy and open understory.

Problems This site is adjacent to a subdivision of single family homes, however, there was no sign of encroachment on the site.

**Acquisition Options/
Acquisition Methods** No acquisition options or methods have been discussed.

Property Code I

Tax Map Number 10-036.00-003

Site Description This 64 acre parcel, 46 acres tidal and 28 acres upland, is in the Lower Army Creek watershed. The site has some industrial development.

Problems None known at this time.

**Acquisition Options/
Acquisition Methods** No acquisition options or methods have been discussed.

Property Code K

Tax Map Number 10-036.00-007

Site Description This 72.88 acre parcel, 61 percent tidal and 39 percent upland is in the Lower Army Creek Marsh. Part of the parcel in residential development.

Problems None known at this time.

**Acquisition Options/
Acquisition Methods** No acquisitions options or methods have been discussed.

Property Code L

Tax Map Number 10-040.00-028

Site Description This 79.73 acre parcel, zoned R-2 for residential use, is not located within the Army Creek watershed. The site,

formerly farm fields, is now entirely wooded with a dense shrub layer.

Problems No significant problems were observed during the field inspection.

Acquisition Options/

Acquisition Methods The landowner has indicated that fee simple acquisition at full fair market value is the only option that will be considered.

Property Code M

Tax Map Number 10-045.00-007

Site Description This 319.31 acre parcel, zoned PEUD for Planned Extractive Use District, is an active gravel quarry. The site, though not located within the Army Creek watershed, does include riparian wetlands. Wooded areas are limited to riparian habitat.

Problems This site is an active quarry. As a result, the cost of rehabilitation and restoration may be prohibitive. The site has been extensively altered and, prior to any restoration, a wetlands delineation would be required to determine upland areas suitable for restoration or rehabilitation.

Acquisition Options/

Acquisition Methods No acquisition options or methods have been discussed.

Property Code N

Tax Map Number 21-016.00-002

Site Description This 5.29 acre parcel, zoned OS+R for open space and recreation, is located on the Delaware River. The site includes meadow and woodlands.

Problems This site includes beach front along the Delaware River. This attraction has resulted in a high degree of human disturbance (dumping of trash) on site. In addition, adjacent lands have a developed trail system which encourages use of this parcel. The level of disturbance would seem to indicate that active management of the parcel would be required.

Acquisition Options/
Acquisition Methods The landowner has indicated that fee simple acquisition at full fair market value is the only option that will be considered.

2.2.3 ACQUISITION OPTIONS

Options for acquisition of a real property interest in land available to the Trustees could include a habitat restoration agreement, acquisition of an easement, or fee-simple acquisition.

Habitat Restoration Agreement

An agreement would bind consenting parties with respect to their rights and duties involved in habitat restoration. Currently, the United States Fish and Wildlife Service (USFWS) uses such an agreement in its Partners for Wildlife program that seeks to restore fish and wildlife habitat (Appendix A). Though this agreement, the landowner grants the USFWS right of entry at reasonable times for the purposes of habitat restoration. Such an agreement may be modified at any time and is terminated at a specified time. The Partners for Wildlife agreement includes a five-year grace period during which the landowner may convert restored wetland habitat to its pre-restoration condition, as allowed by the U.S. Corps of Engineers under section 404 of the Clean Water Act. A habitat restoration agreement does not involve the transfer of any real property interest.

Acquisition of an Easement

An easement is a limited right of use associated with the land. An example of such a limited right would be an easement of access or right-of-way. When a landowner transfers a right-of-way to another, he has

given away a right associated with his land. The holder of the easement of access holds the right to cross the lands of the grantor of the easement. An easement is a real property interest.

A conservation easement is another example of limited right of use associated with land. An easement of access provides a right-of-way to the holder of the easement, whereas a conservation easement transfers the right to protect important conservation values of the property to the holder of the easement. In Delaware, conservation easements are deemed valuable interests in real property and may be acquired by any governmental body or charitable corporation or trust which has the power to acquire interests in land. However, no conservation easement shall be acquired or held until accepted by the secretary or director of the agency or department receiving the easement or having jurisdiction over the subject matter of the easement (7 Del. C. Chapter 69).

An easement may be given for a limited period of time or in perpetuity. A temporary construction easement is an example of a limited right granted for a limited period of time. In Delaware, conservation easements must be granted in perpetuity.

Fee-Simple Acquisition

Holding title to land can be viewed as holding a bundle of rights. This bundle of rights includes, but is not limited to, mineral rights, water rights, and development rights. Ownership of the entire bundle of rights is termed ownership in fee. A fee-simple acquisition consists of acquisition of the entire bundle of rights associated with a parcel of land.

2.2.4 ACQUISITION METHODS

Real property shall be appraised before the initiation of negotiations toward acquisition of any interest. The Trustees will consider purchase of full fair market value, bargain sale, and donation.

