A Sustainable Chesapeake

BETTER MODELS FOR CONSERVATION

Edited by David G. Burke and Joel E. Dunn

THE CONSERVATION FUND

The case study you have downloaded is highlighted below. Other case studies from this Chapter of *A Sustainable Chesapeake: Better Models for Conservation* can be individually downloaded. The editors encourage readers to explore the entire Chapter to understand the context and sustainability principles involved with this and other featured case studies. The full publication contains 6 Chapters in total: Climate Change Solutions, Stream Restoration, Green Infrastructure, Incentive Driven Conservation, Watershed Protection and Stewardship.

CHAPTER 2 STREAM RESTORATION

Converting Drainage Ditches and Nonproductive Farmland into Functioning Streams and Wetlands

A Model for Improving Water Quality and Wildlife Habitat in Delaware

Resource managers and landowners with agricultural drainage networks can learn from the State of Delaware how modifications to their systems can enhance water quality and wildlife habitat while maintaining farm productivity.

Delaware's non-tidal streams and riparian habitats in the Chesapeake Bay watershed have been severely altered and degraded for agriculture, development, roads, towns, and cities. Now, the Delaware Department of Natural Resources and Environmental Control (DNREC) is demonstrating how traditional agricultural drainage ditches and nonproductive farmland have become an asset in their recovery. DNREC has transformed drainage ditches and nonproductive farmland into streams and wetlands capable of reducing the negative impact of nutrients and increasing valuable wildlife habitat.

In Delaware, the need for water management to support agriculture and development dates back to the colonial era when drainage ditches were created to remove excess surface water and alter wetlands. Over time, drainage ditch management shifted from private companies to subdivisions of the state government known as "tax ditches". The tax ditch system provides for the creation of perpetual drainage organizations funded by maintenance taxes. The ditches themselves become inland extensions of natural perennial stream channels, constructed to manage soil and water resources for agricultural and developmental purposes and to provide flood protection.

Delaware's tax ditch management system is making a fundamental shift from its roots in agricultural land drainage and flood control to a broader incorporation of environmental concerns of non-point source pollution and wetland loss. The move parallels the findings of scientists[1,2,3,4,5] who cite the ability of converted drainage ditches, particularly those converted into linear wetlands and functioning stream ecosystems, to reduce sediment, nutrients, and heavy metals exported to sensitive receiving water bodies such as the Chesapeake Bay.

DNREC has developed a series of conservation strategies for areas between significant sources of excess nutrients (active farmland, urban development, etc.) and sensitive receiving water bodies. These applications are particularly well-suited to agricultural areas where drainage ditches are present and/or where unproductive land is available for modification.

RESOURCE MANAGEMENT CHALLENGE

During the 20th century, the construction of ditches and/or concrete-lined stormwater networks in rural, suburban, and urban settings became widespread in the United States. While decidedly reducing the perils associated with flooding and poor drainage, this rapid removal of water has, over time, reduced the potential for groundwater recharge and degraded and polluted streams, estuaries, and coastal habitats. In Delaware alone, extensive ditch systems have altered the state's landscape with more than 2,000 miles of channels, approximately 71% of which lay within the Chesapeake Bay watershed.

Former wetland hydrology restored by blocking drainage flow into adjacent ditch.

Delaware tax-ditch system

A "tax ditch" is a watershed-based organization formed by a prescribed legal process, which includes granting permanent rights-of-ways and the power to tax landowners within a watershed for initial construction and future maintenance of ditches. Tax-ditch organizations also have the authority to procure contractors and accept financial and technical assistance from outside sources.

In Delaware, there are approximately 230 individual tax-ditch organizations representing watersheds that range in size from 56,000 acres to two acres and providing benefits to more than 100,000 people. In addition, the tax ditches benefit approximately one-half of the state-maintained roads. Tax ditches mainly occur in the western half of the Coastal Plain of Delaware and along the southern boundary with Maryland. The majority of constructed channels are ephemeral or intermittent and typically range in size from 6 to 80 feet wide and 2 to 14 feet deep depending on the acreage being drained and the local topography.

