SCHOOL OF
CIVIL ENGINEERING

INDIANA
DEPARTMENT OF HIGHWAYS

JOINT HIGHWAY RESEARCH PROJECT

JHRP-88/10

Final Report

WETLANDS AND DRAINAGE INVENTORY
OF INDIANA INTERSTATE HIGHWAY
SEGMENTS USING AERIAL PHOTOGRAPHS

Refat Barbour
Robert D. Miles

PURDUE UNIVERSITY

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TO: H. L. Michael, Director
Joint Highway Research Project

FROM: Robert D. Miles
Research Engineer
School of Civil Engineering

May 10, 1988
Project: C-36-51-U
File: 1-5-21

Attached is the final report on the JHRP research project "Wetlands and Drainage Inventory of Indiana Interstate Highway Segments Using Aerial Photographs." The research was done and the report prepared by Refat Barbour, Research Assistant, Joint Highway Research Project under my direction.

A total of 128 lineal miles of Interstate highway at six sites 18 to 25 miles long and one-mile wide was investigated on medium scale aerial photographs for wetlands and drainage system changes related to the highway development. Land use changes within the corridors destroyed 101 wetlands with an area of 1044 acres, but 151 highway construction borrow pits created 638 acres of open-water wetlands.

Respectfully submitted,

Robert D. Miles, P.E.
Research Engineer

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FINAL REPORT

WETLANDS AND DRAINAGE INVENTORY OF INDIANA INTERSTATE
HIGHWAY SEGMENTS USING AERIAL PHOTOGRAPHS

by

Refat Barbour
Research Assistant
Robert D. Miles
Research Engineer

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Joint Highway Research Project

Project No. C-36-51U
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Conducted by the
Joint Highway Research Project
Engineering Experiment Station
Purdue University
in cooperation with the
Indiana Department of Highways
Indianapolis, Indiana

Purdue University
West Lafayette, Indiana

May 10, 1988

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ABSTRACT

Barbour, Refat, M.S.C.E., Purdue University, August 1988.
Wetlands and Drainage Inventory of Indiana Interstate
Highway Segments Using Aerial Photographs. Major
Professor: Robert D. Miles, P.E.

Six Interstate highway sites with a total of 128 miles representing different terrains and landforms in Indiana are analyzed for wetlands and drainage systems along a one-mile wide corridor on various scales of aerial photography over a 40-year period for impact of construction of Interstate highway systems and associated landuse changes. Field visits are made for most of the wetlands to determine vegetation classification. The wetland basins and the drainage systems are mapped on the 1987 photographs and the maps are compared with wetlands and drainage systems mapped before constructing the Interstate highway and with County drainage maps made in 1938.

Medium scale 1:24,000 aerial photographs are satisfactory for inventory purposes but the small scale 1:58,000 or 1:80,000 do not record the detail required for

the study. Large scale (1:12,000 or larger) aerial photographs are recommended for investigation of the ecosystems associated with the wetlands as only general information is inferred from medium scale aerial photography.

The total number of wetlands inventoried at all sites is 920. The area is measured for each wetland with an area greater than 0.5 acre. The total number of measured wetlands is 749, and the total area of these wetlands is 6699 acres. The development of new Interstate highways created 151 new wetlands with 638 acres from borrow pits used for highway construction in all six sites. Within the corridors, over about a 40 year period of photographic record, 101 wetlands with an area of 1044 acres were modified or destroyed. The dominant wetland classes within the one-mile wide highway corridor are the emergent wetlands (1746.2 acres) and the forest wetlands (1705.5 acres). The total area of the open-water wetlands is 1500.1 acres and the total area of the scrub-shrub wetlands is 1109.2 acres.

The created wetlands frequently provide areas for recreational activity for the land owner. Complex ecological systems are developing around the perimeter of the created wetlands and provide protective cover for various species. Wetlands replacement and enhancement is an

important part of the process of planning and design of highway systems. Aerial photography used in the planning and design phases is very valuable in the inventory of existing wetlands and in mitigating adverse impacts to the natural environment.

INTRODUCTION

Detailed drainage maps of the 92 counties in Indiana were prepared in the period 1946 to 1956 using stereoscopic aerial photographs. The aerial photographs were obtained by the U.S. Department of Agriculture during the period 1938 - 1942. These drainage maps show the perennial and ephemeral streams and lakes at a scale of 1:63,360. In the more than 40 years, significant changes in the drainage systems, lakes, and wetlands may have occurred. There is a need to detect the man-made changes in the drainage systems, lakes, and wetlands and to determine those features impacted by man-made works.

The construction of new highways, particularly the Interstate system, is a possible cause of changes in the drainage systems along the highway route. Wetlands may be crossed on new locations. The construction of highways may create new wetlands in addition to impacting the ecology of existing wetlands and drainage systems. The current drainage maps are old and there is a need to show the changes in the drainage patterns and to evaluate the impact of new highways on existing wetland habitat and the

development of new wetland habitat along or near the highway rights-of-way.

New photography may be obtained for different sections of the Interstate highways in Indiana to compare with those maps and aerial photographs used for the highway location studies and to compare with the county drainage maps. This photography may be used to determine the need to update the drainage maps of the counties containing these highway sections. Updated drainage maps may be needed to account for changes in the drainage systems and to locate the water bodies which were formed from the borrow pits related to highway construction. Additionally, the photographs and maps may be used to inventory the wetlands along new highways as a part of a study of the interaction between highways and wetlands.

PURPOSE

The purposes of this study are to:

1. Determine the effectiveness of using high altitude photography 1:80,000 and 1:58,000 and medium altitude 1:24,000 photography to map the drainage and wetlands along selected segments of highways:

2. Assess the natural and man-made changes in the perennial and ephemeral drainage systems;
3. Inventory wetlands to determine those created by highway construction; and
4. Attempt to assess the environmental quality of the wetlands using aerial photography obtained after the highway construction.

SCOPE OF WORK

Six sites along segments of Interstate highways representing different types of soil and terrain are selected to examine the changes that are made by highway construction on drainage systems and wetlands along the highway corridor. Four different periods of aerial photography are used for the wetlands and drainage inventory. Drainage and wetlands maps are made for pre-construction black and white (1956-1959) photos, black and white (1980) photos, color infra-red (1980) photos, and new black and white (1987) photos. Comparison between these maps and the drainage maps (1946-1956) is made and the changes in the drainage systems and wetlands are identified. A wetland classification is given for each wetland area in addition to the measurement of wetland area and the edge-to-area ratio. The total wetland areas lost and gained for each of the six sites is provided. Emphasis

is given to those new wetlands created by the construction of the highway. Species and habitat utilizing the wetland are identified by use of site visits and ground photography to show the wetland diversity. The results of the inventory are provided on a map for each of the six sites.

New stereoscopic aerial photography at a scale of 1:24,000 was obtained in 1987 by the Indiana Department of Highways. This photography is compared to the older photography to determine changes in surface drainage and to inventory wetlands along 16-mile to 25-mile segments of the six Interstate highway sites. The impacts of the Interstate system on drainage systems and wetlands are investigated. New wetlands created from borrow pits used for highway construction are examined in more detail. The report is organized into a section on the review of literature, a section on the creation of wetlands, a section on the inventory procedure used in this study, a section on the analysis of each of the six study sites, and the results of the study.

LITERATURE REVIEW

Most of the literature reviewed pertained to wetlands and very little is concerned with the changes in the existing drainage systems. The highway impacts on drainage systems are considered as part of the highway impacts on the wetlands. Alteration of water path alters ground-water regime and surface-water level of the wetland.

Wetlands occur because there is water present on or near the surface on a perennial or ephemeral basis. Alteration of water flow by construction of highway systems impacts on surface-water and ground-water regime and influences water levels of existing wetlands or creates new wetlands by retardation or alteration of drainage path or other construction activities.

Wetlands are defined in different ways because of the different needs and the different agencies concerned with wetlands habitats and their environment. There are two definitions of wetlands used in the classification and legal protection of wetlands.

The Fish and Wildlife Service, Department of Interior, has defined wetlands as has the Corps of Engineers. The Fish and Wildlife Service defines wetlands as:

"lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purpose of classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year [3]".

The Corps of Engineers defines wetlands as:

"areas inundated or saturated by surface water or ground water at a frequency and duration sufficient to support -- and that under normal circumstances do support -- a prevalence of vegetation typically adapted for life in saturated soil conditions [42]".

Wetlands considered in this study are the fresh-water type wetlands. Fresh-water wetlands account for more than 90 percent of total U.S. wetlands and for all the wetlands in the state of Indiana. The main water sources for the fresh-water wetlands are from ground water, surface springs, streams, rain water, runoff from the surrounding terrain, or all of these. Wetlands usually are surrounded by different kinds of vegetation such as: grasses, sedges, waterlilies, reeds, arrowheads, and other hydrophytes.

A. Wetland Values and Functions

Wetlands, in a historical sense, were considered waste land. The environmental movement has increased concern about wetlands and their value and function in the ecology of an area. Their value and function are recognized by a variety of interest groups who seek protection where public monies are involved [1,15,16,17,18,32,42]. Some of the values and functions are the following:

1. Production and detritus availability:

Wetlands provide the vegetation material that is the base for many aquatic and terrestrial food chains. They support large plants and animal populations like waterfowl, local and migratory birds, fur-bearing mammals, beaver, muskrat, amphibians, frogs, salamanders, crayfish, and other wildlife. These animals and wildlife utilize the wetlands for breeding, feeding, and nesting. The wetlands provide critical habitat for threatened, endangered, or other protected species.

2. Erosion and hydrology:

Many wetlands act as effective erosion and flood buffers. The shallow water in the wetland and the associated vegetation slow the velocity of flood water and slack water and reduce the soil erosion. The water collected in the wetlands recharges the water table in the area. Other hydrologic values are: retention of flood waters, low flow augmentation, and reduction of peak flow.

3. Water quality control:

Wetlands can improve water quality through the sequestration and/or dissipation through evaporation of potentially toxic material or nutrients. Dense stands of wetland vegetation act as nutrient traps and remove the suspended solids from polluted waters.

4. Recreational and aesthetic values:

People visit wetlands for bird watching and wildlife observing, duck hunting, mammal trapping, canoe riding, fishing, boating, frog listening, painting, picnics, etc. Wetlands serve as natural laboratories for research on the ecological system or as outdoor classrooms for environmental study. The visual contrast and diversity in landscape and surrounding land have scenic and beauty values along the highway corridor. Other factors that influence the aesthetic values are the wetland size, the edge complexity, the trees or the forest on the wetland border, the waterfowl fly-by, and the visibility and diversity of wildlife.

B. Wetland Protection and Legal Aspects

There is no specific legislation in the State of Indiana that is of direct concern to wetland utilization or that defines wetlands. The Department of Natural Resources (DNR) prohibits alteration of water level or shore line of public lakes that cover an area of 10 acres or more by means of ditches or dams (IC-13-2-15), but DNR does not regulate privately owned bodies of water (IC-13-2-11). DNR prohibits inhibiting the flood plains or obstruction of channels used as floodways (IC-13-2-22) [2].

Executive orders and legislative acts have been issued during the last few decades by different federal government departments and agencies to protect the wetlands [9,14,15,17,19,42,43]. The major federal legislative actions are as follows:

1. The Fish and Wildlife Coordination Act of 1958 (16 U.S.C.) requires that the United States Fish and

Wildlife Service and State conservation agencies be consulted concerning impacts to fish and wildlife resources resulting from federally funded or licensed water resources projects.

2. The National Environmental Policy Act of 1969 (NEPA 42 U.S.C.), which encompasses activity of all federal agencies, requires the preparation of statements in which the possible environmental impacts of the proposed action and all reasonable alternative actions must be considered.
3. Executive Order 11990, Protection of Wetlands (1977), mandates that all federal agencies provide leadership and take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities.
4. In accordance with section 404 of the Clean Water Act (1977), activities which involve the discharge of dredged or fill material into the waters of the United States, including wetlands, require a permit issued by the U.S. Army Corps of Engineers.
5. U.S. Department of Transportation order 5660.1A (1978), describes procedures to preserve the nation's wetlands and requires federal agencies to avoid the long-term and short-term impacts associated with the destruction or modification of wetlands and to avoid construction in wetlands unless the proposed action includes all practicable measures to minimize harm to the wetland.
6. In 1980, The Federal Highway Administration published regulations (23 CFR 777) which state that in order to qualify for federal highway funding, actions to minimize impacts and mitigate wetland losses should include the enhancement of existing wetlands and creation of new wetlands in the highway medians, borrow pit areas, interchange areas, and along the road side.

In implementing these acts, coordination is usually needed with different special interest groups and organizations, such as the general public, conservation organizations, federal, state, and local governmental

agencies, regional commissions, and local institutions.

C. Highway Impacts on Environment

The construction of new highways or the reconstruction of existing highways may impact on wetlands and their dynamic ecological process. The assessment of the ecological impacts requires in addition to the identification of these impacts, the estimation of their probability, duration, and magnitude [4,5,6,7,8,10,14,15,29,32,43,44]. The Corps of Engineers defines an impact on a wetland as anything that affects the normal functioning of a wetland. The types of impact that might occur are as follows:

1. Hydrological Impacts:

The change of the water regime affects wetlands productivity (reduced nesting, shelter, food carrying capacity for birds and animals utilizing the wetland, etc.). This affects certain types of wetland vegetation (grazing and detritus food webs supported by such vegetation). The types of impacts are as follows:

- a. Alteration of the wetlands water level.
- b. Beheading of aquifers.
- c. Changes in runoff and recharge characteristics.
- d. Development of extensive ground-water drains where cuts extend below the water table.
- e. Changes in the ground and surface water divides and basin areas.
- f. Reduction of induced stream-bed infiltration due to sedimentation.
- g. Obstruction of ground water flows by abutments, retaining walls, sheet piling, and cut-off walls.
- h. Loss of flood plain area where highways have been constructed parallel to stream-beds.

- i. Raising water levels on the up-flow side of the highway structure and lower levels on the down-flow side.
- j. Change from diffused to concentrated flow (because of the culvert) which alters the associated ecological system.

2. Water Quality Impacts:

Water quality impact is the change in concentration in wetland water of a particular constituent. The types of impacts are as follows:

- a. Suspended sediment lowers water quality by carrying chemicals and pollutants.
- b. Accidental spills on highways are a potential cause of water pollution.
- c. Ammonia, nitrate, and phosphorus in the runoff may violate public health or aquatic life protection criteria.
- d. Nutrient loadings may accelerate primary wetland productivity (see page 26) that often detract from the recreational use of the water body.
- e. Highway deicing agents increase salt concentration in nearby streams and water-bodies which could damage the vegetation that provides food, nesting cover, and shelter for a variety of species.
- f. Herbicides and pesticides used to control right-of-way vegetation, or mowing operations could damage other species down the stream or in the adjacent wetlands.
- g. Highway runoff has a higher concentration of dissolved metals which could have different effects on different wildlife. These runoff constituents could include: lead, mercury, petroleum, cadmium, vanadium and other metals and particulates.

A summary of water quality criteria for possible constituents of highway runoff is included in Appendix A [14].

3. Biological Impacts:

The biological impacts include both the well-being of individual species (including plant and animal species), and the potential loss of habitat for terrestrial and aquatic wildlife, fishery resources,

threatened or endangered species, or the loss of wetlands themselves. The following are some of the impacts:

- a. Siltation produces an increase in the silt load (resulting from erosion) in the stream or the wetland which reduces dissolved oxygen because of the reduction in light penetration and photosynthesis.
- b. Acute toxic pollution produces an effect from high-level, short-term exposure to toxic pollutants.
- c. Chronic toxic pollution produces a long term effect of low level exposure resulting in a biotic response of bioaccumulation to a critical toxic level.
- d. Eutrophication is the accelerated accumulation of nutrients and organic matter and ultimate destruction of the wetland as a shallow water environment.
- e. Mortality from a road kill of an animal by passing vehicles results in changes in population of local terrestrial ecosystem.
- f. Aquatic vegetation loss produced by highway induced changes in water level.
- g. Benthic habitat loss due to dredging and filling operations.
- h. Reproductive cycle interruption due to highway related noise.
- i. Migration interruption into and out of wetland areas by highway traffic and/or structural barriers (i.e. paved surface, fences, noise barriers, etc). The interruption of animal migration may affect both short-term and long-term migration depending on species requirement of food, water, salt licks, shelter, nesting, and other productive habitat.

D. Amelioration Measures

One of the objectives of highway planning is to minimize any alteration to the natural state of streams, rivers, wetlands, and other surface water features. They are usually treated as inviolable features, preserved in their natural state, and altered with utmost care and when

the alternative is too costly. This is achieved by environmentally sound highway development activities and by satisfying the requirements of various wetland protection policies and statutes at the time of highway planning or construction. Any amelioration measure must relate to retaining the natural habitat for fish and wildlife. Amelioration measures could take the form of avoidance, preservation, minimization, rehabilitation, restoration, replacement, enhancement, mitigation, improvement, augmentation, development, and diversification. The following are examples of these amelioration forms [5,7,8,10,11,15,29,32].

1. Avoid wetland or minimal taking of wetland acreage by careful selection of highway corridor and alignment during the planing and location phase.
2. Create new wetland areas to compensate for loss of wetlands.
3. Restore and enhance productivity of remaining wetlands.
4. Acquisition of land parcel to have maximum buffer and transition zones between the highway and adjacent wetlands.
5. Landscaping the right-of-way to increase the buffering of vehicular noise in wetland areas.
6. Maintaining and creating channel diversity.
7. Controlling runoff water pollution by controlling shallow water flow and using plants such as cattails, to uptake nutrients and trap runoff constituents in roadside ditches and collectors.
8. Using culverts, and non-concrete ditches and drains, and maintaining them unobstructed in order to ensure the free movement of water through wetland areas.
9. Restriction or control of the use of chemicals and application of salts, herbicides, pesticides, preservatives, and paints for maintenance.
10. Mowing guidelines to maintain roadside habitat and avoid impact on nesting and wildlife.
11. Periodic monitoring of wetland muds in order to detect any accumulation of potentially toxic and stressful

- chemicals and materials related to highway use and maintenance.
12. Conducting sanitary surveys of all wetlands adjacent to rest areas in order to detect potential contamination of ground water and surface water supplies.
 13. Periodic monitoring of aquatic biota in order to detect any long-term, highway-related impacts on aquatic habitats.
 14. Provide visual examination of wetland vegetation to detect and correct any diminished productivity due to highway operation.
 15. Minimize the removal of vegetation and detritus and replanting disturbed wetland vegetation to ecologically equivalence.
 16. Create small plantations along streams in order to produce shaded areas for aquatic species and protection from high temperatures.
 17. Excavate pools and create riffles in the stream bed to replace fish habitat lost during construction. Also place gravel, logs, and other materials for fish spawning and cover.
 18. Use fish ladders, elevators, culverts, or other structures to minimize the interference with fish movements and mitigate the highway impact as a barrier.
 19. Construct nesting and other shelters for wetland wildlife in localized areas in order to increase wetland utilization by wildlife.
 20. Increase the edge to surface area of wetland in order to increase the habitat for emergent wetland vegetation.
 21. Careful timing of construction activities and careful management of construction camp and site in order to minimize interference with habitat ecological cycle.
 22. Consider which species are affected by diversification and the potential effects of diversification on wetlands values. Solve the potentially conflicting interests of aesthetic, economic, recreational, construction in the light of stability and productivity of the wetland ecosystem.
 23. Placement of boulders or other obstructions in waterways in order to increase the concentration of dissolved oxygen in localized areas.
 24. Minimize changes in ground topography.
 25. Maintain a stable water level by having an overflow pipe and emergency spill-way during the storm period; and maintain a shallow water level in some part of the wetland.

