Agricultural Best Management Practices (BMP) Database

Phase 1 Literature Review

Prepared by

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Table of Contents

Agricultural Best Management Practices (BMP) Database
Phase 1 Literature Review

1 INTRODUCTION

In 2011, the Water Environment Research Foundation (WERF) and the National Corn Growers Association (NCGA) initiated a collaborative effort to expand the International Stormwater BMP Database to include agricultural BMPs. Improved understanding of agricultural BMP performance will lead to more informed decision-making and more cost-effective solutions for managing agricultural runoff. For many watersheds, scientifically sound knowledge of both urban and agricultural BMP performance is needed to develop watershed-based approaches to reduce pollutant loading to waterbodies. The WERF/NCGA Agricultural BMP Database ("WERF/NCGA Database") effort is intended to build upon research already conducted by a variety of federal and state agencies, university researchers, and others. This effort is being conducted in several phases, as described further on the project website (http://www.bmpdatabase.org/agBMP.htm). The first phase of the project includes a literature review to ensure that previous efforts and existing resources are appropriately considered in the development of the WERF/NCGA Database and to identify studies that may be appropriate for inclusion in the first release of the Database during Phase 2 of the project.

This literature review serves as the Task 2 deliverable for Phase 1 of the WERF/NCGA Database effort. This research also supports Task 1 related to development of a beta version of the WERF/NCGA Database by summarizing previous agricultural BMP database efforts. The Phase 1 literature review is limited to row crops; however, as project sponsors in other agricultural sectors are added, project efforts may extend beyond row crops. The purposes of this literature review include:

- Identify readily available, high value, literature sources to help shape the reporting protocols/data elements in Task 1.
- Identify the general form of agricultural BMP studies to determine the type of information available to populate a database.
- Identify an initial high-priority list of potential data providers/sources for the next phase of the project.

The document describes the literature review approach and provides a description of major existing resources such as databases, bibliographies and other information. Attachment 1 provides a tabulation of studies resulting from the literature review, including a general assessment of their anticipated relevance for Phase 2 of the project (i.e., likelihood that data from a study could be entered into the WERF/NCGA Database). Where available, report abstracts have been pasted into the Excel table in Attachment 1 to provide a brief overview of the study. The "report authors" field in the table is also helpful for identifying researchers to contact during Phase 2 of the project. During Phase 2 of this project, a formal bibliography will be completed to go along with this working table of notes. Additional references may also be added at that time, as well.

2 LITERATURE REVIEW APPROACH

The Project Team conducted an initial review of available studies and data that may be used to populate the WERF/NCGA Database. The initial review focused on identifying studies that evaluate specific BMPs for row crops. Ideally, these studies include side-by-side, before-after, or inflow-outflow comparisons of individual practices or combinations of practices with quantitative, event-based data, or receiving water data monitored over time. Key aspects of the literature review included these activities:

- Reviewing U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) and Agricultural Research Service (ARS) resources (accessible online).
- Identifying existing compilations of agricultural BMP performance through web searches and targeted interviews with national researchers. (These are described in Section 5 of this report).
- Searching environmental and engineering periodical search engines (Web of Science, JSTOR, EBSCO, and others) at the University of Colorado and North Carolina State University using search terms such as: agricultural, row crop, corn, BMP, best management practices, evaluation, assessment, monitoring, stormwater, and water quality.
- Searching Google Scholar using similar search terms to those described above.
- Searching Journal of the American Water Resources Association (JAWRA) and the American Society of Agricultural and Biological Engineers (ASABE) using similar search terms to those described above.
- Identifying and reviewing existing BMP database efforts to identify references that could be used to help shape reporting parameters for various aspects of the current WERF/NCGA Database effort.

For the purposes of this Phase 1 literature review, search results were initially screened to identify study titles and abstracts that were likely to contain quantitative performance monitoring data. If initial screening suggested potential relevance, study information was entered into the table provided in Attachment 1 and information such as study location, crop type, BMP activities evaluated, types of available data and anticipated potential for use in the Phase 2 Database effort were identified. In some cases, detailed performance data may not have been contained in the summary publication, but underlying supporting information may be available from the publication authors. Attachment 1 focuses on 186 publications, although thousands of references were identified as part of the initial screening effort. A directory of PDF files for studies obtained in support of this literature review has also been developed for use during Phase 2 of the project.