DNREC estimates that 90% of Delaware's streams and rivers were modified to support agricultural activities, road-building, residential and commercial development, and drainage. As a result of these changes in land use, much of Delaware's non-tidal stream and riparian habitats have been degraded. In addition, scientists have documented the drainage of forested wetlands, the lowering of local water tables, and the elevated loadings of sediments and nutrients to downstream water bodies. These activities can trigger algal blooms that impact both human economic activities and ecological health.

The degradation of water quality, along with climate change and water availability issues, elevates the need for innovative alternatives to handling "excess" stormwater. Resource managers need alternatives to the traditional piping and channeling of waterways that carry pollutants and inadvertently threaten wildlife habitat, sensitive receiving water bodies, water supply sources, and livelihoods dependent upon unimpaired waters.

CONSERVATION VISION

DNREC hopes to restore its degraded waterways by improving stream corridors and restoring wetlands. The overarching goal of this vision is to restore highly disturbed and/or degraded streams and ditches to natural, stable stream channels or wetlands. DNREC has five waterway restoration objectives:

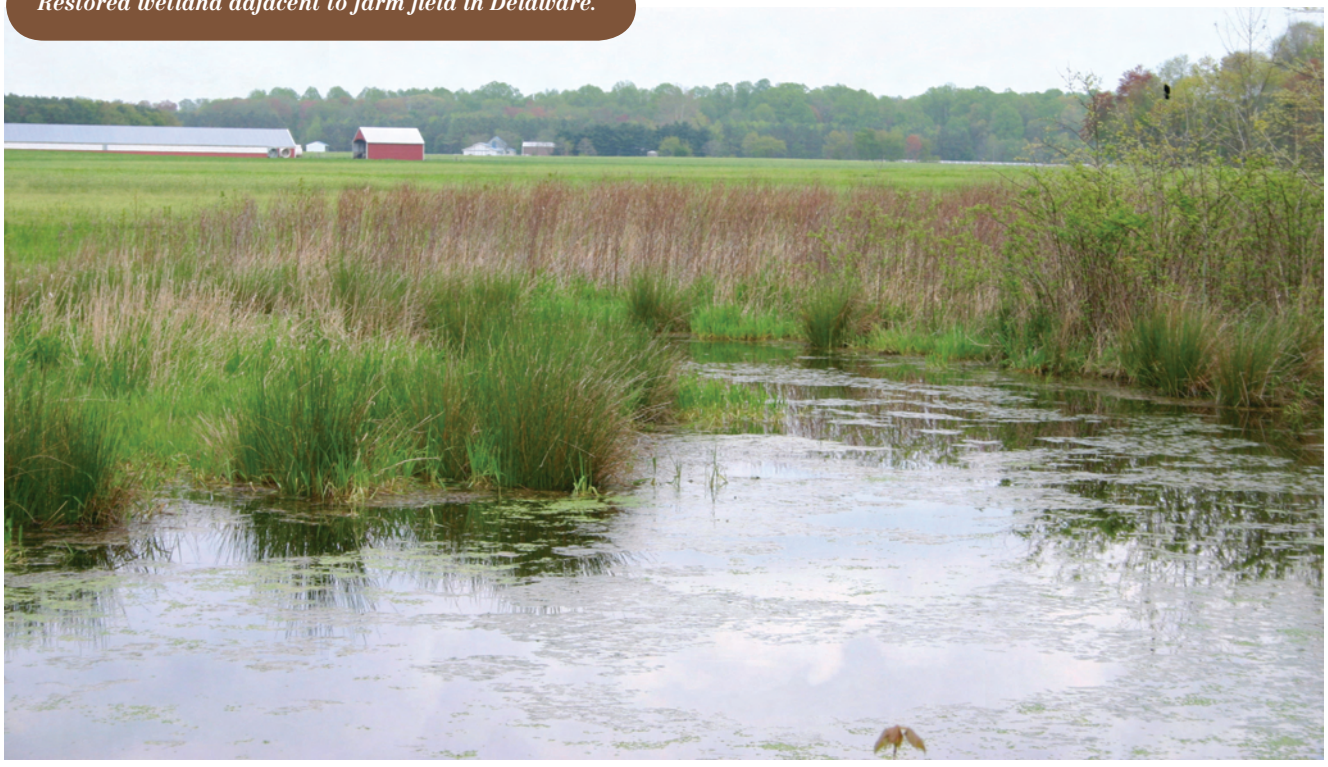
- Restoring more natural morphology
- Re-establishing biological diversity
- Reducing surface water pollutants
- Increasing wildlife habitat
- Protecting and improving water quality