26. Augment hydrological regimes in order to correct for project-induced alterations of natural surficial and ground-water flows.
27. Design and construct means for augmenting wetland water levels in periods of drought in order to maintain hydrologic regime.
28. Avoid ground water and aquifer recharge areas or at least maintain infiltration to these recharge areas.
29. Control water runoff from impervious surfaces by using pervious fill materials wherever possible.
30. Use temporary and permanent erosion and sediment control measures.
31. Stabilize surrounding soils through seeding, planting, or fertilization.
32. Develop guidelines for seeding, planting and fertilization of eroded slopes in order to reduce the impacts of silt on aquatic species and habitats.
33. Implement and test emergency procedures for the clean up of accidental spills, and for the temporary detouring or other control of traffic during especially sensitive periods of wildlife migration or reproduction.
34. Maintain fences, underpasses, and overpasses to ensure the protected migration of wetland species.
35. Increase the recreational value of wetland by having a short natural trail leading to it.
36. Rehabilitate and inspect structures to maintain functions and biological cycles with respect to wetlands habitats (e.g. clogged culverts should be cleaned according to fish-spawning time).
37. Consult with specialists having experience in local wetland ecology to ascertain materials and methods to be used in maintenance and to minimize adverse effects.
38. Wetland improvements coordinated with governmental agencies and public groups having interest and expertise in wetland ecology.

E. Wetland Classification,

Many classifications have been developed during the past decades to satisfy different purposes. The major components in a wetland classification system are vegetation types, life forms, soils, and water characteristics. Life form refers to the appearance of the

mature plant, leaf, shape, size, and whether the plant is woody or herbaceous. The life forms could be: dead trees, live deciduous trees (willow), live tall shrubs (alder), live low shrubs (buttonbush), emergent broad-leaf hydrophytes (arrowhead), emergent narrow-leaf hydrophytes (cattail), and non-vegetated water [3,8,43].

Wetlands are given different names for different classification systems. These names vary and include: seasonally flooded basins or flats, fresh-water meadows, shallow fresh-water marshes, deep fresh-water marshes, open fresh-water, shrub swamps, wooded swamps, bogs, cattail, riparian, etc. Although there is no agreement on these wetland definitions, an example of how swamps and bogs are described is as follows:

"Swamps are characterized by a predominance of woody plants. Swamp vegetation includes willow, oak, maple, gum, alder, and cypress. Swamps usually develop in wet upland depressions, at the edge of lakes and ponds, and along the borders or flood plains of streams and rivers [10]".

"Bogs often form in glaciated depressions in forested regions. A bog has very restricted drainage and, therefore, has, at most, no inflow or outflow. For this reason, dead organic matter accumulates as peat in layers that are often 40 feet or more in depth. Vegetation is characterized by acid-tolerant plants and include cranberries, blueberries, sedges, and insectivorous plants [10]".

The most recent wetland classification is the one used by the Fish and Wildlife Service in its National Wetland

Inventory project. Wetlands are classified into five systems: Marine, Estuarine, Riverine, Lacustrine, and Palustrine. Each first-order system is classified into subsystems which are further classified into classes and subclasses. Most of the wetlands in Indiana are Palustrine, Riverine, and Lacustrine. The classes and subclasses for the Palustrine system is illustrated in TABLE 1 as an example of the classification system.

The quality and accuracy of individual wetland classification maps and portions of the same maps may vary depending upon the quality of aerial photographs used in the preparation of the maps. The National Wetland Inventory Project uses the small scale (1:80,000 and 1:58,000) photography of the National High Altitude Project to identify and classify wetlands. The mapping of different wetland resources may have been accomplished with varying degrees of groundtruth of features originally identified through remote sensing techniques. The maps are published at a scale of 1:24,000 which is the scale of the 7.5-minute topographic quadrangle maps.

TABLE 1. Classes, and subclasses with examples of dominance types for Palustrine system. (Adapted from Fish and Wildlife Classification of Wetlands) [3]

Class	Subclass	Example of Dominance Type
Rock Bottom	Bedrock	Horse sponge
Rubble	Pond snail	
Unconsolidated Bottom	Cobble-Gravel	Freshwater sponge
Sand	Freshwater mollusk	
Mud	Fingernail clam	
Organic	Oligochaete worm	
Aquatic Bed	Algal	Stonewort
Aquatic Moss	Moss	
Rooted Vascular	White water lily	
Floating	Water fern	
Unconsolidated Shore	Cobble-Gravel	Toad bug
Sand	Freshwater mollusk	
Mud	Crayfish	
Organic	Back swimmer	
Vegetated	Summer cypress	
Moss-Lichen	Moss	Peat moss
Lichen	Reindeer moss	

TABLE 1. (Continued)

Class	Subclass	Example of Dominance Type
Emergent	Persistent	Common cattail
Non Persistent	Arrow-arum	
Scrub-Shrub	Broad-leaved Deciduous	Speckled alder
Needle-leaved Deciduous	Tamarack	
Broad-leaved Evergreen	Coastal sweetbells	
Needle-leaved Evergreen	Atlantic white cedar	
Dead	None	
Forested	Broad-leaved Deciduous	Red maple
Needle-leaved Deciduous	Bald cypress	
Broad-leaved Evergreen	Sweet bay	
Needle-leaved Evergreen	Black spruce	
Dead	None	

WETLANDS CREATION

New wetlands are created to replace altered or destroyed natural wetlands and to mitigate and compensate for the highway impacts, or to enhance function and value of the current ecosystem. The sites for the newly created wetlands are: borrow pits used for highway construction, modifications to old stream beds or existing streams flowing perpendicular to the highway, development of drainage channels situated parallel to the highway, etc.

Along the highway corridor, wetlands created from borrow pits are the most common. The location of various borrow pit areas and the excavated configuration of each pit are dictated by the availability of appropriate borrow material, ease of excavation, and length of haul to the construction sites. The success of borrow pit wetland development depends upon availability of water, depth and shape of borrow pit, water flow, morphometry of shoreline, and surrounding land use.

Wetlands created within stream beds usually have a small earthen dam constructed across the old channel scar

at the down stream end of an oxbow bend. These new wetlands are improved by dredging the old oxbow to a depth of about six feet and using the dredged material to create the dam. Old stream bed wetlands have a very high wildlife value and, also, have a high aesthetic value.

In general, wetlands created next to rest areas provide more value than other locations. They have potentially high wildlife value; they provide access to motorists; and most likely, they have the highest aesthetic, recreational, and educational values of all wetland types.

A. Importance of The New Wetlands

The creation of new wetlands is one of the most important amelioration measures to mitigate highway impacts. It is important to mention that the created wetland is not an exact substitute for an existing wetland or even an altered wetland due to the different ecosystems and due to the time it takes to establish the new ecosystems. A brief comparison between the natural wetlands and the created wetlands in terms of advantages and disadvantages is provided to emphasize the importance of the newly created wetlands [14,18]. Since ecosystem construction of a managed wetland could not be judged on alteration of a previous wetland ecosystem, it is not

intended to conclude which one is better than the other.

1. Potential advantages of natural wetlands:

- a. Immediate availability with no construction or vegetation establishment period necessary.
- b. No new land requirements.

2. Potential disadvantages of natural wetlands:

- a. Inconvenient location relative to public need.
- b. Connection to critically sensitive water bodies.
- c. Inadequate size to assimilate waste load.
- d. Discharge to natural wetlands maybe required by regulatory authorities to meet most stringent influent criteria.
- e. Operation of a managed natural wetland may alter ecosystem balance and relationships.
- f. Secondary problems: disease carrying mosquitos, odor, and fog.

3. Potential advantages of constructed wetlands:

- a. Flexibility in site location.
- b. Optimum size for projected waste load.
- c. Construction of topographic features such as channels, shallow bars, islands and levees to make it more ecologically attractive, improve pollutant removal and facilitate maintenance.
- d. The design of new wetlands could be multifunctional, providing highway storm-water management, scenic, recreational, and fish and wildlife functions.
- e. May be exempt from rigorous influent criteria if wetlands considered part of a waste treatment system.
- f. Would supplement existing wetlands.
- g. Wetlands created with diverse species are of greater value than replaced wetlands of single or few species and they have greater value to fish and wildlife.

4. Potential disadvantages of constructed wetlands:

- a. Cost and availability of suitable land.
- b. Construction costs for grading and planting the site.
- c. Unavailability of the system during the construction period.
- d. Possibly reduced performance during revegetation establishment period.

B. Wetland Establishment Criteria

Many factors are recognized to have major effect in creating new wetlands [11,18,32]. The following is a list of some of these factors and the criteria required in any wetland establishment project:

1. Water Regime:

Rectangular form with large length-to-width ratio of wetland sites encourages efficient distribution and mixing of water. The most desirable wetlands are those periodically inundated by water and those that for some part of the edge condition have a very shallow and fluctuating level of water. The water source for the wetland is from streams, runoff, or high-water table that is stable or ephemeral.

2. Substrate Soils:

For porous substrate, a layer of clay and other fine material is added to slow percolation. The site soil slope is treated using regional USDA Soil Conservation Service Specifications to control erosion. USDA requires that the substrate consist of a minimum of one foot of clean inorganic or organic materials of which 80-90 percent by weight pass a No. 10 sieve. An inorganic substrate (gravel, sand, silt, and clay) is to contain less than 12 to 18 percent organic matter. Most borrow and dredged fill material is acceptable as substrate as is subgrade encountered after excavation.

3. Vegetation Types:

Typical plants in wetlands are emergent and herbaceous. Although vegetation diversity is the most important requirement, the following species are desired: alder, cattail, calamus, sedge, and cutgrass. A list of species for perennial wetland plants is provided in Appendix B [11].

4. Vegetation Establishment:

Wetland vegetation is established by seeding or planting of sprigs, bulbs, tubers, rhizomes, plugs, and peat-potted nursery stock. Wetlands establishment

by seeding are the most economical, but their success is least predictable due to temperature and turbidity of water. On the other hand, wetland establishment by transplanting is the most successful and expensive. Peat-potted nursery stock of aquatic plants is produced in field plots or in greenhouses and is the most expensive.

5. Period of Establishment:

The most critical periods for vegetation establishment are the first two growing seasons. During this period, it is important to have monthly site inspections for the full-growing season (May-October) and at the beginning of the second full-growing season. These inspections require:

- a. Transplanting of all unsuccessful seeded areas by using non-seed vegetation establishment.
- b. Replanting of all transplants that have suffered mortalities or otherwise are gone.
- c. Removing all litter and debris deposits throughout the site.
- d. Conducting the specified fertilizations.
- e. Taking any specified measures to exclude wildlife temporarily.

6. Aesthetic and Recreational features:

Desirable recreational features for a man-made wetland include:

- a. One acre wetland size or larger, of irregular shape.
- b. At least six foot depth of water.
- c. 50-70 percent open water.
- d. Shallow water zone of 6- to 12-inch depth for organic plants.
- e. Accommodation of at least 25 persons or motorists using the highway to stop.
- f. Visibility for several miles from the approach highway.
- g. At least one island to help nesting birds.
- h. Close proximity to other wetlands or bodies of water.

7. Costs:

The major items of cost in establishing a new wetland include planning and designing, obtaining the site, preparing the site, constructing any necessary structures, planting the site, and maintaining the site. The cost will be minor if wetland construction occurs simultaneous with highway construction.

C. Ecological Considerations

Ecosystem stability and population dynamics of wetlands are intimately linked to the components and dynamics of both the aquatic and terrestrial ecosystems. The creation of new wetlands is important and these wetlands may experience a life cycle similar to natural wetland succession. Wetlands succession, as in the eutrophication of a pond or the self purification of a stream, is summarized [5,6,9,10,19,43] as follows:

1. Sunlight energy is transformed into the chemical energy of primary producers (plants), consumers (animals), and decomposers (bacteria, fungi, etc.). These sequential transformations of energy constitute a grazing food chain.
2. Organic matters (detritus) is also utilized directly as food by consumers and decomposers. These sequential transformations of energy constitute a detritus food chain.
3. Both grazing and detritus food chains are influenced greatly by the dynamic process characteristics of shallow waters.
4. The decomposition of plant materials and other organic matter results in release of the minerals.

Some of the major ecological relationships and factors influencing wetland succession and the ecosystem are:

1. Creating the maximum lineal footage of wetland edge is ecologically attractive. It is found that the greater the edge to area ratio is the higher the

- concentrations of birds and the development of cattails in shallow water zones.
2. Low elevation wetlands that have a maximum interaction with surface-water and ground-water have more wetland functions and values than do high elevation wetlands which only occasionally interact with surface-water. Approximately six inches of depth of water usually distinguishes between shallow and deep water, but the depth which determines aerobic and anaerobic organisms is defined by the compensation point. The compensation point in water depends on:
 - a. The rate of photosynthesis and respiration of different autotrophic and heterotrophic populations.
 - b. The sunlight penetration in the water.
 - c. The atmospheric oxygen diffusion to lower depths.
 3. An increase in the species diversity is a major characteristic in new wetland ecosystems. Species diversity includes the number of different kinds of organisms, the complexity of the food webs, and the population density of each kind of organism in that area.
 4. Productivity is one of the important ecologically sensitive areas. A high productivity rate is due to the increase in the size of the biota and increase in the amount of internal recycling of nutrients. The factors identifying the productivity are:
 - a. Existing biomass (weight) or population density of plants and animals.
 - b. The rate of production of biomass over some period of time. This rate is influenced by soils, hydrology, and microclimatology.

The major features supporting the productivity in wetlands and aquatic ecosystem include:

- a. Surface waters which support large populations of microscopic algae such as phytoplankton (free floating forms) and periphyton (forms attached to some substrate).
- b. Shore areas which support larger vegetation (macro-phytes), including emergent, floating, or submergent plants.
- c. Pools and riffles which provide suitable habitat for different fish species (nekton).

- d. Bottom muds and other bottom debris and sediment which provide suitable habitat for various benthic organisms.

The biological process of aging in lakes is called eutrophication. TABLE 2 shows some of the characteristics of oligotrophic and eutrophic lakes and ponds.

TABLE 2. Some characteristics of oligotrophic and eutrophic lakes and ponds (Adapted from Welch) [45].

Characteristics	Oligotrophic	Eutrophic
Depth and Temperature	Deep, Cold water	Shallow, Warm water
Organic Material	Little on bottom or in suspension	Abundant on bottom or in suspension
Nutrient Concentrations	Low	High
Dissolved Oxygen Concentrations	High at all depths through the year	Low or absent at lower depths
Aquatic plants	Spares growth of algae and larger plants	Abundant growth of algae and larger plants
Emergent and submersed vegetation	Generally absent	Generally extensive
Benthic animal	High density and diversity (varies)	Low density and diversity (varies)
Fish	Abundance of cold water fishes	Absence of cold water species
Productivity	Low	High
Transparency of water	High	Low
Recreational Value	Excellent for both primary and secondary recreational use	Poor for primary (contact) recreational use

INVENTORY PROCEDURE

The wetland and drainage inventory are made on different photography for each selected segment of Interstate highway in Indiana. The remainder of this section describes the procedure used in the inventory:

A. Site Selection

Interstate highways in Indiana cross different landforms and terrains. Some of these landforms and terrains are abundant with natural wetlands, while natural wetlands are rare in other places. The man-made wetlands created along the highway and especially those created from borrow-pits are very dependent on the terrain, subgrade soil type, and the availability of construction material.

Six Interstate highway segments were selected to represent the different types of terrain and soil landforms. Figure 1 shows the major soil landforms in Indiana and Figure 2 shows the location of selected sites on the Indiana Interstate highways. Each site starts one-half mile from the beginning of a highway interchange and ends about one-half mile beyond the end of another highway

Figure 1. Map of Indiana showing physiographic units and glacial boundaries. (Modified from Indiana Geological Survey Rept. Prog. 7, fig. 1.)

Figure 2. Map of Indiana showing the interstate highways and the location of the six sites selected for analysis.

interchange for a total length between 15 to 25 miles. The width of the area of interest extends one-half mile on both sides of the highway alignment. TABLE 3 lists the Interstate sites, the state highway interchange site, the length of the segment, and the major terrain type within the corridor.

TABLE 3. Selected Highway sites.

Site	Highway	Starting	Ending	Length (miles)	Major Terrain Type
1	I-69	SR-4	I-80	16.7	Ridge Moraine
2	I-65	SR-10	US-231	18.9	Outwash Plain
3	I-69	SR-32	SR-26	22.7	Till Plain
4	I-70	SR-227	SR-3	25.3	Ground and Ridge Moraine
5	I-74	SR-3	SR-229	16.0	Ground Moraine
6	I-65	SR-46	SR-44	22.2	Flood Plain and Outwash Plain

B. Selection of Aerial Photography,

The individual county drainage maps were prepared at a scale of 1:63,300 from 1938-41 aerial photos obtained at an approximate scale of 1:20,000. Four different sets of aerial photography with different scales, are used in this

study to determine changes in the drainage system and to inventory wetlands along the selected sites of the highway.

Pre-construction black and white aerial photographs (1956-1959) used for location studies by the Indiana Department of Highways (IDOH) are available for analysis. All wetlands and drainage systems mapped on these aerial photographs present the original status of drainage and wetlands before constructing the highways.

The IDOH, in April, 1987, obtained new black and white photography at a scale of approximately 1:24,000. The wetlands and drainage mapped on these photos present the current status of wetlands and drainage system.

Some wetlands vary from year to year in shape and between seasons. Also, the scale and type of photography influences the amount of detail obtained from stereoscopic examination of these aerial photographic sets. After conducting a search on all available photography, two more sets of aerial photography are used to determine the effectiveness of using small-scale photography in the inventory. Black and white aerial photography at a scale of 1:80,000 and color infra-red aerial photography at a scale of 1:58,000 are available and were purchased from the National High Altitude Photographic Data Base (NHAP), the Department of Agriculture and the U.S. Geological Survey.

These photographs are used to inventory drainage systems and wetlands for all the sites except site five.

Figure 3 illustrates the four types of aerial photography used in the study. The picture of each type of aerial photography represents a segment of site one along I-69.

C. Wetlands and Drainage Mapping

Wetlands and drainage systems are mapped on acetate overlay for all the four sets of aerial photography of the six sites. Every type of aerial photography for site one and sites three to six is mapped at the contact scale on acetate overlays and these maps scaled to 1:24,000. For each of these sites, the findings obtained from the four types of aerial photography are summarized on a single base map along the corridor at a scale of 1:24,000. Each map shows the changes that have been made on wetlands since the highway construction and, also, shows the changes that have been made on the drainage systems during the past 40 or more years. The changes and their description are discussed for each site in the next section of the report.

D. Digital Mapping

The wetlands and drainage system for each type of aerial photography of site two are digitized on the Indiana

Pre-construction black and white photograph 1:20,000

1987 black and white photograph 1:24,000

NHAP color infra-red photograph 1:58,000

NHAP black and white photograph 1:80,000

Figure 3. Example of the types and scales of aerial photography used in the investigation.

Data Base available on the Intergraph computer at the Photogrammetry Analysis Laboratory in the School of Civil Engineering, Purdue University [12,13]. A digital map for the site is produced from each overlay of the aerial photographs using the Intergraph computer as a digitizer. The digitized maps are at a scale of 1:24,000.