Fair Market Value

Fee-simple interest in land can be purchased at full fair market value as determined by a qualified appraiser. Such a sale may involve transfer of all property interest at one time. A landowner may also choose to sell a portion of land with an option to sell the remainder in successive years. A limited right in property, such as a conservation

easement, may also be purchased after its value has been determined by a qualified appraiser.

Not less than one appraisal report shall be furnished for the proposed acquisition. This appraisal must be in complete accordance with the Uniform Appraisal Standards for Federal Land Acquisitions. The appraised value of the parcel will serve as the basis for negotiations toward purchase.

Bargain Sale

A bargain sale involves the sale of land for less than full fair market value. The difference between the fair market appraised value of the parcel and the purchase price is considered a donation. A bargain sale to a qualified conservation organization can result in tax-benefits for the seller.

Donation

Interest in land can be donated. In an outright donation, the landowner transfers full title and ownership. A donor may choose not to transfer full title to land, but reserve rights, such as hunting or fishing rights, for himself. Conservation easements can be also donated. The donation of either fee-simple title or conservation easements can result in tax-benefits for the donor.

TABLE 2-5: Upland Sites Within Army Creek Watershed

Property Description

PROPERTY CODE	TAX MAP #	OWNERSHIP	ACREAGE	LAND USE CODE	NWI	SOILS	CURRENT USE
B	10-031.00-003	SCC Operations 6064 Ridge Ave. Philadelphia, PA 19128	165.16	Vacant	X	Tm, MeB2, MeC2	marsh, some upland areas, scattered forest
C	10-034.00-067	Hamilton, Forest J. 200 Caravel Dr. Bear, DE 19701	11.65	Vacant	X	MeB2, Ot	some forested areas, some development
D	10-034.00-069	Wilson, Jerry R. 1818 Porter Rd. Bear, DE 19701	13	Vacant	X	MeB2, Ot	forested
E	10-034.00-070	Brennan, Al E., Trustee c/o Brennan & Co. 1028 Weldin Cir. Wilmington, DE 19803	111.12	Farm	X	MeB2, Ot, WsA	50% forested area, 50% farmland
F	10-034.00-077	Szczepanski, Lucian K. 370 Pear St. Dover, DE 19901	6.15	Vacant	X	Jo, Gp, MeB2	forested, possibly development adjacent to Rt. 13
G	10-035.00-005	Petrillo Brothers, Inc. PO Box 628 New Castle, DE 19720	29.56	Vacant		MeB2, WsA, Ot	forested

• Based on examination of air photos, 01-08-92

TABLE 2-6: Other Candidate Sites in the Vicinity of the Army Creek Watershed

Property Description

PROPERTY CODE	TAX MAP #	OWNERSHIP	ACREAGE	LAND USE CODE	NWI	SOILS	CURRENT USE
H	10-035.00-35	Parkway Gravel, Inc 4048 New Castle Ave. New Castle, DE 19720	19.45	Vacant		Os, MeB2, MsB, WsA	forested
L	10-040.00-028	Beyer, Malcolm Jr. 138 Beacon La. Jupiter, FL 33469	79.73	Forest/ Woodland		MeA, MeB2, KeA, KeB2, SaB2, SaC3	farmlands
M	10-045.00-007	Parkway Gravel, Inc 4048 New Castle Ave. New Castle, DE 19720	319.31	Vacant		EmB, Fs, KeA, KeB2, MeA, MeB2, MeC2, MeC3, MeD2, SaB2, SaC3, SaD3, SmE, Tm, WsA	some farmlands, gravel pits and quarries, and some reclaimed lands
N	21-016.00-002	SCC Operations P.O. Box 360 Essington, PA 19029	5.29	Vacant	X	Os, Ou	marsh, some forested areas