DNREC's new channel restoration projects focus on using geomorphic approaches to convert ditches into sinuous channels with reduced flow rates and wider, naturally vegetated floodplains while maintaining adequate drainage functions. The state also seeks to restore wetlands in nonproductive, poorly drained agricultural fields—most of which were formerly forested wetlands. This vision rests on scientific research that points toward new trends in channel and wetland restoration, incorporating micro-topography (humps and bumps), irregular edges, the addition of organic matter and coarse woody debris, and the relocation of trees and shrubs into the restored area. These techniques can reduce water quality problems caused by agricultural run-off while providing functional wildlife environments. All of these techniques seek to replicate natural conditions.

IMPLEMENTATION RESOURCES

Implementation resources for more sustainable and environmentally friendly drainage practices are available through a variety of avenues including legal mandates, grass-roots efforts, and government-led initiatives at the local, state, and federal level. Environmental advocacy groups and

Restored wetland adjacent to farm field in Delaware.



LEFT: ***Water control structure.***
RIGHT: ***One-sided ditch construction minimalizes forest impacts.***

federal and state-level mandates for "no net loss" of wetlands have already championed a shift in how drainage decisions are made to properly weigh environmental impacts against drainage benefits. Nationally, mandates for non-point source pollution control in the Clean Water Act and Swamp Buster provisions of the USDA Farm Bill have put restrictions on drainage activities.

In Delaware, channel restoration efforts are typically implemented at the request of private landowners or by DNREC personnel who have located potential sites on state-owned land. DNREC's Division of Soil and Water Conservation (SWC) is the lead agency for these efforts and is supported by partnerships with other DNREC units, nonprofit organizations, and state, local, and federal agencies. The primary objectives include:

- Preserving and restoring high value wetlands
- Installing water quality measures at ditch sites
- Helping landowners plan and implement restoration projects
- Conducting a rigorous tax-ditch and drainage project review process
- Developing and promoting best management practices (BMPs) for ditch management

CONSERVATION STRATEGY

DNREC has a four-tiered strategy to realize their vision of improved water quality and wildlife habitat enhancement for drainage ditches.

Strategy 1 - Implementation of Best Management Practices: The first conservation strategy is to put in place, wherever possible, proven BMPs developed by DNREC or used by practitioners in other regions. The use of BMPs developed in the last decade has led to fewer impacts to freshwater and tidal wetlands and even the addition of wetland acreage in Delaware. The BMPs address a variety of practices in project design, construction, maintenance, and timing.

Design: DNREC is implementing a dual waterway design with a floodplain and low-flow sinuous channel that traps sediment, creates habitat, and requires less maintenance. The following technology is also recommended:

- Sediment traps, which decrease velocity and reduce sediment loads to sensitive receiving water bodies.
- Water control structures, which limit the flow in ditches when drainage is not needed. These structures recharge groundwater and retain plant-available water while decreasing pollutant export through sediment trapping and denitrification.
- Reverse berms, along channels with a side inlet pipe, which is set at the historical water level in adjacent wetlands.
- Bioreactors or biological curtains, to provide sources of organic matter under reducing conditions to convert nitrate-N to gaseous forms of nitrogen.[6]
- Phosporus-sorbing materials, which sequester dissolved phosphorus from ditch water as well as trace metals.[7]

Construction Equipment: Using modern excavators causes less dis-

turbances to the channel side slopes and results in less sediment export. This minimizes the amount of bare soil which would be free to migrate downstream.