E. Wetlands Classification,

Wetlands in this study are classified on the basis of their patterns on stereoscopic aerial photographs into five categories as follows:

1. Forest wetlands: those that are dominated by wooded areas and trees more than six meters tall.
2. Scrub-Shrub wetlands: those that are dominated by scrub-shrub and trees less than six meters tall.
3. Emergent wetlands: those that are dominated by grasses and herbaceous hydrophytes.
4. Open-water wetlands: those that are dominated by a water surface. They are classified as either natural wetlands for those that existed before the highway construction or created wetlands for those that existed because of the highway construction.
5. Destroyed wetlands: those that are represented on the pre-construction aerial photographs and are not existing on the post-construction aerial photographs.

F. Wetlands Evaluation,

The evaluation and analysis of all wetlands and drainage systems is discussed in the next section "Wetlands Inventory and Analysis" for all sites. The wetlands evaluation involved the determination of the area and edge-to-area ratio for each wetland included in this study. The total existing wetland area, the total destroyed wetland area, and the total created wetland area are determined for each site.

Two field trips were made to check these wetlands and to obtain ground photos for leaf-on and leaf-off conditions. The ground photos were taken only for wetlands observed from the highway or the nearby local roads. A few attempts to obtain permission to photograph private wetlands which can not be seen from the highway were successful. The Division of Location and Environment personnel of IDOH used these ground photos and their field visit to the wetlands to identify the species and habitat of each wetland.

The impacts of the highway on specific wetlands are discussed to include the type and extent of the impact. Although most of the created wetlands are on private lands, the wetland function and use is discussed. A selection of ground photographs showing the species diversity and

environment of a few selected wetlands from each site investigated is provided as a part of the discussion of each site.

DRAINAGE AND WETLANDS INVENTORY AND ANALYSIS

SITE ONE

A. General

The site is located on I-69 with a total length of about 17 miles. It starts at the interchange with SR-4 in Dekalb county at about mile post 139.5 and it extends north to the interchange with Indiana toll road I-80-90 at milepost 156.5. The topography of this site is very diverse (e.g., undulating farm lands, hilly woodlands, lakes, hilly farm lands with numerous basins and lakes). The highest elevation in the section is about 1100 feet above sea level in the northern part and the elevation decreases to about 950 feet above sea level in the southern part.

The predominate land forms on this site are Wisconsinan Till Plain and Wisconsinan Ridge Moraine. There are a few small areas of Outwash Plain and several Peat-Muck Basins approximately one-half mile long along the site. The soil texture is predominantly silt and clay in

the southern part and is predominantly sand and gravel in the northern part.

The segment of I-69 from US-20 interchange north to the Michigan border was opened to traffic on June 30, 1965; and the part south of US-20 was opened to traffic on October 9, 1967. The route location study during the planning phase in 1958 avoided crossing wetlands as much as possible to reduce construction cost. Three route alternatives were abandoned because they crossed extensive deposits of muck and peat. [25,28,31,40,46]

B. Wetlands and Drainage Mapping

The four sets of maps produced from the four different sets of aerial photography along site one are included in this site report as being typical examples of the mapping done for the five other sites. TABLE 4 shows the identification numbers of each set of photography used in mapping this site. Each map is produced at the scale of the original aerial photography without adjustment for the relief errors and perspective errors of the original prints.

The map produced from the new photography (1987) obtained by IDOH showed the most details of the existing wetlands and drainage systems due to its medium scale of approximately 1:24,000 (PLATE 1.1). PLATE 1.2 shows the map

TABLE 4. Identification numbers of the photos used in mapping site one

Photography Type	Serial number	
	From	To
1987 Black and White	138	154
1981 Color Infra Red	459-57	459-63
1981 Black and White	340-37	340-41
1957 Black and White	BFU-2T-42	BFU-2T-46
	BFU-2T-176	BFU-2T-180
	BFU-2T-202	BFU-2T-207
	BFZ-2T-208	-
	BFU-2T-128	-

produced from the small scale color infra-red photography dated May 2, 1981 with an average scale of 1:58,000. It shows most of the wetlands as shown on PLATE 1.1. PLATE 1.2 shows fewer surface drainage features than PLATE 1.1 due to the smaller scale and seasonal variations. The false color of the aerial photography helps in classifying and identifying some of the wetlands. Some wetlands vary in shape between PLATE 1.1 and PLATE 1.2 due to the different dates of the aerial photographs used in preparing these maps (e.g wetland #1 in PLATE 1.0). The map produced from black and white photography with scale 1:80,000 showed only the larger size wetlands and the major rivers and streams due to its small scale (PLATE 1.3). These three maps present the wetlands and drainage systems after the highway construction. The pre-construction map shown on PLATE 1.4 presents the wetlands and drainage status just before the

MAP LEGEND **Open Water Wetlands (Natural)** **Open Water Wetlands (Created)** **Emergent Wetlands** **Scrub-shrub Wetlands** **Forest Wetlands** **Destroyed Wetlands** **Major Rivers** **Channels, Streams, and Minor rivers** **Small Gulleys** **Interstate Highway** **State Roads and Major Roads** **Minor Roads****MP****OFFICIAL MILEPOST****1****MILEPOST****1****WETLAND NUMBER**

41A

1:24 000
0 — 1/2 — 1 MILE

PLATE 1.0-1 Site one base map

41E

1 : 58 000
0 1 2 3 MILES

Continued on PLATE 1.4-3

41J

PLATE 1.4-2 Site one 1957 map

1 : 20 000
0 1/2 1 MILE

41K

PLATE 1.4-3 Site one 1957 map

PLATE 1.5 Site one 1938 county drainage map

construction period and was made from aerial photography dated June 21, 1957 with a scale of approximately 1:20,000.

A composite master map at a scale of 1:24,000 was made for every site. PLATE 1.0 contains all the wetlands and drainage features of the I-69 site obtained from the previous four maps. The maps on PLATE 1.2 and PLATE 1.3 are enlarged to 1:24,000 scale before tracing the wetlands and the drainage systems to the base map. Similarly, PLATE 1.4 is reduced to 1:24,000 for the same purpose.

The drainage map (PLATE 1.5) prepared in 1953 from 1938 AAA aerial photographs shows the wetlands areas as closed basins (dotted lines) and the surface drainage systems (solid lines) at the date of photography. All of these closed basins on PLATE 1.5 are identified and mapped as wetlands in the pre-construction map of PLATE 1.4. The areas may vary because of time of aerial photography and season of the year with antecedent rainfall. PLATE 1.5 shows twenty-one gullies which the highway alignment (dashed-dot) crossed in 1958; and only the eight major gullies are shown on PLATE 1.4 before construction of the highway. The other 13 gullies were destroyed due to the farming and human-activities from the year 1938 to the year 1957. The pre-construction map (PLATE 1.4) shows a considerable number of lost or altered wetlands and a change in small gullies and streams next to the highway

corridor (compare to PLATE 1.0). Most of these changes are due to increased activities of man and land-use developments between 1958-1987 along the highway corridor. The highway crossed 1.1 miles of wetlands and eight major gullies by using bridges and culverts (PLATE 1.0).

The total number of wetlands inventoried within one half mile of both sides of the highway route is 318. The area and perimeter of each wetland larger than 0.5 acres are measured by using the Intergraph digitizing machine. The total number of wetlands measured within this site is 230 with a total area of 2350.9 acres. TABLE 5 shows the total number and area of wetlands according to their classification.

Twenty open-water wetlands were created after construction of the highway with a total area of 72.9 acres and an average area per wetland of 3.6 acres. The created wetlands were either developed from borrow pits used for highway construction or developed by the land owner for recreational purposes. Considering there were only 25 open-water wetlands before the highway construction, the twenty new wetlands are major enhancements to the ecological system. The total area of open-water wetlands before the highway construction is 316.7 acres with an average area per wetland of 12.7 acres. This large area is because many of the natural open-water wetlands are parts

TABLE 5. Summary of the total number and area of each wetland class in site one

Wetland Class	Total Number	Total Area (acre)	Average Area (acre)
Emergent	83	657.1	7.9
Forest	35	212.3	6.1
Scrub-Shrub	31	748.6	24.1
Open Water (Natural)	25	316.7	12.7
Open Water (Created)	20	72.9	3.6
Open Water (Total)	45	389.6	8.7
1987 Existing Total	194	2007.6	10.3
Destroyed	36	343.3	9.5

of large lakes such as Loon Lake and Bower Lake. The total number of natural wetlands before the highway construction was 210 with a total area of 1934.7 acres. The number of wetlands destroyed due to the highway or highway-induced activities is 36 with a total area of 343.3 acres.

Wetlands which are observed directly from the highway or from the nearby local roads were field checked, and ground photos taken for leaf-on and leaf-off conditions. Several of the wetlands hidden inside private property were not possible to visit without the landowner's permission. These field-checked wetlands are numbered from 1 to 45 on PLATE 1.0. TABLE 6 shows the distance from each wetland to the beginning of the site, the area, the perimeter, and the

perimeter to area ratio for each field-checked wetland. The IDOH environmental specialists identified the species and classification of these wetlands from the ground photos and from their visit to the site. Their classification is shown in TABLE 7. Since most of the wetlands in this site were very close to each other, the wetlands species and classifications could include those for adjacent wetlands.

Figure 4 is an illustration of the plant succession occurring in a created wetlands of a borrow pit. Figure 4 is a ground photo of wetland # 25 and shows significant vegetation in and around the water surface of the borrow pit developed for highway construction. A diversity of vegetation exists and provides cover and habitat for many and varied species of birds and animals. Figure 5 shows the ground photo of the natural wetland # 28 which was crossed by the highway. This kettle hole caused by the glacier could not be avoided and a bridge was designed to allow for the continuity of the water surface. The edge condition of the kettle hole with its natural vegetation was impacted by the roadway approach and exit over its entire width and for a short length at the edge of the water surface.

Along site one, very limited areas of wetland were impacted by the highway as the designer avoided natural

TABLE 6. Site one field-checked wetlands and their areas and perimeters.

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A $\frac{(\text{ft})}{(\text{acre})}$
1	0.7 E	6.7	2226	330
2	1.3 E	4.3	1728	402
3	1.4 E	4.0	1773	444
4	1.5 E	81.5	12468	153
5	2.4 E	2.2	1341	600
6	2.6 E	10.5	3624	345
7	3.7 E	9.1	2976	327
8	4.2 E	3.0	1542	522
9	4.6 E	9.9	3234	327
10	5.5 E	12.9	5073	393
11	5.6 W	7.6	4947	651
12	5.7 W	20.9	4185	201
13	5.9 W	32.7	6673	204
14	5.9 E	24.8	744	300
15	6.1 W	5.7	1875	333
16	6.5 W	1.5	1278	858
17	6.6 W	1.3	963	753
18	6.8 W	1.2	972	804
19	7.8 E	15.6	8664	363
20	8.5 E	2.9	1524	537

TABLE 6. (Continued)

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A $\frac{(\text{ft})}{(\text{acre})}$
21	8.5 E	1.4	1191	834
22	8.5 W	6.0	3057	507
23	9.1 W	81.3	21399	264
24	6.4 W	13.6	11937	87
25	12.2 E	3.6	1695	471
26	11.9 W	20.8	4866	234
27	13.0 W	576.0	28380	48
28	13.8EW	15.7	4455	285
29	13.9 W	10.0	3471	348
30	14.2 E	20.5	4440	216
31	14.4 W	0.7	789	1197
32	14.4 W	10.3	2649	258
33	14.3 W	1.0	1230	1185
34	14.8 E	2.9	1800	615
35	14.7 W	0.5	816	1650
36	14.9 W	12.7	4032	318
38	15.1 W	7.7	4230	546
39	15.2 W	22.1	5211	237
40	15.5 W	87.2	9396	108
41	15.7 E	20.3	348	171

TABLE 6. (Continued)

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A
				$\frac{\text{(ft)}}{\text{(acre)}}$
42	15.8 W	10.2	3723	366
43	16.0 W	25.3	6276	249
44	15.9 W	3.1	1446	471
45	16.6 W	2.0	1557	771

TABLE 7. Species and classifications for field-checked wetlands in site one (IDOH report).

Wetland Number	Wetland Species and Class
1	lacustrine, limnetic, open water, unknown bottom, excavated; lacustrine, littoral, unconsolidated shore, mud, excavated;
2	lacustrine, limnetic, open water, unknown bottom, excavated; lacustrine, littoral, partially bordered by unconsolidated shore palustrine, forested, broad-leaved, deciduous; palustrine, scrub/shrub, broad-leaved, deciduous, (cottonwood); palustrine, emergent, narrow-leaved, persistent;
3	palustrine, forested, broad-leaved, deciduous (cottonwood, boxelder); palustrine, scrub/shrub, broad-leaved, deciduous (cottonwood); palustrine, emergent, broad-leaved, persistent (ragweed);
4	palustrine, forested, broad-leaved, deciduous (cottonwood, boxelder); palustrine, scrub/shrub, broad-leaved, deciduous (cottonwood); palustrine, emergent, broad-leaved, persistent (ragweed);
5	palustrine, forested, broad-leaved, deciduous (boxelder, cottonwood, black willow);
6	palustrine, forested, broad-leaved, deciduous, temporarily flooded (cattail);
7	palustrine, scrub/shrub, broad-leaved, deciduous (willow); palustrine, emergent, narrow-leaved, persistent, temporarily flooded (cattail);

TABLE 7. (Continued)

Wetland Number	Wetland Species and Class
8	palustrine, emergent, narrow-leaved, persistent, temporarily flooded (grass);
9	lacustrine, limnetic, open water, unknown bottom, excavated; lacustrine, littoral, unconsolidated shore, sand;
10	palustrine, forested, broad-leaved, deciduous (cottonwood, boxelder); palustrine, scrub/shrub, broad-leaved, deciduous (cottonwood); palustrine, emergent, broad-leaved, persistent (ragweed);
11	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, unconsolidated shore, sand; surrounded by palustrine, forested, broad-leaved, deciduous (cottonwood, black willow); palustrine, scrub/shrub, broad-leaved, deciduous; palustrine, emergent, broad-leaved, persistent, saturated (Solidago);
12	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, unconsolidated shore, sand; surrounded by palustrine, forested, broad-leaved, deciduous (cottonwood, black willow); palustrine, scrub/shrub, broad-leaved, deciduous; palustrine, emergent, broad-leaved, persistent, saturated (Solidago);

TABLE 7. (Continued)

Wetland Number	Wetland Species and Class
13	lacustrine, limnetic, open water, unknown bottom, excavated; lacustrine, littoral, unconsolidated shore, mud, excavated;
14	palustrine, forested, broad-leaved, deciduous; palustrine, emergent, broad-leaved, persistent, persistent; temporarily flooded (Solidago);
15	palustrine, open water, unknown bottom; palustrine, emergent, narrow-leaved, persistent (cattail); palustrine, scrub/shrub, broad-leaved, deciduous; palustrine, forested, broad-leaved, deciduous;
16	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, open water, unknown bottom; palustrine, emergent, narrow-leaved, persistent (cattail); palustrine, scrub/shrub, broad-leaved, deciduous;
17	palustrine, open water, unknown bottom, semipermanently flooded; palustrine, emergent, narrow-leaved, persistent (cattail); palustrine, scrub/shrub, broad-leaved, deciduous, (black willow);
18	palustrine, forested, broad-leaved, deciduous; palustrine, scrub/shrub, broad-leaved, deciduous, seasonally flooded (black willow);

TABLE 7. (Continued)

Wetland Number	Wetland Species and Class
19	lacustrine, littoral, open water, unknown bottom, permanently flooded, impounded; palustrine, forested, dead, semipermanently flooded; the lake is partially bordered by palustrine, emergent, narrow-leaved, persistent, (cattail); palustrine, scrub/shrub, broad-leaved, deciduous, (black willow); palustrine, forested, broad-leaved, deciduous, (cottonwood, black willow);
20	palustrine, open water, unknown bottom; bordered by palustrine, emergent, narrow-leaved, persistent, (cattail);
21	lacustrine, littoral, open water, unknown bottom, excavated; lacustrine, limnetic, open water, unknown bottom; bordered by palustrine, emergent, narrow-leaved, persistent, (cattail); with some palustrine, scrub/shrub, broad-leaved, deciduous, (cottonwood, black willow, maple);
22	palustrine, open water, unknown bottom, permanently flooded, impounded; palustrine, forested, dead, permanently flooded; surrounded by palustrine, emergent, narrow-leaved, persistent;

TABLE 7. (Continued)

Wetland Number	Wetland Species and Class
23	lacustrine, limnetic, open water, unknown bottom; lacustrine, limnetic, open water, unknown bottom; palustrine, emergent, narrow-leaved, persistent, (cattail) on an island; lake surrounded by palustrine, emergent, narrow-leaved, persistent, (cattail); palustrine, scrub/shrub, broad-leaved, deciduous; palustrine, forested, broad-leaved, deciduous, (cottonwood); seasonally flooded;
24	lacustrine, limnetic, open water, unknown bottom; lacustrine, limnetic, open water, unknown bottom; palustrine, emergent, narrow-leaved, persistent, (cattail) on an island; lake surrounded by palustrine, emergent, narrow-leaved, persistent, (cattail); palustrine, scrub/shrub, broad-leaved, deciduous; palustrine, forested, broad-leaved, deciduous, (cottonwood); seasonally flooded;
25	palustrine, forested, broad-leaved, deciduous;
26	palustrine, forested, broad-leaved, deciduous, (cottonwood); palustrine, scrub/shrub, broad-leaved, deciduous, (black willow); palustrine, emergent, narrow-leaved, persistent;

TABLE 7. (Continued)

Wetland Number	Wetland Species and Class
27	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, unconsolidated shore, sand; palustrine, forested, broad-leaved, deciduous, (cottonwood, black willow); palustrine, scrub/shrub, broad-leaved, deciduous; palustrine, emergent, narrow-leaved, persistent, (cattail grasses); homes surrounded the lake
28	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, open water, unknown bottom; palustrine, scrub/shrub, broad-leaved, deciduous; palustrine, emergent, narrow-leaved, persistent, (cattail);
29	lacustrine, limnetic, open water, unknown bottom, impounded; lacustrine, littoral, open water, unknown bottom, impounded; palustrine, forested, broad-leaved, deciduous;
30	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, with some unconsolidated shore, sand; bordered by palustrine, emergent, narrow-leaved, persistent; palustrine, scrub/shrub, broad-leaved, deciduous; palustrine, forested, broad-leaved, deciduous;

TABLE 7. (Continued)

Wetland Number	Wetland Species and Class
31	palustrine, scrub/shrub, broad-leaved, deciduous, (willow); palustrine, emergent, narrow-leaved, persistent, seasonally flooded (cattail);
32	palustrine, forested, broad-leaved, deciduous; palustrine, emergent, narrow-leaved, persistent, (cattail);
33	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, unconsolidated shore, sand; palustrine, forested, broad-leaved, deciduous, (cottonwood, black willow); palustrine, scrub/shrub, broad-leaved, deciduous; palustrine, emergent, narrow-leaved, persistent, (cattail grasses); homes surround the lake
34	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, aquatic bed, floating; palustrine, emergent, broad-leaved, non-persistent; palustrine, emergent, narrow-leaved, persistent, (cattail); palustrine, scrub/shrub, broad-leaved, deciduous, (black willow);
35	lacustrine, limnetic, open water, unknown bottom, excavated; lacustrine, littoral, open water, unknown bottom, excavated; palustrine, scrub/shrub, broad-leaved, deciduous, (black willow); palustrine, emergent, narrow-leaved, persistent, (grasses);

TABLE 7. (Continued)