• Based on examination of air photos, 01-08-92

Table 2-7: Lower Army Creek Marsh

Property Description

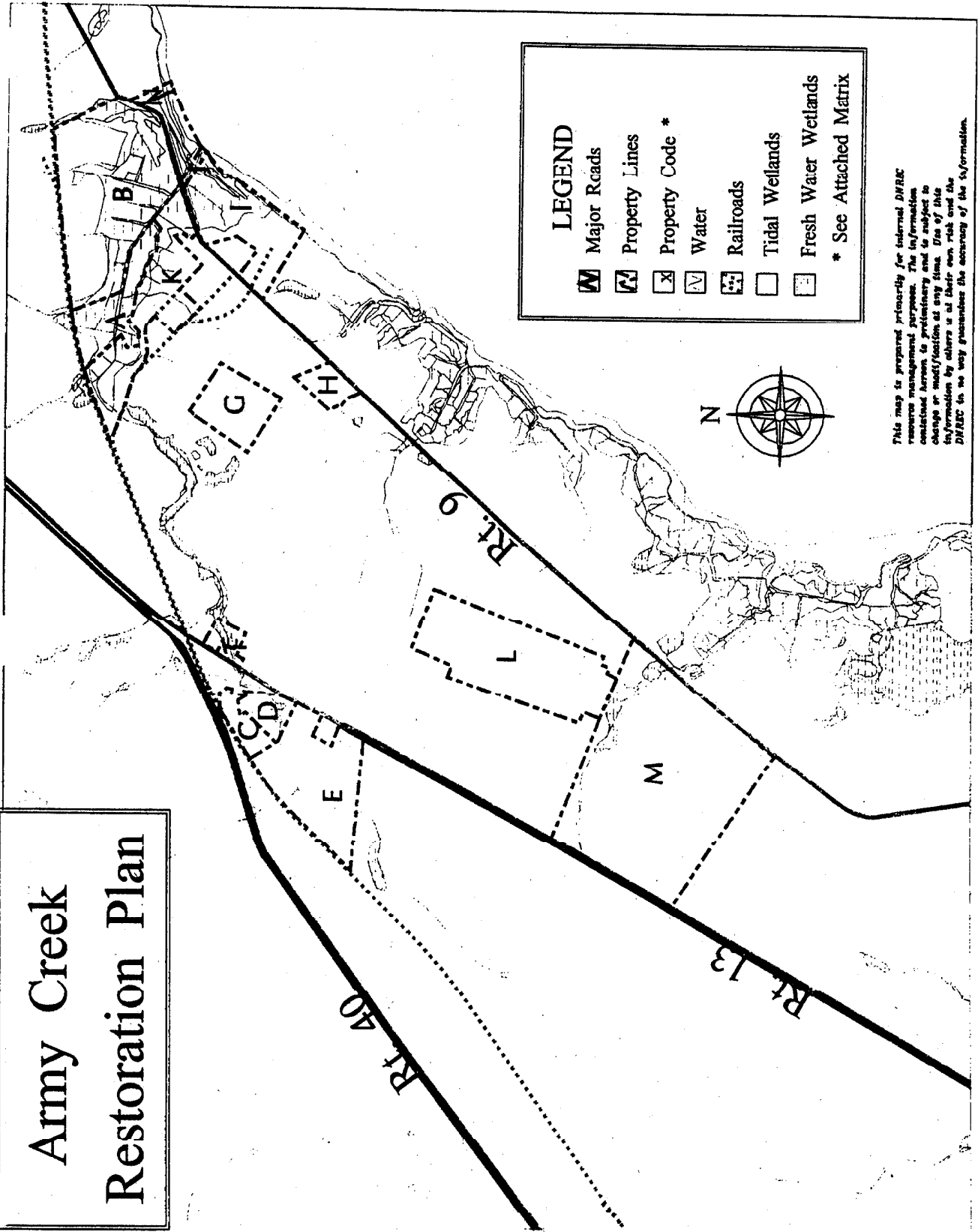
TAX MAP #	OWNERSHIP	ACREAGE	LAND USE CODE	SOILS	CURRENT USE
10-030.00-046	Bank of Delaware, Trustees 300 Delaware Ave. Wilmington, DE 19803	35.98	Vacant	Tm, McB2, McC2	marsh, small area of forested upland
10-031.00-003	SCC Operations 6064 Ridge Ave. Philadelphia, PA 19128	165.16	Vacant	Tm, McB2, McC2	marsh, some upland areas, scattered forest
10-036.00-003	James River 2, Inc. PO Box 110 New Castle, DE 19720	64.68	Vacant	Am, MsB	some marshlands, some industrial development
10-036.00-004	Dureco Chemicals, Inc. 950 River Rd. New Castle, DE 19720	1.69	Residential-Platted	Tm	marsh
10-036.00-007	Dureco Chemicals, Inc. 950 River Rd. New Castle, DE 19720	72.88	Residential-Platted	Am, Tm, McB2, McC2	some scattered forests, some industrial development

- From Soil Survey, New Castle County
- Based on examination of air photos, 01-08-92









TABLE 2-8 RECOMMENDED SITES

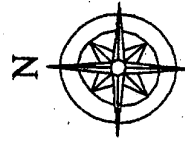
<p><i>Property Code A</i> <i>Tax Map Number 10-030.00-046</i> <i>35.98 Acres</i></p> <p><i>Bank of Delaware</i> <i>300 Delaware Avenue</i> <i>Wilmington, Delaware 19803</i></p> <p><i>Land Use:</i> <i>Vacant</i> <i>Current Use:</i> <i>Marsh, Small upland forest</i> <i>Meets Project Needs:</i> <i>Wetlands and upland</i></p>	<p><i>Property Code I</i> <i>Tax Map Number 10-036.00-003</i> <i>64.68 Acres</i></p> <p><i>James River 2, Inc.</i> <i>P.O. Box 110</i> <i>New Castle, Delaware 19720</i></p> <p><i>Land Use:</i> <i>Vacant</i> <i>Current Use:</i> <i>Marsh, Some Industrial development</i> <i>Meets Project Needs:</i> <i>Wetlands</i></p>
<p><i>Property Code B</i> <i>Tax Map Number 10-031.00-003</i> <i>165.16 Acres</i></p> <p><i>SCC Operations</i> <i>6064 Ridge Avenue</i> <i>Philadelphia, Pennsylvania 19128</i></p> <p><i>Land Use:</i> <i>Vacant</i> <i>Current Use:</i> <i>Marsh, Some upland scattered forest</i> <i>Project Needs:</i> <i>Rewatering, wetlands and uplands</i></p>	<p><i>Property Code K</i> <i>Tax Map Number 10-036.00-007</i> <i>72.88 Acres</i></p> <p><i>Dureco Chemicals, Inc.</i> <i>950 River Road</i> <i>New Castle, Delaware 19720</i></p> <p><i>Land Use:</i> <i>Residential plotted</i> <i>Current Use:</i> <i>Marsh</i> <i>Meets Project Needs:</i> <i>Wetlands</i></p>