Construction: Performing one-sided construction and/or minimizing clearing widths through forested areas reduces impacts and retains ecologically valuable trees, which minimizes forest fragmentation. Other practices include saving trees within the construction zone, minimizing construction of downstream outlets, blocking off old channels that drain wetlands, and relocating channels around sensitive habitat or wetland areas.

Maintenance: Using "weed wiper" equipment that selectively applies herbicides and allows desirable plant species to thrive. This results in minimal disturbance during the removal of accumulated sediment during ditch maintenance.[8]

Timing: Scheduling ditch channel maintenance (sediment removal) during periods of low flow. This also minimizes downstream pollutant loads.

Strategy 2 - Enhanced Sediment/ Nutrient Retention: The second and most recent pollution control conservation strategy suggested by DNREC is aimed at enhancing the sediment/nutrient retention capability within restored watersheds adjacent to agricultural lands. This federally driven strategy is associated with the Environmental Protection Agency's (EPA's) water quality requirements known as the Total Maximum Daily Load (TMDL). Key elements include:

- Redesigning drainage ditches into low-flow, sinuous channels with natural floodplains.
- Introducing in-stream wetlands and/or re-routing portions of the drainage channel through created, longitudinal wetland cells that decrease stream flow and increase the residence time of water within a stream system to promote nutrient processing.

Red Chokeberry Shrub at Battista wetland restoration site.

Strategy 3 - Validation of Restoration Methodology: The third conservation strategy pursued by DNREC is to validate the effectiveness of their TMDL-driven watershed restoration efforts in treating agricultural runoff. DNREC worked with the EPA to document the practice of constructing wetland restoration "cells" that reduce sediment and nutrient export by intercepting agricultural runoff before it reaches receiving drainage ditches or natural stream channels. They selected the Haines Farm stream and wetland restoration project in Kent County, Delaware (see Results below).

The joint study of the Haines Farm reported statistically significant concentration differences between the total nitrogen concentration in the water flowing in (inflow) and flowing out (outflow) of the restored stream channel ($p = 0.038$). (Note: in modern scientific investigations, the generally accepted value for statistical significance must have a probability of occurrence by chance factors equal to or less than five times in 100 $p < 0.05$.) This suggests that nitrogen processing was occurring within the converted drainage ditch and/or constructed wetland cells. The study also reported statistically significant concentration differences for total phosphorous ($p = 0.030$) and soluble reactive phosphorous ($p = 0.030$) between inflow and outflow samples collected in two of the three constructed wetland cells. In addition, total suspended solids concentrations were an order of magnitude higher during storm events than baseflow events while differences for nitrogen concentrations between storm flow and baseflow were not apparent.[9]

In summary, the Haines Farm project suggests that the converted drainage ditch and constructed wetland cells may be filtering and processing agricultural runoff based on inflow-outflow comparisons of nutrients and

Solberg Project Photos

Pre-restoration drainage ditch maintenance and access way.

Post-construction of wetland.

Volunteers planting trees and shrubs.

suspended solids. While limited, the data implies that these land applications may potentially provide nutrient and sediment reduction effects.[10] Evans et al.[11] reports similar results in a summary of more robust studies that involved hydrologic and water quality monitoring of seven projects over a period of two to four years.

Strategy 4 - Landowner Outreach: DNREC's fourth conservation strategy involves working closely with landowners and tax-ditch managers. It is a constant challenge to find and foster cooperative landowner relationships for the acceptance of new BMPs and to offer financial assistance to support these more expensive, yet environmentally friendly designs and maintenance techniques.

The DNREC Drainage Program holds training sessions, presentations, tours, and workshops to address the most significant environmental impacts from channel construction and to offer more sensitive approaches to ditch maintenance. DNREC implements wetland restoration, tax-ditch channel restoration projects, and BMPs through a variety of programs that benefit landowners and tax-ditch organizations.