Wetland Number	Wetland Species and Class
36	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, open water, unknown bottom; palustrine, emergent, narrow-leaved, persistent, (cattail, grass); palustrine, open water, unknown bottom, permanently flooded; palustrine, forested, broad-leaved, deciduous; palustrine, scrub/shrub, broad-leaved, deciduous, (willow);
37	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, open water, unknown bottom; palustrine, forested, narrow-leaved, deciduous, (tamarack); palustrine, scrub/shrub, broad-leaved, deciduous; palustrine, emergent, narrow-leaved, persistent; palustrine, forested, dead;
38	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, open water, unknown bottom; palustrine, emergent, narrow-leaved, persistent, (cattail, grass); palustrine, open water, unknown bottom, permanently flooded; palustrine, forested, broad-leaved, deciduous; palustrine, scrub/shrub, broad-leaved, deciduous, (willow);

TABLE 7. (Continued)

Wetland Number	Wetland Species and Class
39	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, open water, unknown bottom; palustrine, emergent, narrow-leaved, persistent, (cattail, grass); palustrine, open water, unknown bottom, permanently flooded; palustrine, forested, broad-leaved, deciduous; palustrine, scrub/shrub, broad-leaved, deciduous, (willow);
40	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, open water, unknown bottom; palustrine, emergent, narrow-leaved, persistent, (cattail, grass); palustrine, open water, unknown bottom, permanently flooded; palustrine, forested, broad-leaved, deciduous; palustrine, scrub/shrub, broad-leaved, deciduous, (willow);
41	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, open water, unknown bottom; palustrine, emergent, narrow-leaved, persistent; (reeds), permanently flooded, lake surrounded by combination of palustrine, forested, broad-leaved, deciduous, (small areas) temporarily flooded; palustrine, scrub/shrub, broad-leaved, deciduous, temporarily flooded; palustrine, emergent, narrow-leaved, persistent (cattail) permanently flooded;

TABLE 7. (Continued)

Wetland Number	Wetland Species and Class
42	<p>These encompass a single wetlands complex</p> <p>palustrine, forested, broad-leaved, deciduous, (black willow) seasonally flooded;</p> <p>palustrine, forested, dead, semipermanently flooded;</p> <p>palustrine, scrub/shrub, broad-leaved, deciduous,</p> <p>palustrine, emergent, narrow-leaved, persistent, (cattail grass) seasonally flooded;</p> <p>palustrine, open water, unknown bottom, seasonally flooded;</p>
43	<p>These encompass a single wetlands complex</p> <p>palustrine, forested, broad-leaved, deciduous, (black willow) seasonally flooded;</p> <p>palustrine, forested, dead, semipermanently flooded;</p> <p>palustrine, scrub/shrub, broad-leaved, deciduous,</p> <p>palustrine, emergent, narrow-leaved, persistent, (cattail grass) seasonally flooded;</p> <p>palustrine, open water, unknown bottom, seasonally flooded;</p>
44	<p>palustrine, forested, broad-leaved, deciduous, (boxelder, black willow);</p> <p>palustrine, emergent, narrow-leaved, persistent;</p>
45	<p>palustrine, open water, unknown bottom; surrounded by</p> <p>palustrine, emergent, narrow-leaved, persistent, (cattail);</p> <p>palustrine, scrub/shrub, broad-leaved, deciduous, (black willow);</p> <p>palustrine, forested, broad-leaved, deciduous, (black willow);</p> <p>palustrine, forested, dead;</p>

Figure 4. Photo of wetland # 25 at site one

Figure 5. Photo of wetland # 28 at site one

wetlands. The total number of wetlands before the highway construction was 298 with a total area of 2278 acres. New wetlands were created at 20 sites with a total open-water area of 22.9 acres resulting in 3.2 percent increase. Approximately 15.1 percent of the wetlands within the one-mile wide highway corridor were destroyed or modified by the highway-induced activities.

SITE TWO

A. General

The site is located in Jasper, Newton, and Lake counties on I-65 with a total length of about 18 miles. It starts south of the interchange with SR-10 at milepost 230 and it extends to the north of the interchange with US-231 at milepost 247.

The topography of this site is nearly level. The site exhibits a high water table and is poorly drained to very poorly drained. The soils are formed on medium-textured to coarse-textured glacial outwash in the area generally south of SR-2 at milepost 11 on the map, and the area to the north is on ridge and ground moraine of Wisconsinan age. The site elevation ranges between 700 to 720 feet above sea level. The site was opened to traffic on 10-31-1968.

B. Wetlands and Drainage Mapping

The wetlands and drainage inventory of the four sets of aerial photographs used at this site are digitized on Intergraph computer. PLATE 2.0 is the computer print for the site base map. The pre-construction aerial photography

MAP LEGEND

Open Water Wetlands (Natural)

Open Water Wetlands (Created)

Emergent Wetlands

Scrub-shrub Wetlands

Forest Wetlands

Destroyed Wetlands

Major Rivers

Channels, Streams, and Minor rivers

Small Gulleys

Interstate Highway

State Roads and Major Roads

Minor Roads

MP

OFFICIAL MILEPOST

1

MILEPOST

1

WETLAND NUMBER

PLATE 2.0-3 Site two base map

is dated 1957, the post construction photography is dated 1987, and the NHAP for both the color infra-red and black and white photography is dated 1983. TABLE 8. shows the identification numbers of each set of aerial photography used in the mapping.

TABLE 8. Identification numbers of the photos used in mapping site two

Photography Type	Serial number	
	From	To
1987 Black and White	155	169
1983 Color Infra Red	263-74	263-80
1983 Black and White	184-166	184-171
1957 Black and White	BFN-1T-29	BFN-1T-33
	BFJ-1V-68	BFJ-1V-80
	BFJ-1V-120	BFJ-1V-118

Most of this site, particularly the outwash plain segment, is drained by man-made ditches due to the poor natural drainage system. The natural drainage system of the site consists of some surface drainage systems on the moraine north of SR-2. The man-made and natural channels flow to the Kankakee River (milepost 5.5). The highway bridged the Kankakee River and 27 man-made ditches. Thirteen of these 27 man-made ditches were developed between 1938-1957 (milepost 1.5, 3, 4, and 8.5). More man-made ditches were developed in the corridor on both sides of the highway between 1957-1987 (milepost 0 to 3).

The total number of wetlands inventoried within one half mile of both sides of the highway route is 87 wetlands. The area and perimeter of each wetland larger than 0.5 acres are measured by using the Intergraph digitizing machine. The total number of wetlands measured within this site is 71 wetlands with a total area of 1016.8 acres but five wetlands consisting of about 46.7 acres have been destroyed. TABLE 9. shows the total number and area of wetlands according to their classification.

TABLE 9. Summary of the total number and area of each wetland class in site two

Wetland Class	Total Number	Total Area (acre)	Average Area (acre)
Emergent	34	371.6	10.9
Forest	7	415.5	59.3
Scrub-Shrub	1	5.8	5.8
Open Water (Natural)	0	0.0	0.0
Open Water (Created)	24	177.2	7.4
Open Water (Total)	24	177.2	7.4
1987 Existing Total	66	970.1	14.7
Destroyed	5	46.7	9.3

No natural open-water wetlands are encountered except when the forest wetlands next to the Kankakee River are flooded. The site contains numerous created open-water wetlands. Twenty four open-water wetlands were created in constructing the highway and they contain a total area of 177.2 acres and an average area per wetland of 7.4 acres. The largest of the created wetlands at this site within one half mile distance from the highway is 20.6 acres (wetland #34) at milepost 6. Most of the twenty four created open-water wetlands were developed as borrow pits for the highway construction. These wetlands are a major enhancement to the total ecological system due to the rarity of natural open-water wetlands within the site. The highway bridged about one mile of wetlands next to the Kankakee River (mileposts 5 and 6). Two other wetlands were crossed by the highway (milepost 10.5 and 16.7) with a total length of about 0.2 miles. The number of wetlands impacted due to the highway or land-use activities is five wetlands with a total area of 46.7 acres.

The field-checked wetlands for this site are numbered from 1 to 80 on PLATE 2.0. TABLE 10. shows the distance from each wetland to the beginning of the site, the area, the perimeter, and the perimeter to area ratio for each field-checked wetland. The IDOH identification and classification of these wetlands from the ground photos and

TABLE 10. Site two field-checked wetlands and their areas and perimeters.

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A $\frac{(\text{ft})}{(\text{acre})}$
1	0.0 E	3.9	1681	433
3	0.7 W	8.2	2768	337
7	2.8 W	11.1	3171	286
9	3.6 W	4.4	2139	484
15	4.2 W	14.7	4758	325
17	4.4 E	16.6	2139	484
27	5.3 E	15.1	4127	273
34	5.9 W	20.6	3861	187
36	6.8 W	7.8	2571	336
39	7.8 E	11.8	2894	244
41	8.4 E	14.4	3526	245
47	9.2 E	9.2	3003	325
50	10.3 W	5.4	1944	360
55	11.8 W	0.7	792	1145
63	14.6 E	1.9	1235	660
65	15.4 E	17.5	5303	303
70	16.8 W	1.6	1071	686
71	16.8 E	1.0	1059	1017
72	17.0 W	5.3	2133	395
74	17.8 E	5.6	2292	412

TABLE 10. (Continued)

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A $\frac{(\text{ft})}{(\text{acre})}$
76	18.2 E	7.1	2201	311
77	18.2 W	9.2	3197	346
78	18.3 E	2.5	1296	519
79	18.5 E	7.1	2425	340
80	18.5 W	2.2	1368	628

from their visit to the site are shown on TABLE 11.

Most of the natural forest wetlands at this site exist along the Kankakee River. Some emergent and riverine wetlands exist along the tributary gullies of the Kankakee River (wetlands #23 and #24).

Figure 6 is a photograph of a created wetland (wetland #15) north of milepost 4. This wetland was created south of the forest wetlands of the Kankakee River. Figure 7 shows another created wetland (wetland #3) that is used for fishing and boating as well as camping site. Wetland #3 was used as a borrow pit for the SR-10 interchange. No significant wetlands were developed as borrow pits in the ridge moraine areas as cuts and fills balanced.

At site Two both the number and the area of created wetlands exceed the number and the area of destroyed wetlands. The total number of wetlands that existed before the highway construction was 47 wetlands with a total area of 839.6 acres. New wetlands were created at 24 locations with a total open-water area of 177.2 acres or 21.1 percent increase. Approximately 5.5 percent of the wetlands within the one-mile wide highway corridor were modified by the highway activities and land use changes associated with increasing population and the attraction of the Interstate corridor.

TABLE 11. Species and classifications for field-checked wetlands in site two (IDOH report).

Wetland Number	Wetland Species and Class
1	lacustrine, limnetic and littoral, open water, (excavated); palustrine, emergent, narrow-leaved persistent (cattail).
2	riverine, lower perennial, unconsolidated bottom.
3	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, sand.
4	palustrine, emergent, narrow-leaved persistent (cattail) side ditch;
5	riverine, lower perennial, unconsolidated bottom; palustrine, forested, broad-leaved, deciduous (birch).
6	riverine, lower perennial, aquatic bed, floating; palustrine, forested, broad-leaved, deciduous (birch).
7	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous (willow).
8	palustrine, emergent, narrow-leaved persistent (cattail) legal ditch; riverine, lower perennial, aquatic bed.
9	lacustrine, limnetic and littoral, open water, (excavated); lacustrine, littoral, unconsolidated shore, sand; palustrine, emergent, broad-leaved persistent.
10	riverine, lower perennial, unconsolidated bottom, mud (legal ditch).

TABLE 11. (Continued)

Wetland Number	Wetland Species and Class
11	palustrine, emergent, narrow-leaved persistent (cattail) side ditch.
12	palustrine, emergent, broad-leaved persistent (weeded drainage ditch).
13	palustrine, emergent, broad-leaved and narrow-leaved persistent (weeds and cattail) drainage ditch.
14	riverine, aquatic bed; palustrine, emergent, narrow-leaved persistent (cattail).
15	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous.
16	palustrine, emergent, narrow-leaved persistent (cattail).
17	lacustrine, limnetic and littoral, open water, (excavated); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (equisetum).
18	riverine, lower perennial, unconsolidated bottom, (drainage ditch).
19	riverine, lower perennial, unconsolidated bottom.
20	riverine, lower perennial, unconsolidated bottom.
21	palustrine, forested, broad-leaved, deciduous, seasonally flooded (cottonwood and willow) side ditch.

TABLE 11. (Continued)

Wetland Number	Wetland Species and Class
22	riverine, lower perennial, unconsolidated bottom, (side ditch).
23	palustrine, emergent (corn field);
24	palustrine, scrub-shrub, broad-leaved deciduous (man made).
25	riverine, lower perennial, unconsolidated bottom, (man made); palustrine, emergent, narrow-leaved persistent; palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous.
26	palustrine, forested, broad-leaved, deciduous, seasonally flooded (birch/silver maple).
27	palustrine, scrub-shrub, broad-leaved deciduous. palustrine, forested, broad-leaved deciduous; palustrine, open water.
28	riverine, lower perennial, aquatic bed, floating; palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous.
29	riverine, lower perennial, unconsolidated bottom, (man made); palustrine, emergent, narrow-leaved persistent; palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous.
30	riverine, lower perennial, unconsolidated bottom, (Kankakee River).
31	palustrine, forested, broad-leaved deciduous.

TABLE 11. (Continued)

Wetland Number	Wetland Species and Class
32	palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, broad-leaved and narrow-leaved persistent.
33	palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, open water (oxbow); riverine, lower perennial, unconsolidated bottom, (man made);
34	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous; palustrine, forested, broad-leaved deciduous.
35	riverine, lower perennial, unconsolidated bottom, (excavated ditch); palustrine, forested, broad-leaved deciduous.
36	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous (excavated); palustrine, scrub-shrub, broad-leaved deciduous.
37	riverine, lower perennial, unconsolidated bottom, (legal drain).
38	riverine, lower perennial, unconsolidated bottom, (legal drain)
39	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent (cattail); palustrine, scrub-shrub, broad-leaved deciduous (willow).

TABLE 11. (Continued)

Wetland Number	Wetland Species and Class
40	riverine, lower perennial, unconsolidated bottom, (drain).
41	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, broad-leaved persistent; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, forested, broad-leaved deciduous.
42	palustrine, emergent, broad-leaved persistent (horse weed) drainage ditch.
43	riverine, lower perennial, unconsolidated bottom, (legal drain). palustrine, forested, broad-leaved, deciduous (north side of Riverine) (cottonwood).
44	riverine, lower perennial, unconsolidated bottom, (legal drain). palustrine, forested, broad-leaved, deciduous (north side of Riverine) (cottonwood).
45	riverine, lower perennial, unconsolidated bottom.
46	riverine, lower perennial, unconsolidated bottom.
47	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent; palustrine, scrub-shrub, broad-leaved deciduous.
48	palustrine, emergent, persistent, (farmed);
49	palustrine, emergent, narrow-leaved persistent (horsetail) legal ditch.
50	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent.

TABLE 11. (Continued)

Wetland Number	Wetland Species and Class
51	palustrine, emergent, narrow-leaved persistent (excavated) side ditch.
52	palustrine, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous.
53	palustrine, emergent, narrow-leaved persistent (cattail) side ditch SR-2;
54	palustrine, emergent, narrow-leaved persistent (cattail).
55	palustrine, open water, unknown bottom; palustrine, scrub-shrub, broad-leaved deciduous (excavated).
56	palustrine, emergent, narrow-leaved persistent (cattail).
57	palustrine, emergent, narrow-leaved persistent (cattail).
58	palustrine, emergent, narrow-leaved persistent (cattail).
60	palustrine, emergent, narrow-leaved persistent (grass).
61	palustrine, emergent, narrow-leaved persistent (cattail).
62	palustrine, emergent, narrow-leaved persistent (cattail) and broad-leaved persistent (weeds).
63	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, forested, broad-leaved deciduous.
64	palustrine, emergent, broad-leaved and narrow-leaved persistent temporarily flooded (farmed); palustrine, scrub-shrub, broad-leaved deciduous.

TABLE 11. (Continued)

Wetland Number	Wetland Species and Class
65	palustrine, emergent, narrow-leaved persistent (grass).
66	palustrine, scrub-shrub, broad-leaved deciduous; riverine, intermittent; East of I-65 riverine, intermittent; palustrine, emergent, broad-leaved and narrow-leaved persistent; West of I-65.
67	palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous; riverine, intermittent (organic).
68	palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous; riverine, intermittent (organic).
69	palustrine, scrub-shrub, broad-leaved deciduous (background); palustrine, forested, broad-leaved deciduous.
70	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent (cattail); palustrine, scrub-shrub, broad-leaved deciduous.
71	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent (grass).
72	lacustrine, limnetic and littoral, open water; palustrine, scrub-shrub, broad-leaved deciduous (excavated).
73	lacustrine, limnetic and littoral, open water, (excavated).

TABLE 11. (Continued)

Wetland Number	Wetland Species and Class
74	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent (cattail); palustrine, scrub-shrub, broad-leaved deciduous.
75	lacustrine, limnetic and littoral, open water, (excavated); palustrine, scrub-shrub, broad-leaved deciduous.
76	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous.
77	palustrine, scrub-shrub, broad-leaved deciduous (excavated); palustrine, emergent, narrow-leaved persistent (cattail).
78	palustrine, emergent, narrow-leaved persistent (cattail) man-made.
79	lacustrine, limnetic and littoral, open water, (excavated); palustrine, emergent, narrow-leaved persistent (cattail).
80	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent (cattail).

Figure 6. Photo of wetland # 15 at site two

Figure 7. Photo of wetland # 3 at site two

SITE THREE

A. General

The site is located in the west side of Delaware county on I-69 with a total length of about 23 miles. It starts at the south end of the interchange with SR-32 at milepost 33.5 and it extends north to the north end of the interchange with SR-26 at milepost 55.5 in Grant county. The topography of this site is nearly level to gently sloping. The land form is till plain of Wisconsin age and the soil texture is clay-silt with sand. The site is somewhat poorly drained except along the terraces and flood plains of the White River, Killbuck Creek, and Mud Creek, where the surface drainage is well developed. The site elevation ranges between 880 to 920 feet above sea level. The site was opened to traffic on December 15, 1964. [28,30,31,35]

B. Wetlands and Drainage Mapping

The inventory of wetlands and drainage features of the site is shown on PLATE 3.0. PLATE 3.0 is a combination of the four maps used in the inventory superimposed onto the site base map. The pre-construction map is made from aerial

MAP LEGEND **Open Water Wetlands (Natural)** **Open Water Wetlands (Created)** **Emergent Wetlands** **Scrub-shrub Wetlands** **Forest Wetlands** **Destroyed Wetlands** **Major Rivers** **Channels, Streams, and Minor rivers** **Small Gulleys** **Interstate Highway** **State Roads and Major Roads** **Minor Roads****MP****OFFICIAL MILEPOST****1****MILEPOST****1****WETLAND NUMBER**

PLATE 3.0-2 Site three base map

photography dated 1956, and the post-construction map is made from the 1987 photography. TABLE 12 shows the identification numbers of each set of photography used in the mapping.

TABLE 12. Identification numbers of the photos used in mapping site three

Photography Type	Serial number	
	From	To
1987 Black and White	121	137
1981 Color Infra Red	65-202 201-140	65-209 -
1981 Black and White	42-103	42-108
1956 Black and White	BFA-1R-7 BFC-2R-147	BFA-1R-23 BFC-2R-152

The highway bridged all the streams, creeks, and rivers running perpendicular to the highway corridor (e.g. the White River). Some of the small streams running parallel to the highway corridor became part of the highway drainage ditches. Some of the tributaries of Killbuck Creek were obstructed by the highway between mileposts 8 to 10. The length of a demolished gully that is now the side ditch is about 1000 feet. A gully at milepost 3 was shortened by 1000 feet due to the highway crossing and a similar shortening happened to a creek at mile post 11.5. No changes are encountered on the drainage system of the White River, Hoppas Ditch, and Fowler Ditch due to the highway

construction. The pre-construction map shows major changes on Hoppas Ditch tributaries from 1938 to 1957. No man-made channels are made after the highway construction except for the highway side ditches and median drainage paths along the alignment.