Army Creek Restoration Plan

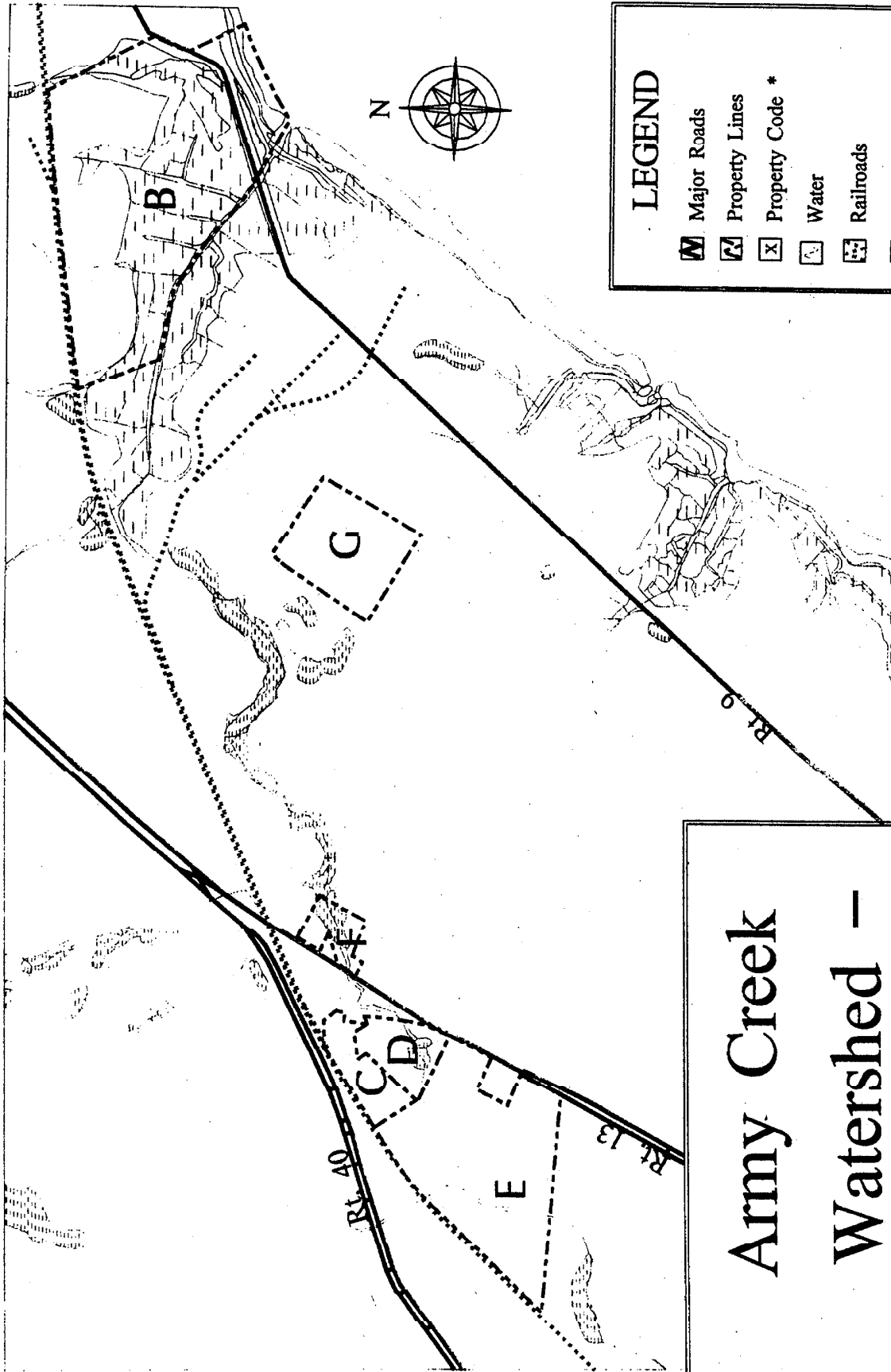


LEGEND

-  Major Roads
-  Property Lines
-  Property Code *
-  Water
-  Railroads
-  Tidal Wetlands
-  Fresh Water Wetlands
-  * See Attached Matrix



This map is prepared primarily for internal DMRC resource management purposes. The information contained herein is preliminary and is subject to change or modification at any time. Use of this information by others is at their own risk and the DMRC in no way guarantees the accuracy of the information.