RESULTS

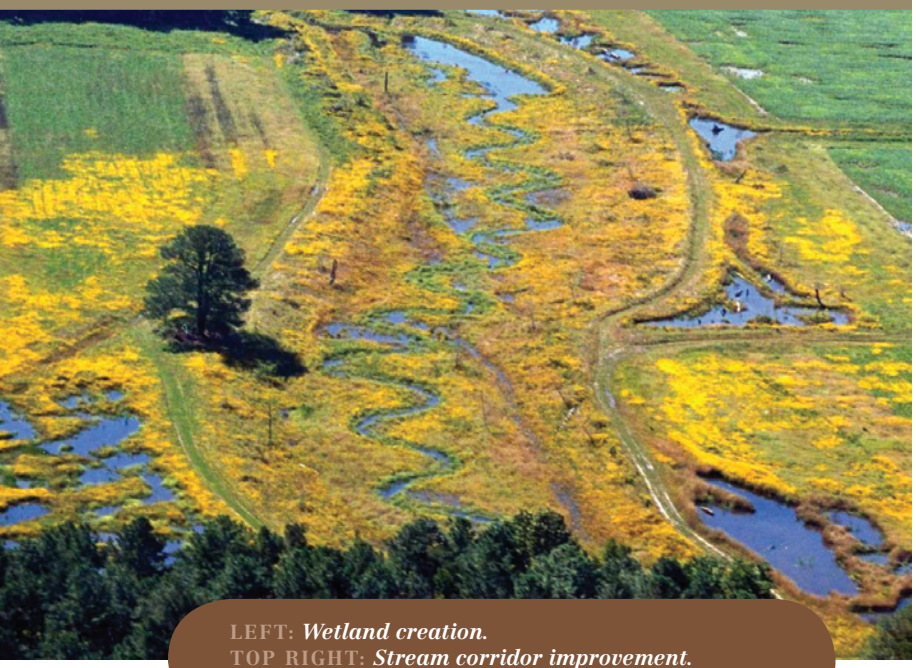
DNREC's Division of Soil and Water Conservation has completed an extensive array of restoration projects over the past 20 years. The five projects highlighted below represent some of the most successful and notable efforts.

Solberg Wetland/Stream Creation and Restoration Project

Location: Kent County, Delaware
Year Completed: 2006

The Carl Solberg stream and wetland restoration project involved 1,700 feet of stream restoration. The project elevated the ditch bottom, installed three water-control structures and

Haines Project Photos



LEFT: ***Wetland creation.***
TOP RIGHT: ***Stream corridor improvement.***
BOTTOM RIGHT: ***Pre-restoration drainage ditch.***

created a man-made beaver dam. The project restored two acres of floodplain wetlands adjacent to the original channel. The project is unique because the entire tax-ditch right-of-way has been eliminated and portions of the tax-ditch maintenance access-way have been restored to wetlands.

Core partners: DNREC Division of Soil and Water Conservation, U.S. Fish and Wildlife Service, Kent Conservation District, Kent County Parks and Recreation, and property owner Carl Solberg

Haines Stream and Wetland Restoration Project
Location: Kent County, Delaware
Year Completed: 2002

The Haines stream corridor and wetland restoration project restored 1,600 linear feet of straight, steep-sided tax-ditch channel. The tax ditch was restored to a natural flood plain stream system with a meandering, low flow channel. In addition, approximately 7.75 acres of wetlands were restored in adjacent agricultural fields. The wetland cells capture runoff from adjacent agricultural fields (ranging in drainage area of 4 to 30 acres) which eventually discharge into the tax ditch. The drainage area upstream of the project site is approximately 1,600 acres. Agricultural crops at the farm consist of typical continuous corn/wheat/soybean rotation with fertilization application rates mandated by the Delaware Department of Agriculture's nutrient management program.