The total number of wetlands inventoried within one half mile of both sides of the highway route is 153. The area and perimeter of each wetland larger than 0.5 acres are measured by using the Intergraph digitizing machine. The total of 123 wetlands are measured within this site, with a total area of 790.7 acres. TABLE 13 shows the total number and area of wetlands according to their classification.

TABLE 13. Summary of the total number and area of each wetland class in site three

Wetland Class	Total Number	Total Area (acre)	Average Area (acre)
Emergent	53	378.1	7.1
Forest	12	53.4	4.5
Scrub-Shrub	19	96.6	5.1
Open Water (Natural)	3	4.6	1.5
Open Water (Created)	23	102.8	4.5
Open Water (Total)	26	107.4	4.1
1987 Existing Total	110	635.5	5.8
Destroyed	13	155.2	11.9

Due to the nature of this site, the most dominate wetland class is emergent wetlands (378.1 acres). The site contains very few natural open-water wetlands and lakes (4.6 acres). Twenty-three open-water wetlands were created in constructing the highway with a total area of 102.8 acres and an average area per wetland of 4.5 acres. The average size of the created wetland at this site is high because most of the wetlands were created as borrow pits for the highway (the size of the borrow pit is as high as 15 acres for wetlands 39, 55, and 61). Since there were only three open-water wetlands before the highway construction, the twenty three new wetlands are enhancing the total ecological system for this site. The highway crossed three emergent wetlands at mileposts 2.5, 9, and 20. The number of wetlands impacted due to the highway or land-use activities is 13 with a total area of 155.2 acres.

The field-checked wetlands for this site are numbered from 1 to 65 on PLATE 3.0. The distance from each wetland to the beginning of the site, the area, the perimeter, and the perimeter-to-area ratio for each field-checked wetland are indicated on TABLE 14. The IDOH identification and classification of these wetlands from the ground photos and from the visit to the site are shown on TABLE 15.

TABLE 14. Site three field-checked wetlands and their areas and perimeters.

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A $\frac{(ft)}{(acre)}$
1	0.0 W	32.3	6534	202
5	2.8 E	6.1	2427	399
6	2.9 E	0.8	981	1241
7	3.4 W	3.3	1527	466
8	3.8 W	3.0	1461	487
9	4.7 W	0.7	1029	1194
10	5.1 E	5.0	2241	448
11	6.0 E	3.8	1653	433
12	6.3 W	1.5	1062	712
14	7.2 W	0.6	792	1434
15	7.1 W	0.7	1005	1477
21	7.9 E	2.9	1788	623
22	8.2 E	5.2	2628	506
23	8.3 E	4.3	1716	402
24	8.3 W	3.4	1524	448
25	8.6 E	6.0	2745	455
26	8.7 W	0.3	705	2738
29	8.8 W	0.2	630	2560
31	9.0 E	1.3	1086	868
36	10.5 E	7.5	3474	464

TABLE 14. (Continued)

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A $\frac{(\text{ft})}{(\text{acre})}$
37	10.6 W	2.0	1260	626
38	11.4 W	4.1	1935	467
39	11.6 W	14.3	3669	256
40	12.8 E	2.6	1479	574
41	13.7 W	3.3	1965	604
42	14.2 E	0.8	1056	1333
43	14.6 W	1.3	1410	1059
44	15.4 E	1.6	1395	887
45	15.9 W	0.2	606	2728
47	16.5 W	1.1	1188	1086
48	16.9 W	2.8	2160	775
51	18.5 E	17.8	4185	235
52	18.7 E	9.8	2871	294
55	19.3 W	14.5	3240	224
56	19.3 W	3.4	1764	525
58	20.3 E	2.4	1596	678
59	20.7 W	0.9	918	1071
61	21.2 E	13.7	3261	238
62	21.8 E	0.7	1014	1535
63	22.1 E	13.1	4959	379

TABLE 15. Species and classifications for field-checked wetlands in site three (IDOH report).

Wetland Number	Wetland Species and Class
1	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, sand/gravel; palustrine, forested, broad-leaved, deciduous (cottonwood); palustrine, emergent, narrow-leaved persistent (cattail).
2	palustrine, emergent, narrow/broad-leaved deciduous (grass, foxtail, sedge) farmed.
3	palustrine, emergent, narrow-leaved persistent (cattail, horsetail, flood-plain side ditch).
4	riverine, lower perennial, unconsolidated bottom, mud; palustrine, forested, broad-leaved, deciduous.
5	palustrine, emergent, broad-leaved persistent.
6	lacustrine, littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent.
7	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, aquatic bed, floating leaved; palustrine, scrub-shrub, broad-leaved deciduous.
8	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated bottom mud; palustrine, emergent, narrow-leaved persistent (cattail); palustrine, scrub-shrub, broad-leaved deciduous (willow).
9	palustrine, scrub-shrub, broad-leaved deciduous.

TABLE 15. (Continued)

Wetland Number	Wetland Species and Class
10	lacustrine, littoral, aquatic bed, floating leaved (excavated, 12 mallards); palustrine, emergent, narrow-leaved persistent; palustrine, scrub-shrub, broad-leaved deciduous.
11	lacustrine, littoral, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, sand.
12	palustrine, emergent, farmed.
13	palustrine, forested, broad-leaved, deciduous; palustrine, scrub-shrub, broad-leaved deciduous.
14	riverine, lower perennial, unconsolidated bottom, mud; palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent (grass and cattail).
15	palustrine, open water, unknown bottom (excavated from pond); palustrine, aquatic bed, floating; palustrine, emergent, narrow-leaved persistent (grass and cattail) located south of open water.
16	riverine, lower perennial, unconsolidated bottom, mud; palustrine, emergent, broad-leaved persistent (aster); palustrine, emergent, narrow-leaved persistent (grass).
17	riverine, intermittent, unconsolidated bottom, mud; palustrine, forested, broad-leaved, deciduous (boxelder, honey locust, hawthorn).

TABLE 15. (Continued)

Wetland Number	Wetland Species and Class
18	riverine, intermittent, unconsolidated bottom, mud; palustrine, forested, broad-leaved deciduous.
19	riverine, lower perennial, unconsolidated bottom, mud; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, broad-leaved persistent; palustrine, aquatic bed, floating.
20	riverine, intermittent, unconsolidated bottom, mud; riverine, aquatic bed, floating; palustrine, forested, broad-leaved, deciduous (sycamore and boxelder); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, broad-leaved persistent.
21	palustrine, forested, broad-leaved, deciduous (excavated, cottonwood).
22	palustrine, open water, unknown bottom (excavated); palustrine, forested, broad-leaved, deciduous (cottonwood); palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent.
23	palustrine, scrub-shrub, broad-leaved deciduous (willow and cottonwood); palustrine, emergent, narrow-leaved persistent (grass and cattail).
24	palustrine, forested, broad-leaved deciduous; palustrine, emergent, broad-leaved persistent; palustrine, emergent, narrow-leaved persistent.
25	palustrine, emergent, narrow/broad-leaved deciduous (grass, foxtail, sedge) farmed.

TABLE 15. (Continued)

Wetland Number	Wetland Species and Class
26	palustrine, open water, unknown bottom (excavated); palustrine, forested, broad-leaved deciduous.
27	palustrine, open water, unknown bottom (30'X40'); palustrine, forested, broad-leaved, deciduous (aspen and cottonwood); palustrine, scrub-shrub, broad-leaved deciduous.
28	riverine, intermittent, unconsolidated bottom, mud; palustrine, forested, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent (side ditch of I-69).
29	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, mud.
30	palustrine, forested, broad-leaved persistent; palustrine, scrub-shrub, broad-leaved deciduous.
31	riverine, intermittent, unconsolidated bottom, mud.
32	palustrine, forested, broad-leaved deciduous (drainage swale);
33	palustrine, emergent, broad-leaved persistent (pickerelweed); palustrine, emergent, narrow-leaved persistent (grass).
34	riverine, lower perennial, unconsolidated bottom (30' strip); palustrine, forested, broad-leaved deciduous.

TABLE 15. (Continued)

Wetland Number	Wetland Species and Class
35	riverine, intermittent, unconsolidated bottom, mud; palustrine, scrub-shrub, broad-leaved deciduous (willow).
36	palustrine, forested, broad-leaved deciduous (pockets in upland).
37	palustrine, forested, broad-leaved, deciduous (cottonwood); palustrine, scrub-shrub, broad-leaved deciduous.
38	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, open water, unknown bottom; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent (cattail).
39	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, sand/mud; palustrine, emergent, narrow-leaved persistent (grass and cattail); palustrine, scrub-shrub, broad-leaved deciduous (willow).
40	lacustrine, littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent (grass and cattail).
41	palustrine, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent (cattail).

TABLE 15. (Continued)

Wetland Number	Wetland Species and Class
42	palustrine, scrub-shrub, broad-leaved deciduous (willow).
43	palustrine, open water, unknown bottom (excavated).
44	lacustrine, littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent (cattail).
45	palustrine, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, forested, broad-leaved deciduous.
46	riverine, lower perennial, unconsolidated bottom, mud; palustrine, forested, broad-leaved deciduous (Pipe Creek);
47	palustrine, open water, unknown bottom (excavated); palustrine, forested, dead (pig lot).
48	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated bottom, mud; palustrine, forested, broad-leaved, deciduous (cottonwood).
49	riverine, lower perennial, aquatic bed, floating.
50	palustrine, emergent, broad-leaved persistent (framed); palustrine, emergent, narrow-leaved persistent.

TABLE 15. (Continued)

Wetland Number	Wetland Species and Class
51	palustrine, emergent, narrow-leaved persistent (cattail).
52	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, mud/artificial (tires); palustrine, emergent, narrow-leaved persistent (grass and cattail).
53	palustrine, emergent, narrow-leaved persistent; palustrine, aquatic bed, floating.
54	palustrine, emergent, narrow-leaved persistent (grass) on east-side road.
55	palustrine, open water, sand/gravel/mud bottom (4' depth, excavated); palustrine, aquatic bed, floating; palustrine, unconsolidated shore, mud; palustrine, forested, broad-leaved, deciduous (cottonwood); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass and cattail).
56	palustrine, scrub-shrub, broad-leaved deciduous (willow).
57	riverine, intermittent, unconsolidated shore, vegetated pioneer (grass) of Fowler Ditch.
58	lacustrine, littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent (cattail); palustrine, scrub-shrub, broad-leaved deciduous.
59	lacustrine, limnetic, open water, unknown bottom (excavated); palustrine, forested, broad-leaved deciduous.

TABLE 15. (Continued)

Wetland Number	Wetland Species and Class
60	palustrine, emergent, narrow-leaved persistent (Fowler Ditch).
61	lacustrine, littoral, aquatic bed, floating (excavated); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass and cattail).
62	palustrine, scrub-shrub, broad-leaved deciduous (willow).
63	palustrine, emergent, narrow-leaved persistent (grass); palustrine, emergent, broad-leaved persistent.
64	riverine, intermittent, unconsolidated shore, vegetated pioneer (grass) of Fowler Ditch.
65	palustrine, aquatic bed, floating (interchange side ditch); palustrine, emergent, broad-leaved persistent; palustrine, emergent, narrow-leaved persistent (cattail).

Most of the natural forest and scrub-shrub wetlands at this site exist along the Killbuck Creek (wetlands #13 and # 24). Some emergent and riverine wetlands exist along the tributary gullies and creek edges. The riverine wetlands #4 and #19 are too small in area to map. The highway construction created similar wetlands along the drainage ditch (wetland #2) and, also, along the gullies which became part of the drainage ditch (wetlands #34 and #35). The areas of these riverine wetlands along the natural drainage system and highway ditches are not measured due to their small size as they are generally smaller than 0.5 acre (see points 4, and 27 on PLATE 3.0).

Figure 8 is a photo of a natural wetland (wetland # 48). Figure 9 is an example of a borrow pit wetland (wetland #39). The borrow pit wetland shows a significant number of deciduous trees with a few conifers along the edge of the wetland similar to the natural wetland in Figure 8 but with more diversity. It also shows birds utilizing the wetland edge.

The highway crossed a wide wetland area at milepost 2.8 and also at milepost 20. A wetland was truncated near milepost 18. The remainder area is visible from the highway rest area

Figure 8. Photo of wetland # 48 at site three

Figure 9. Photo of wetland # 39 at site three

on the west side of I-69. The rest area on the east side of I-69 at milepost 17 is a part of the visual scene for travelers.

The highway alignment was curved between mileposts 8 to 9 to minimize the impact on Killbuck Creek. Only minor tributaries of the Creek were destroyed with minor wetlands area.

Along I-69 Site Three, a total of 130 wetlands existed before the highway construction, with a total area of 687.9 acres. Twenty three new wetlands were created with a total open-water area of 102.8 acres or 14.9 percent increase. Approximately 22.5 percent of the wetlands within the one-mile wide highway corridor were modified mostly by the changing land-use activities and partially by the highway construction.

Major borrow pit wetlands of diverse type were developed at mile post 3.4 (#7), at milepost 3.9 (#8), milepost 5 (#10), mile post 6 (#11), milepost 8 (#21 and #22), milepost 11.5 (#38 and #39), milepost 13 (#40), milepost 13.6 (#41), milepost 14.5 (#43), mile post 16.5 (#47), milepost 19 (#52 and #55), milepost 20.3 (#58), and milepost 21.2 (#61).

SITE FOUR

A. General

The site is located in Henry and Wayne counties on I-70 with a total length of about 30 miles. It starts about three quarter miles east of the interchange with SR-227 at milepost 153 on the west side of Middle Fork Reservoir on the Whitewater River. It extends westward to the west end of the interchange with SR-3 at milepost 122.

The topography of this site is nearly level to gently sloping on the ground moraine and outwash plains. Steep slopes exist along the valleys of Middle Fork River, Whitewater River, Nolands Fork, Greens Fork, Martindale Creek, and Flatrock River. The drainage system on the outwash plains is primarily internal and the soil texture is gravel and sand with minor amount of silt and clay near the surface. The land form between the outwash plains is dominated by low ridge moraines and till plains with the soil texture consisting of mixed silt and clay with some sand and gravel. The topography in these glacial plains is nearly level to gently sloping, and the terrain is poorly to somewhat poorly drained with man-made ditches, such as

Mercer Ditch. The site elevation ranges between 1000 to 1100 feet above sea level. The eastern part of the site (east of Centerville Road) was opened to traffic on June 17, 1961, the western part (west of SR-1) was opened to traffic on July 10, 1967, and the remaining part of the site was opened to traffic on August 30, 1963. [26,27,28,31,36,41]

B. Wetlands and Drainage Mapping

The wetlands and drainage inventory of the four sets of aerial photographs used at this site are superimposed onto the site base map PLATE 4.0. The pre-construction aerial photography is dated 1955, the post-construction photography is dated 1987, and the NHAP for both the color infra red and black and white photography is dated 1983. TABLE 16 shows the identification numbers of each set of aerial photography used in the mapping.

The highway bridged all the 16 rivers, creeks, and ditches running perpendicular to the highway corridor (Middle Fork River, West Fork, Clear Creek, Lick Creek, Nolands Fork, College Corner Branch, Greens Fork, Dry Branch, Martindale Creek, Whitewater River, Symonds Creek, Glue Run Branch, Symons Creek, Mercer Ditch, Flatrock River, and Buck Creek), and the highway also bridged their major tributaries. Although I-70 is running parallel to

MAP LEGEND

Open Water Wetlands (Natural)

Open Water Wetlands (Created)

Emergent Wetlands

Scrub-shrub Wetlands

Forest Wetlands

Destroyed Wetlands

Major Rivers

Channels, Streams, and Minor rivers

Small Gulleys

Interstate Highway

State Roads and Major Roads

Minor Roads

MP

OFFICIAL MILEPOST

1

MILEPOST

1

WETLAND NUMBER

95A

PLATE 4.0-1 Site four base map

PLATE 4.0-2 Site four base map

PLATE 4.0-3 Site four base map

PLATE 4.0-5 Site four base map

TABLE 16. Identification numbers of the photos used in mapping site four

Photography Type	Serial number	
	From	To
1987 Black and White	253	273
1983 Color Infra Red	201-237	201-238
	201-245	201-246
	63-180	63-181
	65-28	65-29
	65-70	65-71
	65-126	65-127
1983 Black and White	134-115	134-116
	40-199	40-200
	40-237	40-238
	42-14	42-15
	42-52	42-53
1956 Black and White	FK-3R-113	FK-3R-141
	FK-3R-142	FK-3R-143
	FK-3R-196	FK-3R-198
	FK-4R-13	FK-4R-15
	FK-4R-68	FK-4R-70
	FK-4R-97	FK-4R-99
	FK-4R-151	FK-4R-153
	FK-4R-180	FK-4R-182
	FK-2R-27	FK-2R-29
	FJ-2R-67	FJ-2R-69
	FJ-2R-120	FJ-2R-122
	FJ-2R-159	FJ-2R-161
	FJ-2R-177	FJ-2R-179
	FJ-2R-215	FJ-2R-217
	FJ-2R-107	FJ-2R-109

Symons Creek (mileposts 21 to 22) for about one mile, the highway avoided obstructing the creek. The highway and land use developments have altered a few tributaries to Lick Creek (milepost 5.5), Glue Run Branch (milepost 19.5), Flatrock River (milepost 26), and Buck Creek (milepost 28).

The farming and land use activities before 1955 made major changes in the area between mileposts 0 to 5 (see the tributaries and drainage system of the Middle Fork River, West Fork, and Clear Creek on the 1938 county drainage map). The Middle Fork Reservoir is not shown on the 1938 drainage map but it existed on the 1955 pre-construction map and it is bridged by the highway without any major impact. Two man-made ditches are encountered at this site (Gephart Ditch at milepost 6.5 and Mercer Ditch at milepost 23).

The total number of wetlands inventoried within one half mile of both sides of the highway route is 146. The area and perimeter of each wetland larger than 0.5 acres are measured by using the Intergraph digitizing machine. The total number of wetlands measured within this site is 129, with a total area of 1170.9 acres. TABLE 17 shows the total number and area of wetlands according to their classification.

Due to the nature of this site, the most dominate wetland class is forest wetlands (439.9 acres). The site is very poor in natural open-water wetlands, and it has only one natural open-water wetland (wetland #1). Middle Fork Reservoir is considered a natural wetland here because it existed before the highway construction (see natural wetland definition). Twenty four open-water wetlands were

TABLE 17. Summary of the total number and area of each wetland class in site four

Wetland Class	Total Number	Total Area (acre)	Average Area (acre)
Emergent	34	212.0	6.2
Forest	41	439.9	10.7
Scrub-Shrub	21	165.3	7.9
Open Water (Natural)	1	87.3	87.3
Open Water (Created)	24	153.4	6.4
Open Water (Total)	25	240.7	9.6
1987 Existing Total	121	1057.9	8.7
Destroyed	8	113.0	14.1

created in constructing the highway with a total area of 153.4 acres and an average area per wetland of 6.4 acres.

The largest of the created wetlands at this site within one half mile distance from the highway is 15.2 acres (wetland #8). Most of the twenty four created open-water wetlands were created as borrow pits for the highway construction, and they are a major enhancement to the total ecological system due to the rarity of natural open-water wetlands. The highway crossed 13 wetlands at mileposts 0.5, 1.3, 2.3, 5.9, 8.6, 8.8, 11.3, 12.7, 14.5, 16.3, 23.8, 25, and 26.9 with a total length of 1.5 miles. The number of wetlands impacted due to the highway or land-use activities is eight, with a total area of 113 acres.