LEGEND

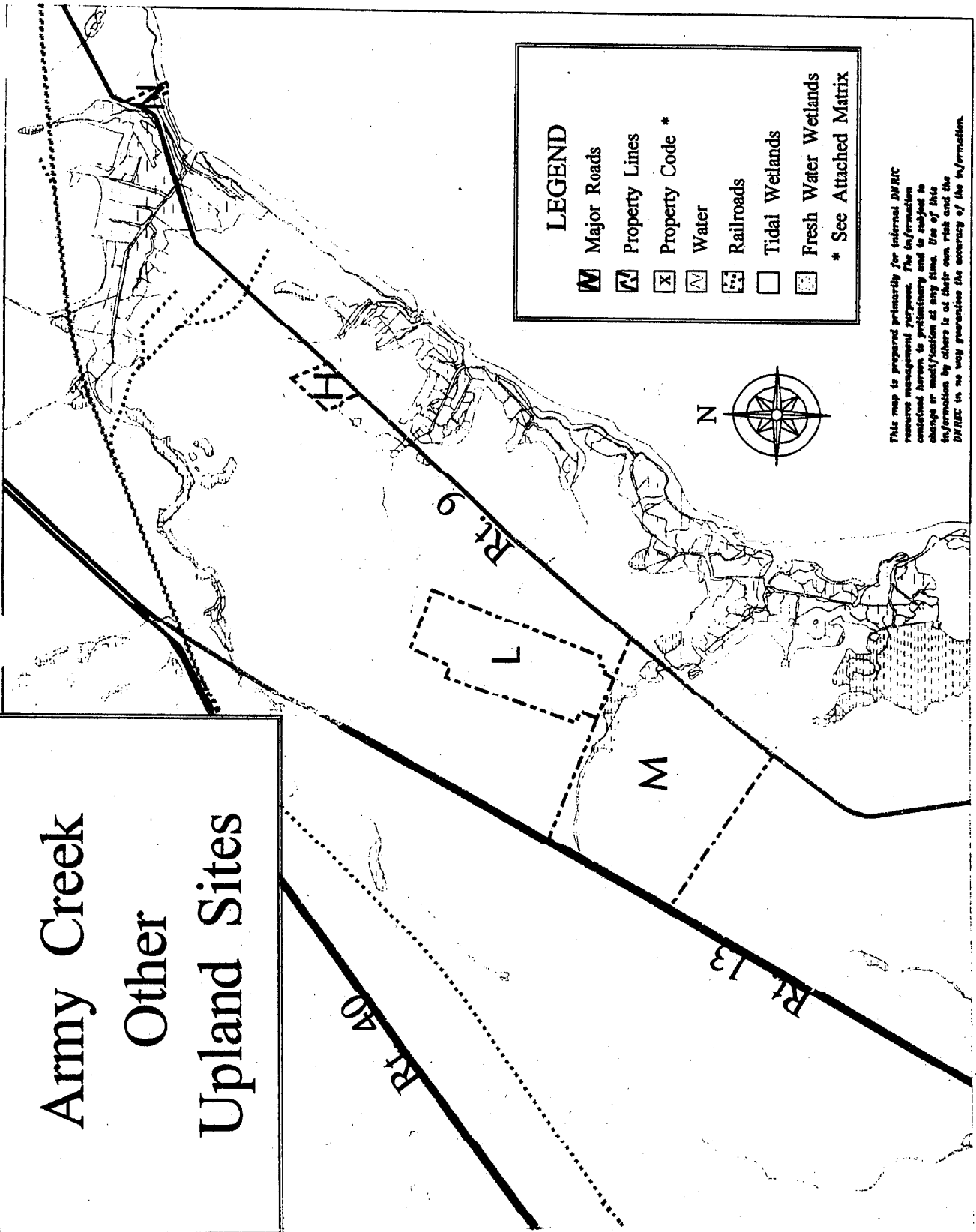
- Major Roads
- Property Lines
- Property Code *
- Water
- Railroads
- Tidal Wetlands
- Fresh Water Wetlands

* See Attached Matrix

This map is prepared primarily for internal DMREC resource management purposes. The information contained herein is preliminary and is subject to change or modification at any time. Use of this information by others is at their own risk and the DMREC is no way guarantee the accuracy of the information.