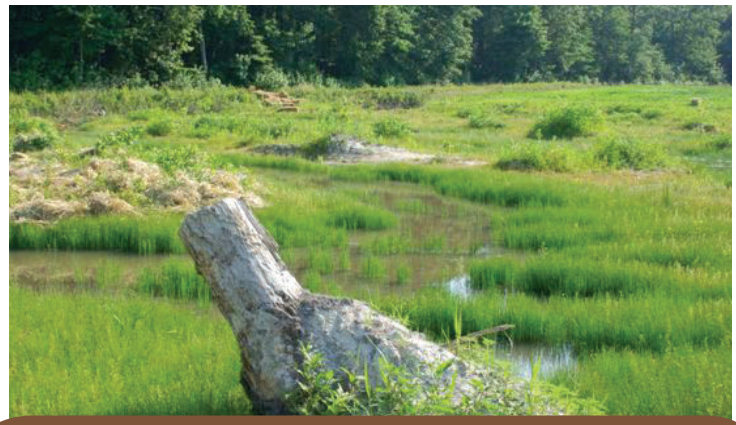
Core partners: DNREC Division of Soil and Water Conservation, DNREC Division of Fish and Wildlife, Petersburg Tax Ditch, EPA, Polytech High School, Sussex Tech High School, and Kent Conservation District

Heron Drain Tax Ditch
Location: Kent County, Delaware
Year Completed: 2008

The Heron Drain project included construction of a one-acre wetland and restoration of two wetland acres located on DNREC Division of Fish and Wildlife (DFW) property. This project represents Delaware's first attempt to use a constructed wetland to reduce nutrients and sediment flowing through the ditch system before reaching downstream estuarine waters. Water flow was redirected into a series of constructed wetland pools, and a water-control structure was installed just downstream of the site to help retain water.

After DFW purchased this former farm site, the design team abandoned an unnecessary 900-foot segment of the tax ditch to dispose of excess spoil. Filling the ditch reconnected a small four-acre field to the adjoining field, resulting in a large contiguous tract of land. The reconnection also eliminated ditch maintenance and made it possible to restore former wetlands by impounding water on two acres. Overall, the project significantly enhanced water quality, increased biological diversity in the area, and made the tract much more manageable for DFW staff.

Heron Drain Project Photos



TOP: ***Stream corridor project under construction.***
BOTTOM RIGHT: ***Pre-restoration agricultural field and tax ditch.***
BOTTOM LEFT: ***Post-construction with adjacent wetland cells.***

Core partners: DNREC Division of Soil and Water Conservation, U.S. Fish and Wildlife Service, Heron Drain Tax Ditch, Kent Conservation District, and DNREC Division of Fish and Wildlife

Battista Wetland Restoration Project
Location: Kent County, Delaware
Year Completed: 2004

The Battista Wetland Restoration Project restored and enhanced an abandoned agricultural field/pasture that was once a wetland. The project involved selectively excavating areas to a depth of 12 to 18 inches to create pockets of water and small islands, replicating a natural wetland. Drainage was also eliminated to retain water. The unique part of this project involved constructing a half-acre wetland in the back yard of the property owner. This backyard habitat compliments the flower gardens, butterfly gardens, and other plantings located immediately behind the 150-year old brick farm house. Plants grown by the Polytech High School students were planted to finish the project.

Core Partners: Property owners Rose Ann and Bill Battista, DNREC Division of Soil and Water Conservation, Kent Conservation District, EPA, and Polytech High School

Smith Wetland Restoration Project
Location: Sussex County, Delaware
Year Completed: 2003

The Dave Smith Wetland Project restored three acres of marginal agricultural field at two locations on the farm. These sites are within close proximity to the property owner's home and can be easily seen from the kitchen window. This project effectively demonstrates that not all restoration activities are conducted out of sight in the "back forty." Additionally, Mr. Smith planted trees and grasses through the Delaware Conservation Reserve Enhancement Program in his remaining fields, which resulted in the total restoration of 35 acres. The Sussex Tech High School environmental science class planted approximately 300 trees and shrubs in the fall of 2003. In the spring of

Battista site pre-restoration back yard.