The field-checked wetlands for this site are numbered from 1 to 41 on PLATE 4.0. TABLE 18 shows the distance from each wetland to the beginning of the site, the area, the perimeter, and the perimeter to area ratio for each field-checked wetland. The IDOH identification and classification of these wetlands from the ground photos and from their visit to the site are shown on TABLE 19.

Most of the natural forest wetlands at this site exist along the West Fork, Nolands Fork, Green Fork, Martindale Creek, Whitewater River, and Glue Run Branch. Some emergent and riverine wetlands exist along the tributary gullies and creek edges next to the forest wetlands (#24 and #37).

Figure 10 is a photograph of a created wetland (wetland #18) surrounded by cottonwood and willow trees. It is designed to be similar to a natural wetland. This wetland is open for public use by the Department of Natural Resources and it is used for fishing and boating. Figure 11 shows another created wetland (wetland #37) where it is surrounded by deciduous trees and an island with a single willow tree inside the wetland. The very small island inside the created wetland gives the wetland some ecological value for birds.

At site four, both the number and the area of created wetlands exceed the number and the area of destroyed

TABLE 18. Site four field-checked wetlands and their areas and perimeters.

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A $\frac{(\text{ft})}{(\text{acre})}$
1	0.3	87.3	18222	209
3	1.2 N	0.5	864	1753
4	2.3 S	39.2	7077	180
5	4.0 S	1.6	1197	769
6	4.1 S	0.8	921	1183
7	4.9 N	11.9	3177	267
8	6.1 N	15.2	3255	213
9	6.8 S	3.8	1851	486
10	6.8 N	1.6	1467	930
11	7.5 S	22.6	5592	247
12	8.1 N	0.7	1170	1651
13	8.5 S	19.4	4209	216
14	11.1 N	1.5	1194	801
15	11.3 S	7.4	2400	325
16	11.3 N	4.9	1785	365
18	12.8 S	12.0	2829	235
19	13.4 N	1.6	1188	724
20	14.5 N	25.8	4773	185
21	15.1 S	6.7	2484	371
22	16.0 S	0.9	822	958

TABLE 18. (Continued)

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A $\frac{(\text{ft})}{(\text{acre})}$
23	16.2 S	6.5	2637	408
25	16.4 S	3.6	2136	595
27	20.4 S	1.5	1113	755
28	21.0 S	6.9	2256	394
29	21.5 N	27.6	5451	197
31	22.3 N	4.9	1878	381
32	23.1 N	4.8	1983	414
33	23.8 S	2.2	1281	576
34	24.3 N	4.1	1797	440
35	26.0 N	0.8	1995	2601
36	26.1 N	12.1	2952	244
37	26.1 S	8.3	3105	373
38	26.9 N	2.7	1695	630
39	28.0 N	4.3	1893	444
40	29.2 N	11.2	2736	244
41	29.5 N	9.3	2646	284

TABLE 19. Species and classifications for field-checked wetlands in site four (IDOH report).

Wetland Number	Wetland Species and Class
1	<p>riverine, lower perennial, open water, unknown bottom; lacustrine, littoral, unconsolidated shore, mud; lacustrine, limnetic, open water, unknown bottom; palustrine, forested, broad-leaved, deciduous (willow and cottonwood); palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent (grass and cattail).</p>
2	<p>riverine, lower perennial, open water, unknown bottom; lacustrine, littoral, unconsolidated shore, mud; lacustrine, limnetic, open water, unknown bottom; palustrine, forested, broad-leaved, deciduous (willow and cottonwood); palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent (grass and cattail).</p>
3	<p>palustrine, open water, unknown bottom (excavated); partially edged by palustrine, unconsolidated shore, cobble/gravel; palustrine, emergent, narrow-leaved persistent (cattail).</p>
4	<p>riverine, upper perennial, open water; lined by palustrine, forested, broad-leaved, deciduous (cottonwood, willow, and sycamore); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass).</p>

TABLE 19. (Continued)

Wetland Number	Wetland Species and Class
5	lacustrine, limnetic, open water, unknown bottom (excavated); edged by palustrine, emergent, narrow-leaved persistent; palustrine, forested, broad-leaved, deciduous (cottonwood).
6	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, partially edged by unconsolidated shore; surrounded by palustrine, emergent, narrow-leaved persistent (grass); palustrine, scrub-shrub, broad-leaved deciduous (at thin line).
7	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, some unconsolidated shore, sand; partially surrounded by palustrine, emergent, narrow-leaved persistent (cattail).
8	lacustrine, (excavated).
9	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, open water, unknown bottom; partially surrounded by a narrow band of palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent.
10	palustrine, emergent, farmed.
11	riverine, lower perennial, open water; lined with palustrine, forested, broad-leaved, deciduous (cottonwood); palustrine, scrub-shrub, broad-leaved deciduous (willow).

TABLE 19. (Continued)

Wetland Number	Wetland Species and Class
12	palustrine, open water, unknown bottom (excavated); palustrine, unconsolidated shore, mud; palustrine, emergent, narrow-leaved persistent (cattail).
13	palustrine, open water, unknown bottom; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, forested, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent.
14	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, limnetic, open water, unknown bottom; with small amount of palustrine, forested, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent (cattail).
15	riverine, unknown perennial, open water; lined by palustrine, forested, broad-leaved, deciduous (cottonwood, boxelder, sycamore and willow).
16	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, open water, unknown bottom; palustrine, forested, broad-leaved, deciduous (cottonwood); palustrine, scrub-shrub, broad-leaved deciduous (willow).
17	riverine, intermittent, streambed, mud; lined by palustrine, forested, broad-leaved, deciduous (cottonwood).

TABLE 19. (Continued)

Wetland Number	Wetland Species and Class
18	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, open water, unknown bottom; partially surrounded by a narrow band of palustrine, forested, broad-leaved, deciduous (cottonwood and willow).
19	palustrine, emergent, narrow-leaved persistent (cattail) farmed.
20	riverine, lower perennial, open water; lined with palustrine, forested, broad-leaved, deciduous (willow and sycamore); palustrine, scrub-shrub, broad-leaved deciduous (willow and boxelder).
21	palustrine, forested, broad-leaved deciduous (only lowest portion of woodlot).
22	palustrine, open water, unknown bottom (excavated); palustrine, unconsolidated shore, cobble/gravel/mud; surrounded by palustrine, emergent, narrow-leaved persistent (grass); palustrine, scrub-shrub, broad-leaved deciduous (willow); -portions of wetlands have been filled in with junk.
23	riverine, unknown perennial, open water (drainage ditch); lined with palustrine, forested, broad-leaved, deciduous (willow and sycamore); palustrine, scrub-shrub, broad-leaved deciduous (willow and boxelder).
24	lustrine, emergent, farmed.
25	palustrine, emergent, broad-leaved persistent (solidago) -legal drain.

TABLE 19. (Continued)

Wetland Number	Wetland Species and Class
26	riverine, unknown perennial, open water; lined by palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous (cottonwood).
27	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, aquatic bed; partially bounded by palustrine, emergent, narrow-leaved persistent (cattail); palustrine, scrub-shrub, broad-leaved deciduous.
28	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, open water, unknown bottom; palustrine, forested, broad-leaved, deciduous (cottonwood and willow); palustrine, emergent, narrow-leaved persistent.
29	palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous (willow).
30	riverine, unknown perennial, open water; lined by palustrine, scrub-shrub, broad-leaved deciduous (willow and boxelder); palustrine, emergent, broad-leaved persistent (solidago).
31	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, open water, unknown bottom; with scattered palustrine, scrub-shrub, broad-leaved deciduous (willow and sycamore).

TABLE 19. (Continued)

Wetland Number	Wetland Species and Class
32	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, mud; partially bordered by palustrine, scrub-shrub, broad-leaved deciduous (willow and cottonwood); palustrine, emergent, narrow-leaved persistent.
33	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, limnetic, open water, unknown bottom; some palustrine, scrub-shrub, broad-leaved deciduous (willow); rest of perimeter palustrine, emergent, narrow-leaved persistent (cattail).
34	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, limnetic, open water, unknown bottom; bordered by palustrine, emergent, narrow-leaved persistent (cattail).
35	riverine, lower perennial, open water, unknown bottom; lined by palustrine, forested, broad-leaved, deciduous (cottonwood, boxelder, and sycamore).
36	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, with portions of unconsolidated shore, mud; palustrine, forested, broad-leaved, deciduous (cottonwood); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (cattail).

TABLE 19. (Continued)

Wetland Number	Wetland Species and Class
37	lacustrine, limnetic, open water, unknown bottom (excavated); partially surrounded by palustrine, forested, broad-leaved, deciduous (willow) island; palustrine, forested, broad-leaved, deciduous (sycamore and cottonwood).
38	palustrine, forested, broad-leaved, deciduous, seasonally flooded (cottonwood, sycamore, and willow).
39	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, partially bounded with unconsolidated shore, cobble/gravel/sand/mud/artificial (riprap); there are also portions of palustrine, emergent, narrow-leaved persistent (cattail) surrounding the lake; palustrine, scrub-shrub, broad-leaved deciduous (willow).
40	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, mud; surrounded by palustrine, emergent, narrow-leaved persistent (cattail).
41	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, limnetic, open water, unknown bottom; with some scattered palustrine, emergent, narrow-leaved persistent (cattail).

Figure 10. Photo of wetland # 18 at site four

Figure 11. Photo of wetland # 37 at site four

wetlands. The total number of wetlands before the highway construction was 105, with a total area of 1017.5 acres. New wetlands were created at 24 locations, with a total open-water area of 153.4 acres or 15.1 percent increase. Approximately 11.1 percent of the wetlands within the one-mile wide highway corridor were modified by the highway activities and land use changes associated with increasing population and the attraction of the Interstate corridor.

SITE FIVE

A. General

The site is located on I-74, with a total length of about 17 miles. It starts at the interchange with SR-229 in Franklin county at milepost 149.5 near Batesville and extends north-west to the interchange with SR-3 in Decatur county at milepost 132.5. The topography of this site is nearly level to gently sloping. The slopes along the entrenched streams are gently undulating on the flood plain to very steep and vertical where the underlying limestone bedrock is exposed in benches.

The predominate land form is Illinoian ground moraine composed of loess and glacial drift. The soil texture is predominately old drift silts and silty-clays. The soil is poorly drained on the nearly level and gentle slope. The soil is well drained on the valley walls and steep slopes along the benches. The site elevation ranges from 950 to 1000 feet above sea level. Interstate 74 was the first Interstate route completed across Indiana. The site included here was opened to traffic on October 29, 1963. [21,28,31,34]

B. Wetlands and Drainage Mapping

Two sets of aerial photography are used in mapping this site. The pre-construction map is made from aerial photography dated 1955, and the post-construction map is made from the 1987 photography. PLATE 5.0 is the combination of the two maps into the site base map. TABLE 20 shows the identification numbers of each set of photography used in the mapping.

TABLE 20. Identification numbers of the photos used in mapping site five

Photography Type	Serial number	
	From	To
1987 Black and White	191	201
1957 Black and White	RM-2P-74	-
	RM-2P-79	RM-2P-80
	RM-2P-136	-
	CMF-1P-6	-
	CMF-1P-32	-
	CMF-1P-48	CMF-1P-49
	CMF-1P-70	-
	CMF-1P-95	-
	CMF-1P-114	-

PLATE 5.0 shows no major change in the surface drainage system due to the highway construction. The highway bridged all the streams, creeks, and rivers running perpendicular to the highway corridor (e.g. Sand Creek). Some of the small streams running parallel to the highway corridor became part of the highway drainage ditches. Due

MAP LEGEND

Open Water Wetlands (Natural)

Open Water Wetlands (Created)

Emergent Wetlands

Scrub-shrub Wetlands

Forest Wetlands

Destroyed Wetlands

Major Rivers

Channels, Streams, and Minor rivers

Small Gulleys

Interstate Highway

State Roads and Major Roads

Minor Roads

MP OFFICIAL MILEPOST

1 MILEPOST

1 WETLAND NUMBER

1 : 24 000
0 1/2 1 MILE

112B

PLATE 5.0-2 Site five base map

to the nature of the natural drainage system at this site, no man-made channels are encountered except for side ditches and median drainage paths along the alignment.

The total number of wetlands inventoried within one-half mile of both sides of the highway route is 76. The area and perimeter of each wetland larger than 0.5 acres are measured by using the Intergraph digitizing machine. The total number of wetlands measured within this site is 65 including three destroyed wetlands, with a total area of 281.8 acres. TABLE 21 shows the total number and area of wetlands according to their classifications.

TABLE 21. Summary of the total number and area of each wetland class in site five

Wetland Class	Total Number	Total Area (acre)	Average Area (acre)
Emergent	6	20.6	3.4
Forest	13	84.7	6.5
Scrub-Shrub	12	70.3	5.9
Open Water (Natural)	2	36.7	18.4
Open Water (Created)	29	39.0	1.3
Open Water (Total)	31	75.7	2.4
1987 Existing Total	62	251.3	4.1
Destroyed	3	30.5	10.2

Twenty-nine open-water wetlands were created after constructing the highway, with a total area of 39.0 acres and an average area per wetland of 1.3 acres. The average size of the created wetland at this site is small because more wetlands were created for private use by the land owners rather than those created as borrow pits for the highway. Usually a borrow pit size ranges from 4 to 15 acres. Since there were only two open-water wetlands before the highway construction, the twenty-nine new wetlands are enhancing the total ecological system for this site. The total area of open-water wetlands before the highway construction is 36.7 acres with an average area per wetland of 18.4 acres. This large average area is because Lake McCoy is one of the two natural wetlands adjacent to the highway corridor. Although there were no wetlands crossed by the highway, the number of wetlands destroyed due to the highway or highway-induced activities is three, with a total area of 30.5 acres.

The field-checked wetlands for this site are numbered from 1 to 52 on PLATE 5.0. TABLE 22 shows the distance from each wetland to the beginning of the site, the area, the perimeter, and the perimeter to area ratio for each field-checked wetland. The IDOH identification and classification of these wetlands from the ground photos and from their visit to the site are shown on TABLE 23.

TABLE 22. Site five field-checked wetlands and their areas and perimeters.

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A ($\frac{\text{ft}}{\text{acre}}$)
1	0.4 N	4.1	1668	411
3	0.5 S	4.2	1722	407
7	2.8 S	0.2	654	363
10	4.8 N	0.5	759	1471
15	6.3 N	1.4	1404	1026
17	7.2 N	7.1	2670	375
18	7.3 N	6.4	3819	594
19	7.4 S	1.7	1506	877
20	8.0 S	0.9	933	1041
21	8.2 S	0.6	1044	1620
22	8.3 S	7.9	3318	420
23	8.6 S	1.1	1296	1136
27	9.3 S	2.7	1782	668
28	9.4 N	4.8	2229	465
30	9.7 S	2.7	1812	670
31	10.0 S	7.0	3351	476
33	9.9 N	5.1	4335	842
34	10.2 S	2.7	1686	625
35	10.3 N	3.2	1866	578
36	10.4 S	31.5	7251	230

TABLE 22. (Continued)

Wet- land #	Location (mileage)	Area	Perimeter	L/A
		A (acre)	L (ft)	($\frac{\text{ft}}{\text{acre}}$)
40	11.3 S	1.0	990	1033
51	15.7 S	6.0	2084	347
52	15.9 S	15.8	3267	206

TABLE 23. Species and classifications for field-checked wetlands in site five (IDOH report).

Wetland Number	Wetland Species and Class
1	palustrine, emergent, narrow-leaved persistent (cattail).
2	riverine, lower perennial, unconsolidated bottom, mud; palustrine, forested, broad-leaved, deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass).
3	riverine, intermittent, streambed, mud; palustrine, forested, broad-leaved, deciduous (sycamore).
4	riverine, intermittent, streambed, mud; palustrine, forested, broad-leaved, deciduous (willow); palustrine, unconsolidated shore, mud (farmed).
5	riverine, lower perennial, unconsolidated bottom, mud (Laughery Creek); palustrine, forested, broad-leaved, deciduous (sycamore and cottonwood); palustrine, emergent, narrow-leaved persistent (grass).
6	palustrine, forested, broad-leaved, deciduous (sycamore and cottonwood); riverine, lower perennial, unconsolidated bottom, mud (Laughery Creek); same complex as #22.
7	palustrine, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass).

TABLE 23. Continue.

Wetland Number	Wetland Species and Class
8	riverine, intermittent, streambed, mud; same complex as #22.
9	riverine, intermittent, streambed, mud; palustrine, emergent, narrow-leaved persistent (grass); same complex as #22.
10	palustrine, open water, unknown bottom; palustrine, unconsolidated shore, sand; palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (cattail).
11	riverine, lower perennial, unconsolidated bottom, mud; palustrine, forested, broad-leaved, deciduous (cottonwood).
12	riverine, lower perennial, unconsolidated bottom, mud/sand/gravel (Salt Creek Complex); palustrine, forested, broad-leaved, deciduous (sycamore and boxelder); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass); palustrine, emergent, narrow-leaved persistent (solidago).
13	riverine, lower perennial, unconsolidated bottom, mud (drainage ditch).
14	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated bottom mud; palustrine, emergent, narrow-leaved persistent (grass).
15	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, rock bottom, bedrock.

TABLE 23. (Continued)

Wetland Number	Wetland Species and Class
16	palustrine, emergent, narrow-leaved persistent (cattail).
17	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, aquatic bed, floating; lacustrine, littoral, unconsolidated shore, mud; palustrine, forested, broad-leaved, deciduous (silver maple); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass).
18	palustrine, emergent, narrow-leaved persistent (cattail).
19	riverine, lower perennial, unconsolidated bottom, mud; palustrine, emergent, narrow-leaved persistent (grass); palustrine, emergent, narrow-leaved persistent (solidago).
20	palustrine, emergent, narrow-leaved persistent, farmed (grass).
21	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, mud; palustrine, emergent, narrow-leaved persistent (cattail).
22	lacustrine, limnetic, open water, unknown bottom (Lake McCoy); lacustrine, littoral, unconsolidated shore, mud/cobble (impounded); palustrine, forested, broad-leaved, deciduous (sycamore); palustrine, emergent, narrow-leaved persistent (grass).

TABLE 23. (Continued)

Wetland Number	Wetland Species and Class
23	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, mud; lacustrine, littoral, aquatic bed, floating; palustrine, scrub-shrub, broad-leaved deciduous (immature cottonwood); palustrine, emergent, narrow-leaved persistent (cattail).
24	palustrine, emergent, narrow-leaved persistent (cattail); palustrine, scrub-shrub, broad-leaved deciduous (willow).
25	riverine, lower perennial, unconsolidated bottom, mud; palustrine, emergent, narrow-leaved persistent (cattail).
26	riverine, lower perennial, unconsolidated bottom, mud; palustrine, forested, broad-leaved, deciduous (sycamore); palustrine, emergent, narrow-leaved persistent (grass).
27 28	palustrine, scrub-shrub, broad-leaved deciduous (maple); palustrine, emergent, narrow-leaved persistent (grass). palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow/broad-leaved deciduous (solidago and grass) farmed.
29	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, unconsolidated bottom mud; palustrine, unconsolidated shore, cobble/gravel (riprap).