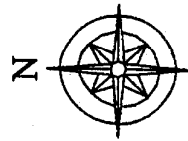
**Army Creek
Watershed -
Upland Sites**

Army Creek Other Upland Sites



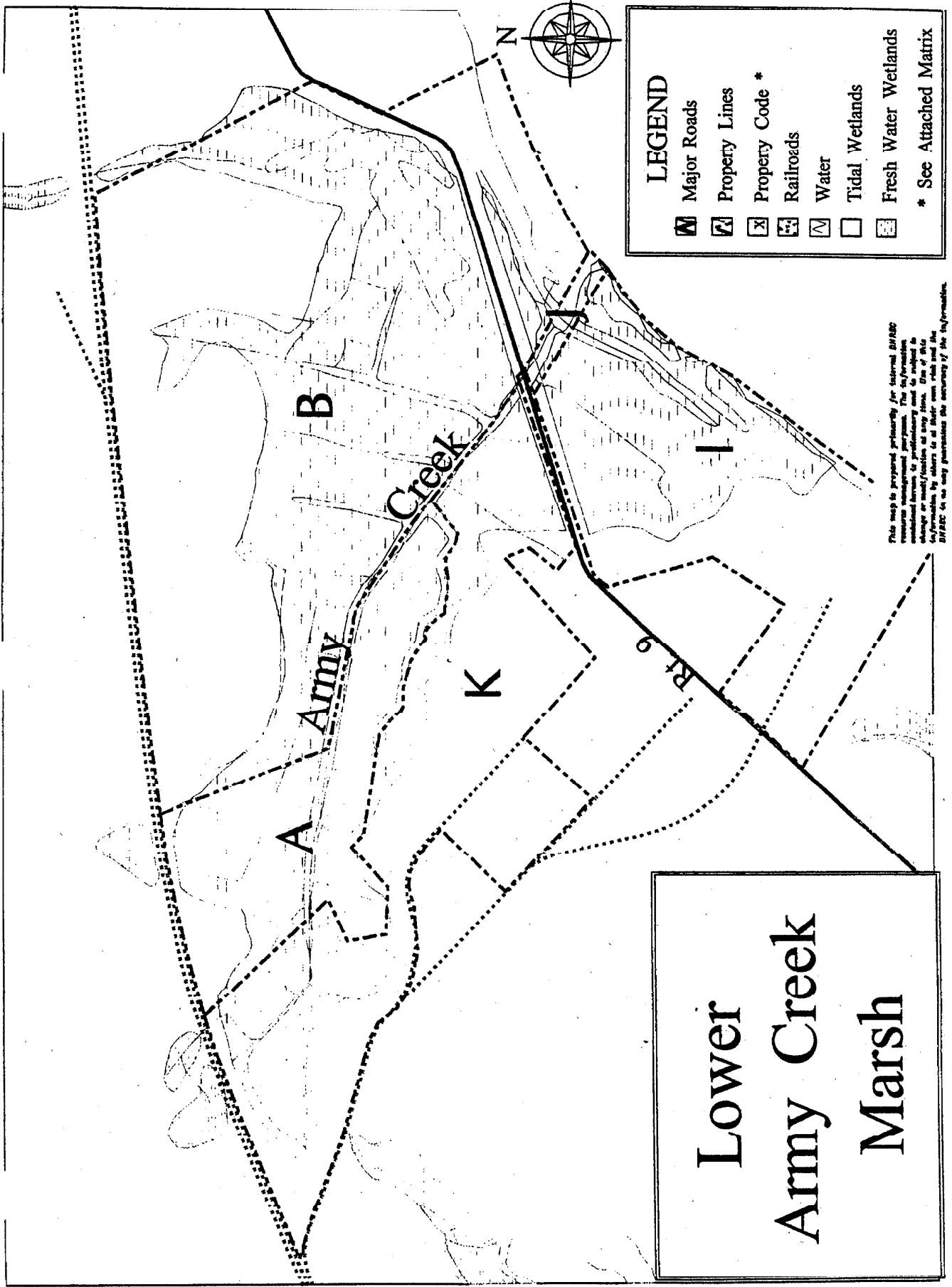
LEGEND

- Major Roads
- Property Lines
- Property Code *
- Water
- Railroads
- Tidal Wetlands
- Fresh Water Wetlands
- * See Attached Matrix



This map is prepared primarily for internal DNR resource management purposes. The information contained herein is preliminary and is subject to change or modification at any time. Use of this information by others is at their own risk and the DNR is not responsible for the accuracy of the information.

Enlargement of Map 2-1



3.0 ENVIRONMENTAL MONITORING PLANS

3.1 Army Creek Wetlands

A requisite to any restoration program is a well designed and cost-effective monitoring effort. Such an effort forms the foundation of and a prerequisite of restoration plans because it is the sole means of providing a measure of the viability, stability and persistence of the restoration and, therefore, an assessment of the effective use of public and private funds that have been allocated for the project.

The goals and benefits of the Army Creek restoration program are to increase acreage of suitable natural resources habitat, improve habitat quality, increase species diversity of fishes, waterfowl and invertebrates and, secondarily, reduce the use of chemical insecticides required to minimize mosquito populations in the vicinity of Army Creek. A monitoring plan that is designed with these in mind not only will provide an assessment of the success of the restoration but also will provide the necessary information to establish criteria for and evaluate need for mid-course corrections, should they be necessary. In fact, there is no other procedure that will provide Trustees and the public with the basis to make rational decisions to modify initial approaches to satisfying the established goals.