Battista site post-construction of wetland.

Smith site restored wetland.

2004, employees of the Drainage Section planted approximately 150 trees and shrubs.

Core partners: Property owner Dave Smith, DNREC Division of Soil and Water Conservation, Sussex Conservation District, Sussex Tech High School, U.S. Fish and Wildlife Service, and EPA

KEYS TO SUCCESS

Over a 20 year period, DNREC managers have learned a number of important lessons. While difficult to summarize, the following represents the main components behind the success of DNREC's Channel and Wetland Restoration Program:

- Cultivating a spirit of cooperation with landowners and tax-ditch managers to allow the use of new BMPs through technical guidance and financial resources that make enhancements a simple, managed process with few administrative burdens
- Showcasing projects with unique functional features through compelling outreach materials and graphic exhibits
- Capitalizing on opportunities to implement projects when landowners express interest
- Using low-tech design and construction techniques to minimize costs and reduce environmental impacts
- Reducing the number of restrictions and obligations required of landowners
- Demonstrating to landowners that restoration can be accomplished without adverse impacts to farm operations and that projects can improve productivity
- Using the positive testimony of agricultural landowners to leverage additional restoration opportunities

PHOTOS AND FIGURES

Pages 33-37, 42: Photos, David Burke
Pages 38-41: Photos, Thomas Barthelmeh

REFERENCES

[1,9,10]Biddle, M.A., R.M. Tyler, T.G. Barthelmeh and T.J. Canfield. 2008. *Effectiveness of Restored Wetlands for the Treatment of Agricultural Runoff*. Delaware Department of Natural Resources and Environmental Control, Dover, DE. 39 pp.

[2,11]Evans, R.O., K.L. Bass, M.R. Burchell and R.D. Hinson. 2007. Management alternatives to enhance water quality and ecological function of channelized streams and drainage canals. *Journal of Soil and Water Conservation*. 62(4):308-302.

[3]Schmidt, J.P., C.J. Dell, P.A. Vadas and A.L. Allen. 2007. Nitrogen export from Coastal Plain field ditches. *Journal of Soil and Water Conservation*. 62(4):235-243.

[4]Smith, D.R. and E.A. Pappas. 2007. Effect of ditch dredging on the fate of nutrients in deep drainage ditches of the Midwestern United States. *Journal of Soil and Water Conservation*. 62(4):252-261.

[5,7]Penn, C.J., R.B. Bryant, P.J.A. Kleinman and A.L. Allen. 2007. Removing dissolved phosphorus from drainage ditch water with phosphorus sorbing materials. *Journal of Soil and Water Conservation*. 62(4):269-276.

[6,8]Needelman, B.A., P.J.A. KleinÐman, J.S. Stock and A.L. Allen. 2007. Improved management of agricultural drainage ditches for water quality protection: An overview. *Journal of Soil and Water Conservation*. 62(4):171-178.

Haines project wetland restoration.

FOR MORE INFORMATION

Project Contact:
Thomas G. Barthelmeh
Ecological Restoration Manager
Delaware Department of Natural Resources and Environmental Control
89 Kings Highway, Dover, DE 19901
Phone: (302) 739-9921 | Email: Thomas.Barthelmeh@state.de.u

Project tours and wetland restoration training workshops are available.

Further Reading:

Strock, J. S., C. J. Dell and J. P. Schmidt. 2007. Managing natural processes in drainage ditches for nonpoint source nitrogen control. *Journal of Soil and Water Conservation*. 62(4):188-196

Department of Natural Resources and Environmental Control (DNREC). 2008. Delaware Tax Ditches. In, http://www.swc.dnrec.delaware.gov/Drainage/Pages/TaxDitches.aspx. DNREC, Division of Soil and Water Conservation.

Department of Natural Resources and Environmental Control (DNREC). 2008. *Tax Ditch Right-of-Way Task Force Report: A Report in Response to Senate Concurrent Resolution No. 27, 144th General Assembly*. DNREC, Division of Soil and Water Conservation.