TABLE 23. (Continued)

Wetland Number	Wetland Species and Class
30	lacustrine, limnetic, open water, unknown bottom (impounded); lacustrine, littoral, unconsolidated shore, mud; lacustrine, littoral, aquatic bed, floating; palustrine, forested, broad-leaved, deciduous (cottonwood).
31	riverine, lower perennial, unconsolidated bottom, mud/cobble; palustrine, forested, broad-leaved, deciduous (sycamore and cottonwood); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (cattail).
32	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, unconsolidated shore, mud; palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (cattail).
33	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, unconsolidated shore, mud; palustrine, forested, broad-leaved, deciduous (willow).
34	riverine, lower perennial, unconsolidated bottom, mud (part of Lake McCoy complex); palustrine, forested, broad-leaved, deciduous (sycamore and cottonwood); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass).

TABLE 23. (Continued)

Wetland Number	Wetland Species and Class
35	riverine, lower perennial, unconsolidated bottom, mud (part of Lake McCoy complex); palustrine, forested, broad-leaved, deciduous (sycamore and cottonwood); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass).
36	lacustrine, limnetic, open water, unknown bottom (Lake McCoy); lacustrine, littoral, unconsolidated shore, mud/cobble (impounded); palustrine, forested, broad-leaved, deciduous (sycamore); palustrine, emergent, narrow-leaved persistent (grass);
37	palustrine, emergent, narrow-leaved persistent (cattail), drainage ditch.
38	(cattail).
39	riverine, lower perennial, unconsolidated bottom, mud; palustrine, forested, broad-leaved, deciduous (sycamore and cottonwood); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (solidago spp.); palustrine, emergent, narrow-leaved persistent (grass).
40	lacustrine, limnetic, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, mud; palustrine, emergent, narrow-leaved persistent.
41	palustrine, emergent, narrow-leaved persistent (cattail), drainage ditch.

TABLE 23. (Continued)

Wetland Number	Wetland Species and Class
42	riverine, lower perennial, unconsolidated bottom, mud; palustrine, scrub-shrub, broad-leaved deciduous (willow);
43	palustrine, emergent, narrow-leaved persistent (grass and cattail) drainage ditch.
44	palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (cattail).
45	palustrine, emergent, narrow-leaved persistent (grass); palustrine, emergent, narrow-leaved persistent (solidago).
46	palustrine, emergent, narrow-leaved persistent (grass); palustrine, emergent, narrow-leaved persistent (solidago).
47	palustrine, emergent, narrow-leaved persistent (cattail).
48	riverine, lower perennial, unconsolidated bottom, mud; palustrine, forested, broad-leaved, deciduous (sycamore and cottonwood); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass).
49	riverine, lower perennial, unconsolidated bottom, mud (Sand Creek); palustrine, forested, broad-leaved, deciduous (sycamore and cottonwood) palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (grass).

TABLE 23. (Continued)

Wetland Number	Wetland Species and Class
50	riverine, intermittent, streambed, mud; palustrine, emergent, narrow-leaved persistent, farmed (grass).
51	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, unconsolidated shore, mud; palustrine, scrub-shrub, broad-leaved deciduous (willow and cottonwood); palustrine, emergent, narrow-leaved persistent (grass).
52	lacustrine, limnetic, open water, unknown bottom; lacustrine, littoral, unconsolidated shore, mud; palustrine, scrub-shrub, broad-leaved deciduous (willow and cottonwood); palustrine, emergent, narrow-leaved persistent (grass).

Most of the natural forest wetlands at this site exist along the main rivers and streams of the ground moraine (wetlands #31 and # 34). Small riverine wetlands exist along the tributary gullies and creek edges (for example wetlands #3 and #4) and are too small in area to map. The highway construction created similar wetlands along the drainage ditch (wetland #13). The areas of these riverine wetlands along the natural drainage system and highway ditches are not measured due to their small size as they are generally smaller than 0.5 acres (see points 4, 5, and 6 on PLATE 5.0-1).

Figure 12 is an example of a wetland created along the highway ditches as related to construction near wetland # 35. Figure 13 is a photograph of a borrow pit wetland (wetland #23). The photo shows a significant number of coniferous trees along the edge of the wetland and, also, shows the recreational use of the wetland associated with borrow pit lakes.

Wetland # 15 is a large (1.5 acres) lacustrine wetland with limestone bedrock at a shallow depth. Further west at wetland # 17 about 7.1 acres of excavated wetlands of mixed lacustrine-palustrine type supports a mixed vegetation that

Figure 12. Photo of wetland # 25 at in site five

Figure 13. Photo of wetland # 23 at site five

provides cover and protection for animals as well as open water.

The highway alignment was curved between points 9 to 12 to minimize the impact on Lake McCoy identified as wetland # 36. Only minor tributaries that drain into the lake were crossed with minor riverine wetlands.

Along site five, very limited areas of natural wetlands were impacted by the highway. A few small riverine wetlands were impacted at gully, stream and riverine crossings. The total number of wetlands before the highway construction was 49, with a total area of 242.8 acres. New wetlands were created at 29 locations with a total open-water area of 39.0 acres or 15.5 percent increase. Approximately 12.1 percent of the wetlands within the one-mile wide highway corridor were destroyed or modified by the highway activities and land use changes.

SITE SIX

A. General

The site is located in Bartholomew, Shelby, and Johnson counties on I-65 with a total length of about 22 miles. It starts at the south end of the interchange with SR-46 at milepost 68 and it extends north to the north end of the interchange with SR-44 at milepost 90.

The topography of this site is nearly level on outwash plains to strongly sloping on terrace faces and valley walls. The soil is developed on floodplains and outwash plains with medium to coarse texture in the southern part to silty to loamy outwash in the northern part. The site is well drained to somewhat poorly drained in the northern three miles. The site elevation ranges from 620 to 650 feet above sea level in the southern part and it rises up to 700 feet in the northern part. The southern part of the site (south of US-31) was opened to traffic in October 29, 1962, the northern part (north of SR-252) was opened to traffic in June 30, 1972, and the remaining part of the site was opened to traffic in August, 1970. [20,24,28,31,33,37,39]

B. Wetlands and Drainage Mapping

The wetlands and drainage inventory of the four sets of aerial photographs used at this site are superimposed onto the site base map PLATE 6.0. The pre-construction photographs are dated 1956, and the post-construction photography is dated 1987. TABLE 24 shows the identification numbers of each set of aerial photography used in the mapping.

TABLE 24. Identification numbers of the photos used in mapping site six

Photography Type	Serial number	
	From	To
1987 Black and White	172	190
1981 Color Infra Red	201-5 61-63	201-12 61-62
1981 Black and White	132-151	132-156
1956 Black and White	RC-2P-88 FN-3R-66 FO-3R-78 FO-3R-156	RC-2P-98 FN-3R-62 FO-3R-80 FO-3R-157

The highway bridged all the streams, creeks, and rivers running perpendicular to the highway corridor (e.g. Driftwood River, Big Blue River, and Sugar Creek). Although I-65 is running parallel to Driftwood River for about eight miles, the highway avoided obstructing the river tributaries and streams and their wetlands. A stream

MAP LEGEND

Open Water Wetlands (Natural)

Open Water Wetlands (Created)

Emergent Wetlands

Scrub-shrub Wetlands

Forest Wetlands

Destroyed Wetlands

Major Rivers

Channels, Streams, and Minor rivers

Small Gulleys

Interstate Highway

State Roads and Major Roads

Minor Roads

MP

OFFICIAL MILEPOST

1

MILEPOST

1

WETLAND NUMBER

Continued on PLATE 6.0-2

129A

PLATE 6.0-1 Site site base map

Continued on PLATE 6.0-3

PLATE 6.0-2 Site six base map

1:24,000
0 1/2 1 MILE

Continued on PLATE 6.0-4

129C

PLATE 6.0-3 Site site base map

running parallel to the highway corridor became part of the highway drainage ditches at milepost 20. A tributary of Driftwood River at milepost 12.8 is shown on the county drainage map (1938), and it is not shown on the pre-construction map due to the Edinburgh land development from 1938 to 1956. The gully shown on PLATE 6.0-2 is the remaining part of that Driftwood River tributary. Also, the 1938 map shows about eight minor gullies in the area between Big Blue River and Sugar Creek which are not in existence on the pre-construction map due to increased farming activities from 1938 to 1956. Highway I-65 did not change the drainage system of Driftwood River, Big Blue River, and Sugar Creek. No man-made channels have been developed after the highway construction except for the highway side ditches and median drainage paths along the alignment.

The total number of wetlands inventoried within one half mile of both sides of the highway route is 140. The area and perimeter of each wetland larger than 0.5 acres are measured by using the Intergraph digitizing machine. The total number of wetlands measured within this site is 131 including 36 destroyed wetlands, with a total area of 1087.9 acres. TABLE 25 shows the total number and area of wetlands according to their classifications.

TABLE 25. Summary of the total number and area of each wetland class in site six

Wetland Class	Total Number	Total Area (acre)	Average Area (acre)
Emergent	25	106.8	4.3
Forest	31	499.7	16.1
Scrub-Shrub	2	22.6	11.3
Open Water (Natural)	6	11.2	1.9
Open Water (Created)	31	92.7	3.0
Open Water (Total)	37	103.9	2.8
1987 Existing Total	95	733.0	7.7
Destroyed	36	354.9	9.9

Due to the nature of this site, the most dominate wetland class is forest wetlands (499.7 acres). The site has six natural open-water wetlands, with total area of 11.2 acres. Thirty-one open-water wetlands were created in constructing the highway, with a total area of 92.7 acres and an average area per wetland of 3.0 acres. The largest size of the created wetland in this site within half mile distance from the highway is 8.3 acres (wetland #22). Most of the thirty-one created open-water wetlands were created as borrow pits for the highway construction, and they are considered a major enhancement to the total ecological system (compare to only six open-water wetlands before constructing the highway). The highway crossed six wetlands, at mileposts 0.8, 2.0, 14.0, 15.2, and 17.7, with

total length of 0.65 miles. The number of wetlands impacted due to the highway or land-use activities is 36, with a total area of 354.9 acres.

The field-checked wetlands for this site are numbered from 1 to 34 on PLATE 6.0. TABLE 26 shows the distance from each wetland to the beginning of the site, the area, the perimeter, and the perimeter-to-area ratio for each field-checked wetland. The IDOH identification and classification of these wetlands from the ground photos and from their visit to the site are shown on TABLE 27.

Most of the natural forest wetlands at this site exist along the Driftwood River, Big Blue River, and Sugar Creek. Some emergent and riverine wetlands exist along the tributary gullies and creek edges next to the forest wetlands (#23 and #26). The highway construction created wetlands along the drainage ditch and, also, along the gullies which became part of the drainage ditch (milepost 20). The areas of these riverine wetlands along the natural drainage system and highway ditches are not measured due to their small size as they are generally smaller than 0.5 acres. Soil erosion is noticed in some parts in this site, and some wetlands exhibited edge erosion (wetland #26).

TABLE 26. Site six field-checked wetlands and their areas and perimeters.

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A (ft) (acre)
1	0.4 E	10.4	3282	317
2	0.7 W	4.8	2217	460
3	0.6 E	0.3	843	2687
6	2.0 E	2.5	1545	608
7	3.4 E	0.6	927	1429
9	3.6 E	2.1	1290	604
10	3.7 E	3.0	1785	603
12	7.3 W	0.5	780	1476
13	8.4 E	0.7	927	1307
14	8.5 W	3.0	1587	533
15	9.2 E	4.5	2100	468
16	11.8 E	3.3	1551	465
17	12.4 E	7.0	2682	384
18	12.7 W	5.9	2424	412
19	12.8 W	4.0	1707	432
20	13.7 W	6.8	2253	331
21	13.8 W	32.3	9723	301
22	14.0 W	8.3	2601	314
25	16.3 E	2.0	1626	800
27	18.4 E	5.5	2145	392

TABLE 26. (Continued)

Wet- land #	Location (mileage)	Area A (acre)	Perimeter L (ft)	L/A $\frac{(ft)}{(acre)}$
29	19.2 E	2.1	1575	745
31	19.7 W	2.6	1566	611
32	20.5 W	3.0	1713	559
33	21.0 W	5.2	3615	701
34	22.0 E	1.8	1404	781

TABLE 27. Species and classifications for field-checked wetlands in site six (IDOH report).

Wetland Number	Wetland Species and Class
1	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous (excavated); palustrine, scrub-shrub, broad-leaved deciduous.
2	palustrine, open water, unknown bottom; palustrine, scrub-shrub, broad-leaved deciduous (excavated).
3	lacustrine, limnetic and littoral, open water, unknown bottom (excavated): palustrine, scrub-shrub, broad-leaved deciduous; palustrine, forested, broad-leaved deciduous.
4	River, not considered a wetland.
5	palustrine, emergent, narrow-leaved persistent (grass).
6	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous.
7	palustrine, scrub-shrub, broad-leaved deciduous (excavated); palustrine, emergent, narrow-leaved persistent (cattail).
8	palustrine, scrub-shrub, broad-leaved deciduous (background); palustrine, forested, broad-leaved deciduous.
9	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, forested, broad-leaved deciduous: palustrine, scrub-shrub, broad-leaved deciduous.

TABLE 27. (Continued)

Wetland Number	Wetland Species and Class
10	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, sand; palustrine, emergent, narrow-leaved persistent.
11	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent (grass).
12	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, forested, broad-leaved deciduous.
13	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous (willow).
14	lacustrine, limnetic and littoral, open water; palustrine, scrub-shrub, broad-leaved deciduous (excavated).
15	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); lacustrine, littoral, unconsolidated shore, sand.
16	riverine, lower perennial, unconsolidated bottom, (man made); palustrine, emergent, narrow-leaved persistent; palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous.
17	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent (cattail).
18	riverine, lower perennial, unconsolidated bottom, mud (drainage ditch); palustrine, forested, broad-leaved deciduous.

TABLE 27. (Continued)

Wetland Number	Wetland Species and Class
19	palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, open water (oxbow); riverine, lower perennial, unconsolidated bottom, (man made).
20	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous (willow); palustrine, emergent, narrow-leaved persistent (equisetum).
21	palustrine, emergent, narrow-leaved persistent (grass).
22	palustrine, open water, unknown bottom (excavated); palustrine, scrub-shrub, broad-leaved deciduous.
23	palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent.
24	palustrine, scrub-shrub, broad-leaved deciduous; palustrine, forested, broad-leaved deciduous; palustrine, open water.
25	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent.
26	riverine, lower perennial, unconsolidated bottom, (man made); palustrine, emergent, narrow-leaved persistent; palustrine, forested, broad-leaved deciduous; palustrine, scrub-shrub, broad-leaved deciduous.

TABLE 27. (Continued)

Wetland Number	Wetland Species and Class
27	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent (cattail); palustrine, scrub-shrub, broad-leaved deciduous (willow).
28	palustrine, emergent, narrow-leaved persistent (horsetail) legal drain.
29	palustrine, scrub-shrub, broad-leaved deciduous (man made).
30	palustrine, emergent, narrow-leaved persistent (cattail) side ditch.
31	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, broad-leaved persistent; palustrine, scrub-shrub, broad-leaved deciduous.
32	palustrine, forested, broad-leaved deciduous; palustrine, emergent, narrow-leaved persistent, seasonally flooded.
33	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, narrow-leaved persistent (cattail).
34	lacustrine, limnetic and littoral, open water, unknown bottom (excavated); palustrine, emergent, broad-leaved persistent; palustrine, scrub-shrub, broad-leaved deciduous; palustrine, forested, broad-leaved deciduous.

Figure 14 is a photograph of a created wetland (wetland #1) surrounded by new developments to serve the travelers (Mc Donalds, Ramada Inn, Shell and Amoco Gas Stations, etc.). Figure 15 shows another created wetland, where a large number of ducks feed on the grass and use the water surface as part of their flyway.

The total number of wetlands along site six before the highway construction was 109, with a total area of 995.2 acres. New wetlands were created at 31 locations, with a total open-water area of 92.7 acres, or a 9.3 percent increase. Approximately 35.7 percent of the wetlands within the one-mile wide highway corridor were modified by the highway activities and land use changes.

Figure 14. Photo of wetland # 1 at site six

Figure 15. Photo of wetland # 32 at site six

SUMMARY AND CONCLUSIONS

Six Interstate highway sites (Two on I-65, two on I-69, one on I-70, and one on I-74) were selected for the drainage and wetlands study to represent different terrain and soils in Indiana. Two sites (Site one, I-69 & Site four, I-70) contained ridge moraine of Wisconsinan Age, two sites (Site three, I-69 & Site four, I-70) exhibits ground moraine of Wisconsinan Age, two sites (Site two, I-65 & Site six, I-65) are located in part on outwash plain of Wisconsinan Age, one site (Site five, I-74) is on ground moraine of Illinoian Age, and one site (Site six, I-65) is, in part on flood plain. Drainage systems and wetlands were inventoried at these sites along a one mile wide corridor for a total length of 128 miles and a total area of 128 square miles. The following summarizes the results and findings of the literature review, the effectiveness of using different types of photography with different scales, the highway and man-made changes on the drainage system, the highway impacts on wetlands since the highway construction, and the number and the area of wetlands along the Interstate highway at these sites.

Wetlands support vegetation and wildlife by providing the necessary water for living and ecosystem production. They are considered important features of Indiana landscapes and they are a natural resource. Wetlands vegetation also mitigates soil erosion, improves water quality, and provides scenic value. Wetlands, natural and man-made, are used for a variety of recreational and aesthetic purposes. They provide visual enjoyment, ecological research areas, and, in some cases, recreational business enterprise for Indiana citizens.

Different Federal and State executive orders and legislative acts have been issued during the last few decades to preserve the wetlands in their natural state, to minimize the man-made impacts on wetlands, and to create wetlands to enhance the ecological system and/or to substitute for the altered or destroyed wetlands.

Soils and landforms are deterministic factors on the quantity and the extent of the drainage patterns, and, thus, on the amount of highway impacts on the drainage system. The Interstate highways bridged all the major rivers and streams with minor impact on the drainage system. Small gullies in the various land forms crossed by the highway alignment became part of the highway drainage system with minor impact. Man-made ditches are encountered frequently along the corridor on the outwash plain at site

two, two ditches existed on the ground moraine at the site four corridor, and no ditches are found on the land forms at the other four sites. Land-use development in the highway corridor caused changes on the drainage systems and impacted the wetlands from 1938 to 1987 as recorded on the aerial photography.

The total number of wetlands inventoried at all sites is 920. The area is measured for each wetland with an area greater than 0.5 acre. The total number of measured wetlands is 749, and the total area of these wetlands is 6699 acres. TABLE 28 shows the total number and area of wetlands for each site. The most extensive wetlands in both number and area are in the I-69 corridor along site one in the ridge moraine. Site five on the Illinoian ground moraine exhibits the least number and area of wetlands.

The development of new Interstate highways created new wetlands from borrow pits used for highway construction in all six sites. At least twenty wetlands were created at every site but the total number and area of the created wetlands depend on the site terrain and soil type. Thus, site two which is primarily an outwash plain of low relief exhibits extensive open-water created wetlands and site one in rolling ridge moraine has the least number of borrow pit wetlands.

TABLE 28. The wetlands total number and area for all sites

Site #	Location	Inventoried Wetlands #	Measured Wetlands Area (acres)	
1	I-69	318	230	2350.9
2	I-65	87	71	1016.8
3	I-69	153	123	790.7
4	I-70	146	129	1170.9
5	I-74	76	65	281.8
6	I-65	140	131	1087.9
	Total	920	749	6699.0

TABLE 29 provides the total number and area for both the created wetlands and the destroyed or altered wetlands from the period before the highway construction until the 1987 period. Most of these destroyed wetlands are due to the land-use developments and highway-induced activities related to land-use changes. The table shows that the number and area of created wetlands exceed the number and area of destroyed wetlands for sites four and five. Sites three, four, and five are very poor in natural open-water wetlands and the created wetlands balanced the number and area of open-water wetlands and the number of destroyed wetlands (295.2 vs. 298.7 acres, respectively).