The most cost-effective restoration plan for Army Creek wetlands includes not only evaluating the success of the restoration effort but also establishing a baseline of scientific information upon which to make the necessary comparisons and determinations of mid-course correction needs and restoration success. By necessity, the monitoring plan does not include all aspects of the functional value of wetland and aquatic habitats because of financial constraints. The plan does, however, include those environmental and ecological factors deemed most measurable within the project framework and goals. Pre-construction and post-construction assessment of the development of the wetland plant communities which evolve using both aerial photography and ground truth assessments; evaluation of the fishery and waterfowl communities that use the restored habitats; and comparisons of these data at Army Creek and Gambacorta and Broad Dyke Marshes to determine the degree of

convergence by Lower Army Creek, will provide the foundation of the requisite monitoring plan. We have sacrificed evaluation of sediment developmental aspects, e.g., changes in particle size and organic content, and the macrobenthic invertebrate community (both of which were in the original monitoring plan design), as part of the plan. While we recognize that the plan establishes a limited monitoring effort, it none-the-less incorporates those physical and biological components that integrate a number of non-measured environmental parameters, and those system components that are of utmost concern to the Trustees.

Details of the expected benefits, measures of success, specific monitoring procedures, schedules and estimated costs are provided in Appendix E.

3.2 Army Creek Uplands

Plans for monitoring restoration of uplands are, out of necessity, at an early stage of development because upland site selection procedures will not commence until the restoration plan is finalized. At that time, procedures will be implemented to identify an upland site and, after choosing a location, trustees will develop a monitoring plan to document habitat changes resulting from active restoration. After trustees establish an interest in the site, the ecological characteristics of the site will be determined. Restoration opportunities which are cost effective and within the scope of the monitoring effort will be identified. Components of the uplands which most closely replace service losses from capping the landfill area of the Army Creek Superfund site have highest priority for restoration.

The upland monitoring plan will describe restoration objectives applicable to important or desirable habitat categories that are present at the site, and ecological factors that objectively measure changing condition of the site. Trustees plan to develop services that increase nesting, feeding, and resting habitat for neotropical migratory birds. Also, functions of the upland site will be restored to improve quality of runoff and improve the ability of this upland habitat to buffer stream and wetland habitats adjacent to the site. Trustees will select and implement appropriate measures in the plan which monitor improvements in

habitat and which document increases in services in the categories identified in the objectives.

4.0 OPERATIONS AND MAINTENANCE PLANS

4.1 LOWER ARMY CREEK WETLANDS

Implementation activities and long-term management needs associated with the restoration of the Lower Army Creek Wetlands will be funded, operated, maintained, and managed by a combination of agencies including: the Army Creek Natural Resources Trustees (Trustees), the Delaware Division of Fish and Wildlife (Division), the Delaware Department of Transportation (DelDOT), and the New Castle Conservation District (NCCD). An operation, maintenance, and management plan(s) identifying these responsibilities will be signed among the participating agencies prior to construction of the proposed water control structure and implementation of the water and vegetation management plans.

An agreement outlining the agency responsibilities associated with the proposed retrofitting of the water control structure at Army Creek Marsh have been identified in Appendix F. This agreement identifies funding, construction, maintenance, and operation responsibilities associated with the structure. As outlined, the Trustees will provide all funding for the construction of the proposed structure in an amount not expected to exceed \$150,000. The Division shall operate the proposed structure by implementing the proposed water management schedule outlined in Appendix C. This management plan is subject to modifications dependent upon: a) ecological responses of the marsh system following implementation of the initial water management schedule; b) availability of additional biological, hydrological, and topographical information; c) engineering factors or constraints; d) climatic conditions; e) commitment limitations for operation and maintenance; f) economic costs; g) landowner cooperation, and h) better achieving all anticipated benefits and regional objectives of the proposed project.

The Division shall implement the proposed vegetation management plan for the Lower Army Creek Wetlands, outlined in Appendix D. The Trustees will provide financial assistance for phragmites control in the amount of \$30,000. The Division may be able to recover a portion of this funding through the Division's 50:50 cost-sharing phragmites spraying program. Through this two-year program, landowners are eligible to have between 5 and 200 acres of phragmites treated with herbicide at a 50:50 cost-share with the Division. The Trustees will also provide an additional \$2,000 in funding for the installation

of wildlife enhancement structures and the establishment of beneficial plant species, such as native millet or wild rice, for waterfowl and other wildlife.

The Division shall implement and fund, as mandated by State statute, all mosquito control practices utilizing insecticide treatments within the lower Army Creek Wetlands. If biological control of mosquitoes utilizing water management and predacious fishes is desired, the Division will request funding assistance from the Trustees. This assistance, estimated to be approximately \$15,000, will provide the funding required to selectively excavate the shallow ponds and ditches needed to provide refuges for predacious fish species and improve their access to isolated mosquito-breeding sites, respectively.