TABLE 29. The total number and area of created and destroyed wetlands for all sites

Site		Created Wetlands		Destroyed Wetlands	
#	#	area (acres)	#	area (acres)	
1	20	72.9	36	343.3	
2	24	177.2	5	46.7	
3	23	102.8	13	155.2	
4	24	153.4	8	113.0	
5	29	39.0	3	30.5	
6	31	92.7	36	354.9	
Total	151	638.0	101	1043.6	

CONCLUSIONS

The following conclusions are based on the use of aerial photography for the inventory of surface drainage systems and wetlands impacted by highway construction.

- a. Small scale color-infrared (1:58,000) and black and white (1:80,000) aerial photography do not record the detail required for drainage systems investigation and wetlands studies.
- b. Medium scale (1:24,000) black and white aerial photography is satisfactory for drainage system

studies, wetland inventory studies, and wetland classification.

- c. More detailed studies and classification are feasible using the large scale (1:12,000) aerial photography.
- d. The detailed county drainage maps prepared from medium (1:20,000) scale aerial photography of the 1938-1944 period are adequate except in those few counties that contain outwash plains and till plains that need man-made drainage improvements.
- e. Wetlands replacement and enhancement as a part of the highway construction is viable and is an important part of the highway location and design process. Properly placed as open-water wetlands they might serve ground water recharge.
- f. Borrow pits used for highway construction are the major attribute for creating 151 wetlands in the six sites with total area of 638.0 acres.
- g. The total area of wetlands larger than 0.5 acres inventoried along 128 miles of interstate highways is 6699.0 acres. Most of these wetlands exist on site one (2350.9 acres) on ridge moraine. Site five on Illinoian ground moraine exhibits the least area of wetlands (281.8 acres).
- h. The dominant wetland classes within the one-mile from the highway corridor are the emergent wetlands (1746.2 acres) and the forest wetlands (1705.5 acres). The

total area of the open-water wetlands is 1500.1 acres and the total area of the scrub-shrub wetlands is 1109.2 acres.

- i. Ecological succession, species diversity, and aesthetics are noticeable at most of the created wetlands, and these wetlands are used for a variety of purposes including water-related recreational activities.
- j. Environmental quality of the inventoried wetlands includes determining the wetland area and edge-to-area ratio, the types of species dominating the wetland, and the wetland classification.
- k. No environmental assessments or measurement are made for the quantity of edge vegetation, species diversity rating, depth of water, water quality, highway runoff constituents, aesthetic rating, or wildlife use and rating. These measurements require intensive site visits and special equipment, and they are beyond the scope of this study.

RECOMMENDATIONS

The study indicates a need to extend this drainage system and wetlands inventory to include all the Indiana highway system. This is to enable IDOH to preserve these

wetlands and to minimize any possible impact resulting from routine highway maintenance or highway relocation. Wetland inventory is essential for further monitoring and environmental assessments. The following are recommended for further studies.

1. Conduct a complete inventory of all wetlands along the Indiana Interstate highways using existing aerial photography used for the highway location studies before constructing the highways. Use it as a permanent record to represent the original status of the wetlands.
2. Conduct a complete inventory of wetlands along the Interstate highways every 15 to 20 years and determine the highway and highway-induced activities on these wetlands.
3. Update the county drainage maps in those counties with man-made ditch systems (areas of low relief such as ground moraines, outwash plains, and lacustrine plains), and determine the changes made by the highway and road system.
4. Create a data base of the existing wetlands and drainage system by digitizing them on the available computer digitizing machines. This data base is readily available for further environmental

assessments, statistical analysis, and other areas of research, if needed.

5. Select a few created wetlands in major land form types for comprehensive environmental impact assessment which could include determining the quantity of edge vegetation, species diversity rating, depth of water, water quality, highway runoff constituents, aesthetic rating, or wildlife use and rating on a regular basis at a five-years interval.

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APPENDICES

Appendix A: Highway Runoff Constituents [14]

Constituent	Description of Critical Level	Year of Criteria Issuance	Basis for Criteria or Water Use	Constituent	Description of Critical Level	Year of Criteria Issuance	Basis for Criteria or Water Use
Suspended solids	Should not reduce the depth of the compensation point for photosynthetic activity by more than 10% from the seasonally established norm for aquatic life	1976	Freshwater fish and other aquatic life	Nickel (cont.)	7.1 g/l (24-hr average) 140 g/l (not to exceed) 13.4 g/l (ingestion of water of water & contaminated organisms) 100 g/l (ingestion of contaminated organisms alone)	1980 1980 1980 1980	Saltwater aquatic life aquatic life Human health Human health
Ammonia	0.02 mg/l (un-ionized as $\text{NH}_3\text{-N}$)	1976	Freshwater aquatic life	Zinc (total) recoverable ^e	47 g/l (24-hr average) (0.83[ln(hardness)] + 1.95) (not to exceed)	1980 1980	Freshwater aquatic life Freshwater aquatic life
Dissolved oxygen	Greater than or equal to 5.0 mg/l	1976	Freshwater aquatic life		58 g/l (24-hr average) 170 g/l (not to exceed) 5 mg/l	1980 1980 1980	Saltwater aquatic life aquatic life Taste & odor
Phosphorus	0.10 g/l (elemental)	1976	Marine or estuarine waters	Mercury (total) recoverable	0.00057 g/l (24-hr average) 0.0017 g/l (not to exceed) 0.025 g/l (24-hr average) 3.7 g/l (not to exceed) 144 ng/l (ingestion of water and contaminated organisms) 146 ng/l (ingestion of contaminated organisms alone)	1980 1980 1980 1980 1980 1980	Freshwater aquatic life aquatic life Saltwater aquatic life aquatic life Human health Human health
Nitrate	10 mg/l (as N)	1976	Domestic water supply (health)	Iron	0.3 mg/l 1.0 mg/l	1976 1976	Domestic water supply/welfare Freshwater aquatic life
Chlorides	250 mg/l	1976	Domestic water supply (welfare)	Manganese	50 g/l 100 g/l	1976 1976	Domestic water supply/welfare Ingestion of marine mollusks
Sulfates	250 mg/l	1976	Domestic water supply (welfare)	Arsenic	440 mg/l (not to exceed) 508 g/l (acute toxicity*)	1980 1980	Freshwater aquatic life Saltwater aquatic life
Lead, g/l (total recoverable)	^e (2.35[ln(hardness)]-9.24) 24-hour average ^e (1.22[ln(hardness)]-0.47) (not to exceed) 668 g/l (acute toxicity*) 25 g/l (chronic toxicity*) 50 g/l	1980 1980 1980 1980 1980	Freshwater aquatic life Freshwater aquatic life Saltwater aquatic life aquatic life Human health		Zero (cancer risk levels also specified)	1980	Human health
Cadmium (total recoverable)	^e (1.05[ln(hardness)]-3.73) (not to exceed) 4.5 g/l (24-hr average) 59 g/l (not to exceed)	1980 1980 1980	Freshwater aquatic life Saltwater aquatic life aquatic life	Cyanides (free cyanide)	3.5 g/l (24-hr average) 52 g/l (not to exceed) 30 g/l (acute toxicity*) 2.0 g/l (chronic toxicity*) 200 g/l (ingestion of water and contaminated organisms)	1980 1980 1980 1980 1980	Freshwater aquatic life aquatic life Saltwater aquatic life aquatic life Human health
Chromium (total recoverable hexavalent)	0.29 g/l (24-hr average) 21 g/l (not to exceed) 18 g/l (24-hr average) 1,260 g/l (not to exceed) 50 g/l	1980 1980 1980 1980 1980	Freshwater aquatic life aquatic life Saltwater aquatic life aquatic life Human health	Asbestos	No toxicity data available for aquatic organisms Zero (cancer risk levels also specified)	1980 1980	Aquatic life Human health
Chromium (total recoverable trivalent)	^e (1.08[ln(hardness)]+3.48) (not to exceed) 44 g/l (chronic toxicity*) 10,300 g/l (acute toxicity*) 170 mg/l (ingestion of water and contaminated organisms) 3,433 mg/l (ingestion of contaminated organisms alone)	1980 1980 1980 1980 1980	Freshwater aquatic life aquatic life Saltwater aquatic life aquatic life Human health	PCB	0.014 g/l (24-hr average) 0.030 g/l (24-hr average) Zero (cancer risk levels also specified)	1980 1980 1980	Freshwater aquatic life aquatic life Saltwater aquatic life Human health
Copper (total recoverable)	5.6 g/l (24-hour average) ^e (0.94[ln(hardness)]-1.23) (not to exceed) 4.0 g/l (24-hr average) 23 g/l (not to exceed) 1 mg/l	1980 1980 1980 1980 1980	Freshwater aquatic life aquatic life Freshwater aquatic life aquatic life Taste & odor	Oil & Grease	0.01 times lowest continuous flow 96-hr LC_{50} for several important freshwater species; minimize sediment levels; surface waters free from floating oils	1976	Freshwater aquatic life
Nickel (total recoverable)	^e (0.76[ln(hardness)] + 1.06) (24-hr average) ^e (0.76[ln(hardness)]+4.02) (not to exceed)	1980 1980	Freshwater aquatic life aquatic life				

^e Specified as the lowest level that toxicity has been measured for certain organisms; other organisms could be affected at lower levels.

^e Specified as the lowest level that toxicity has been measured for certain organisms; other organisms could be affected at lower levels.

Vegetation Type	Aboveground Height	Belowground Characteristics	Plant Occurrences or Tolerances				Air Temp.*	Comments and References
			Soil	pH (water)	Salinity	Water Depth		
Sedges-bulrushes (<i>Scirpus</i> spp.)	0.3-3 m	Thick, creeping rhizomes	Refer to <i>Carex</i>	4-9	4-20 ppt optimum, 0-32 ppt range	Minimum 5-10 cm, maximum depth variable w/ species	17-28°C varies w/ geographical location	Water level is critical for <i>Scirpus</i> success; <i>S. olneyi</i> - .75 cm to 6 m; <i>S. acutus</i> and <i>S. validus</i> 1 m; <i>Scirpus</i> spp. at Suisun Marsh, CA. 0.75-25 cm. All <i>Scirpus</i> require freshwater for germination; <i>S. acutus</i> tolerates salinities to 32 ppt; <i>S. validus</i> & <i>S. heterochaetus</i> restricted to lower salinities; <i>S. olneyi</i> inhibited by 20 ppt; <i>S. robustus</i> thrives below 22 ppt. (86,87,88,92,116,117,118).
Canarygrasses (<i>Phalaris</i> spp.)	30 cm flower spikes 0.6-2 m	Creeping rhizomes	Silt loam (no data on content)	6.1-7.5	No data, but generally freshwater only	At or just below soil surface	15-25°C (up to 30°C some spp.) Seed germ. @ 18-35°C	Generally an upland grass that tolerates high moisture, high water tables & occasional inundation. <i>P. arundinacea</i> (reed canarygrass) is most commonly found & subject to study (118,119,120,121,122,123,124,125).
Cordgrasses (<i>Spartina</i> spp.)	Short forms; 0.3-0.4 m; tall forms; 1.2-2 m	Scalpy rhizomes	Sandy substrate	4.7-7.8	9-34 ppt	-.15 to .7 m	12-29°C Seed germ. @ 18-35°C	<i>S. alterniflora</i> tolerates salinities to 32 ppt; <i>S. foliosa</i> and <i>S. pogens</i> only to 18 ppt; most <i>Spartina</i> require low salinity (4-8 ppt) for germination. <i>Spartina</i> grows best in freshwater, but cannot compete w/cattails and rushes; common in salt marshes (126,127,128,129,130,131,132,133,134,135).
Pickweed (<i>Salicornia</i> spp.)	0.2-0.6 m dense, erect clumps	Thick spreading roots 2-5 mm thick	Mud, clay w/low organic content	3.9-8.0	.4-34 ppt (tolerates up to 80 ppt)	-.15 to .3 m	11-32°C	Found in brackish & saltwater marshes; requires saline conditions for growth; can withstand seasonal drying & alkaline conditions (116).

* During growing season

Vegetation Type	Morphology	Plant Occurrences or Tolerances			Comments and References
		pH	Air Temp.	Water Temp.	
Water hyacinth (<i>Elchhornia crassipes</i>)	Spongy, multi-leaved plant 8 to 127 cm; lavender flowers; underwater rhizomes w/long fine roots	7-optimal; occurs over a wide range	20-30°C optimal; inhibited at 8-15°C; lethal under -5°C	28-30°C optimal	Tropical plant that will not overwinter in colder temperature climates. Extensive root system serves as a mechanical filter & support structure for bacteria (138,139,140,141,142,143,144,145,146,147)
Duckweed (<i>Lemna</i> spp., <i>Spirodela</i> spp., <i>Wolffia</i> spp., <i>Wolffiella</i> spp.)	Small plants, each with one flat, oval frond 1 cm in length; without roots or with 2 or more threadlike roots on each frond	4.5-7.5 optimal; tolerates wide range	20-30°C optimal.	17.5-30°C optimal; inhibited over 35°C	Duckweed grows in dense mats in still water, effectively restricting gas transfer and attenuating light; can overwinter in milder temperature climates. Mats of duckweed can raise water temperature up to 12°C above air temperature (144,148,149,150,151,152,153,154,155,156,157,158,159,160,161)
Water fern (<i>Azolla</i> spp.)	Small fernlike plant 1 cm in diameter with simple roots	3.5-11	27.5°C optimal; range 5-45°C	27.5°C optimal	Nitrogen-fixing blue-green algal symbiont (<i>Anabaena</i>) grows within <i>Azolla</i> , enabling it to colonize nitrogen-deficient waters. Poor growth in open waters with wind/wave action (144,162,163)

Vegetation Type	Plant Occurrences or Tolerances					Comments and References
	Morphology	pH	Water Temp.	Water Depth.	Salinity	
Pondweed (<u>Potamogeton</u> spp.) 90-100 species	Plants w/thread-like to ribbon-like leaves scattered singly on flexible underwater stems; well-developed root system comprises up to 49% of plant mass.	6.3-10	10-35°C; 45° lethal 23-26° req. for seed germination	1-7 m; max. 10 m <u>P. pectinatus</u> opt.=30-46 cm	0-15 ppt max. 19 ppt	Reproduces by seeds, winter buds, rhizomes or tubers; tules are a major waterfowl food; cosmopolitan 90-100 species; <u>P. pectinatus</u> most brackish water, & pollutant tolerant; <u>P. crispus</u> , <u>P. pusillus</u> , <u>P.</u> <u>perfoliatus</u> & <u>P. natans</u> also tolerate brackish water and polluted habitats. (164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181)
Elodea (<u>Elodea</u> <u>canadensis</u> , <u>E. densa</u> <u>E. occidentalis</u>)	Branched stems 5-15 cm; covered thickly w/.5- 1.5 cm long leaves; found in groups of 2-6 de- pending on spp.; well developed root system.	6.5-10	10-25°C; 2-18° optimum for P uptake	1-7 m; max. 12 m	0.2-3.6 ppt (<u>E. canadensis</u> 9.2-14.4 ppt (<u>E. nuttallii</u>)	Reproduces by fragmentation; over winters as winter buds; best adapted for calcareous inland lakes, ponds, slow-moving streams & slightly brackish coastal waters; good water oxygenator; marl deposits are common (79, 164, 166, 170, 172, 175, 182, 183, 184, 185)
Cootail (<u>Ceratophyllum</u> <u>demersum</u> , <u>C. echinatum</u>)	Many-branched bare stalk 1-2 m long; brittle, forked leaves with small thorns; found in clusters of 5-12 from central nodes.	4.0-8.7; optimum 7.1-8.0	10-20°C; optimum 18°; min. 5.5° (for one species)	No data, probably similar to Elodea	0-3.8 ppt	Reproduces by winter buds and fragmentation; requires still or very slow moving water; aquatic birds eat fruits; upright growth in spring; broad floating habit in summer/fall. (164, 172, 175, 185, 186, 187, 188, 189)
Watermilfoil (<u>Hydrrophyllum</u> spp.)	Slender stems & few branches; divided leaves grouped in whorls	5-10	0.2-30°C; optimum 15 to 25°	1-3 m; max. 5 m min. 50- 80 cm	0-15 ppt optimum 0.83- 3.33 ppt	Reproduces by fragmentation and/or formation of winter buds; cosmopol- itan-45 species (164, 166, 168, 169, 172, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199)

Appendix C: Glossary of Important Terms [5,8,10]

ABIOTIC : The nonliving portion of the environment, comprised of basic inorganic and organic compounds.

AEROBIC : The condition associated with the presence of free oxygen in the environment.

ALLUVIAL PLAIN : An essentially level surface underlain by stream deposited material. Broad flood plains are alluvial plains.

AMELIORATION : An act of making better or improvement. Includes actions designed to mitigate or reduce adverse effects of highways as well as actions to enhance or increase the desirable effects of highways on wetlands.

BIOMASS : The total mass of living organisms in some biological system.

BIOTA : All the species of plants and animals occurring within a certain area.

CONSUMER : An organism that utilizes existing organic matter as a source of food.

DECOMPOSER : An organism that breaks down complex organic matter into simpler constituents; for example, fungi and bacteria.

EMERGENT VEGETATION : Aquatic vegetation that emerges through the water surface; for example, cattail and pickerel weed.

ENHANCEMENT : Raising the value of wetlands, through improvement, augmentation, development and diversification.

FLOOD PLAIN : The area along a stream which may be covered at times of high water and where deposition of stream carried material takes place.

FLYWAY : A major geographic region of North America where migratory waterfowl tend to fly during their seasonal migrations.

HABITAT : The physical location or natural environment where an organism lives, and where it derives food, shelter and breeding area.

KETTLE HOLE : A depression resulting from the melting of a buried ice block; usually found associated with glacial moraines.

LACUSTRINE : Pertaining to an aquatic system that is impounded and does not flow, which includes permanently flooded lakes and reservoirs; in contrast with riverine

LITTORAL : Pertaining to the shore or bank.

MORaine : Deposits made by a glacier commonly as hummocks and irregular hills at the edge of the ice.

OLIGOTROPHIC : A condition in a water resource characterized by low levels of nutrients and relatively small biomass of plants; in contrast with a eutrophic condition.

OUTWASH PLAIN : A more or less level surface formed of deposits made by streams flowing out from a glacier. Usually of gravel, sand or silt.

OXBOW : A part of a meander bend which has been abandoned by the stream.

PALUSTRINE : An aquatic system characterized by no defined channel, no bedrock shoreline, and a generally well-developed aquatic vegetation; may be sections of rivers, lakes or estuaries.

PRODUCER : An organism that can manufacture food from inorganic nutrients; includes plants.

PRODUCTIVITY : A measure of the amount of energy (or biomass) produced by a biotic group in a specific time period.

RIDGE : A range of hills or mountains. Also, the upper part or crest of such a range.

RIVERINE : Pertaining to an aquatic system that is flowing along a gradient, which includes most rivers and streams; in contrast with lacustrine

SUBSTRATE : The immediate physical material on or in which an organism lives: for example, soil.

SUCCESSION : The orderly process of community change, involving sequential replacement of regular stages, until the stable climax condition is reached.

TERRACE : A level and usually narrow plain with commonly a steep front or scarp bordering a river or a lake.

TILL PLAIN : A glacial plain underlain by boulder clay

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