In order to address the impact of non-point source (NPS) pollution on the water quality of the Lower Army Creek Wetlands, the Trustees will contract with the NCCD (for approximately \$10,000) to preform a NPS pollution assessment of the Army Creek watershed. This assessment should identify the most serious NPS pollution issues within the basin, and recommend site-specific actions needed to reduce or eliminate these problems. The Trustees will not spend Natural Resources Damages monies to remediate these NPS pollution problems, but will use the NCCD's study results to encourage clean-up via the appropriate state and county agencies responsible for NPS reduction.

Policies addressing public access, permissible public uses, vandalism, and trash removal will be developed for all publicly-acquired lands within the Lower Army Creek Wetlands. These policies will be developed by the Trustees and the agency(ies) responsible for land management. However, all property rights, privileges, and responsibilities of privately-owned lands will not be changed unless identified as a condition of an easement or sale agreement.

4.2 UPLAND SITES

Activities and long-term management needs associated with the management and restoration of publicly-acquired upland areas will be funded, operated, maintained, and managed by a combination of agencies. An operation, maintenance, and management plan(s) identifying these responsibilities will be signed among the participating agencies prior to acquisition and implementation of restoration plans. Policies addressing public access,

permissible public uses, habitat management, vandalism, and trash removal will be developed for all publicly-acquired upland areas. These policies will be developed by the Trustees and the agency(ies) responsible for land management.

5.0 BUDGET SUMMARY (damages allocations)

The Natural Resources Damages Assessment for Army Creek Marsh was for \$800,000, per settlement agreement with the Primary Responsible Parties (PRP's). \$200,000 of this amount was used by the DNREC to undertake restoration activities as partial compensation for losses or injuries to groundwater resources. The remaining \$600,000 is to be spent by the NRD Trustees for restoration activities to compensate for losses or injuries to surface natural resources, with an emphasis on injuries to fish and wildlife populations or their habitats.

The following breakdown of NRD fund expenditures is a preliminary proposed allocation, subject to revision as new information or conditions warrant, or as other supplemental monies might become available, with any changes to be made by consensus of the Trustees adhering as closely as possible to the goal of the restoration plan. For example, we do not know yet what wetlands, if any, we might have to acquire to enable the wetlands restoration to work to proceed. We will not know which potential upland acquisition site(s) we will purchase until we initiate land purchase negotiations. Land acquisition cost estimates may be affected by matching funding partnerships, thereby, lowering the Trustees' costs to acquire the compensatory lands. We will not be able to estimate precisely the costs of the new water control structure until the results of the hydrological engineering studies are available. These studies also will enable us to more effectively estimate the long-term operations and maintenance (O & M) costs for the water control structure. Finally, since the O & M costs for management of acquired wetlands or uplands properties will be site-specific, refinement of those costs will not be possible until after acquisition.

Note that the Trustees took NO administrative costs from the \$600,000 in NRD's, even though the Trustee agencies incurred considerable expenses (especially in personnel time) in developing this Restoration Plan.

1) Wetlands Restoration = \$222,000-\$227,000+

Water Management = \$195,000+

- a) Hydrological modelling, engineering design = \$30,000
- b) Structure's cost and installation = \$150,000+ (?)
- c) Selected ponding/ditching (if needed) = \$15,000
- d) Rt. 9 roadbed raising = \$0 (DELDOT)

Vegetation Management = \$27,000-\$32,000

- a) Intensive 2-3 year phragmites treatment = \$20,000-\$25,000
- b) Long-term phragmites spot treatment = \$5000
- c) Waterfowl food plots (plantings) = \$2000

2) Uplands Restoration = \$70,500-\$289,000+

- a) Property purchase costs = \$60,000-\$275,000
- b) Appraisals, environmental audits = \$5500-\$7500
- c) Surveys, title exams = \$5000-\$5500
- d) Habitat restoration = ? (if needed, site dependent)

3) Environmental Monitoring = \$90,000

- a) Wetlands monitoring = \$90,000 (maximum)
- b) Uplands monitoring = \$10,000 (if needed, to come out of the \$90,000 for wetlands monitoring)

4) Operations and Maintenance = \$34,500-\$52,000+

Wetlands Operations and Maintenance = \$34,500-\$52,000+

- a) Structure's long-term management = \$7500-\$25,000
(higher end of range to create a management trust)
- b) Structure's routine maintenance and repair = \$25,000
(to create a maintenance/repair trust)
- c) Structure's major repair/replacement = ?
- d) Structure's security measures (personnel) = ?
- e) Interpretive signs for public I&E = \$2000
- f) Public access control to publicly-owned wetlands = ?
- g) Trash prevention/removal on publicly-owned wetlands = ?

Uplands Operations and Maintenance = ?

- a) Long-term habitat management = ? (site dependent)
- b) Public access control to publicly-owned uplands = ?
- c) Trash prevention/removal on publicly-owned uplands = ?