In addition to identifying agricultural BMP studies for potential future entry into the WERF/NCGA Database, the literature review effort also supported the WERF/NCGA Database design task by identifying existing BMP databases and BMP design parameters or conservation practice classification systems that can support design of the WERF/NCGA Database structure. The USDA NRCS and ARS resources are fundamental cornerstones of this effort—it is essential that any agricultural BMP database effort be consistent with existing nomenclature and classification systems established by these agencies. For this reason, the USDA NRCS BMP design standards and nomenclature are briefly introduced in Section 3 prior to discussing the results of the literature review.

3 OVERVIEW OF USDA NRCS BMP DESIGN STANDARDS

The USDA NRCS is the preeminent source for design, installation, and maintenance standards for agricultural BMPs. To date, the NRCS has published 155 agricultural BMP standards. Attachment 2 contains a spreadsheet listing these practices and providing links to underlying supporting information. Each practice has a unique three-digit NRCS code number, technical design guide, non-technical information sheet (for most practices), "conservation practice physical effects" (CPPE) worksheet, job worksheet, statement of work sheet, and "network of effects" diagram. Of particular interest, the three-digit NRCS identification code is a well known standard that has been incorporated into most of the databases reviewed as part of this literature review.

The Project Team recommends that the NRCS conservation practice code numbers and associated narrative practice descriptions be integrated into the WERF/NCGA Database as the primary organizational framework for individual BMP practices.

Modifications to the NRCS design standards system for purposes of this WERF/NCGA Database effort that may be considered include:

- Adding an "other" category and accompanying code for innovative BMPs that may not yet have established design guidelines or be well characterized under the NRCS system.
- Adding a "composite" or "site-scale" BMP option to enable studies to be entered into the WERF/NCGA Database that study the effectiveness of systems of BMPs, including both treatment trains and distributed practices/controls.
- Providing an additional data element (data entry field) to group many similar individual practices into general BMP categories such as:
    - Ponds and Basins
    - Grading and Tillage
    - Drainage and Conveyance
    - Irrigation Control
    - Buffers and Filter Strips

- Plantings and Vegetated Covers
- Non-Vegetated Covers
- Source Management: Nutrients
- Source Management: Pesticides/Herbicides

- For Phase 1 of the BMP Database effort, the practice data set evaluated would be limited to those pertinent to row crops. (The full practice list could be retained, but non-row crop practices could be hidden or categorized differently.)

4 LITERATURE REVIEW FINDINGS: STUDIES

After screening general search results to studies expected to be potentially useful in the current BMP Database effort, the Phase 1 literature review resulted in these findings:

- The literature review identified 186 studies in 31 states and 12 countries and included approximately 26 BMP types for approximately 40 different types of row crops. These studies span the early 1980's to the present.

- Out of the 186 references in Attachment 1, 134 are recommended for further review and consideration in the Phase 2 WERF/NCGA Database effort. Approximately a dozen references have been identified as "excellent," indicating that they have pre-existing, easy-to-access data tables that are ready for data entry into a database with minimal additional research. Additionally, of the 134 references, 62 reference event-based data sets that could potentially be obtained by contacting the original researcher for underlying data (e.g., the data are summarized graphically or narratively in the report, but event-based data are not tabulated). The remaining reports typically display data on longer time scales, such as monthly, seasonally, or annually. Additional follow up with the authors of these papers may be required to obtain underlying detailed unpublished data and the methods used to summarize the data at these time scales.

- Of the studies included in Attachment 1, corn is the most studied crop (approximately 70 papers), followed by soybeans, wheat and other grains, and cotton. Most studies examined a period of one to five years, although some extend up to a decade, with a few extending longer than a decade.

- The most commonly studied BMPs in Attachment 1 were various tillage techniques followed by filter strips and vegetated buffers. Cover crops, fertilizer management, crop rotation, and detention ponds were also well represented. Approximately 35 papers studied watershed-scale implementation of multiple BMPs.

- Individual studies ranged in scale from tens of square feet to hundreds of square miles. Differentiation between plot, field, watershed, and basin studies is somewhat subjective.

- Plot studies often contained several replicates, but reporting is often varied – from raw data to averages among treatments.

- Often, plot experiments test two BMPs simultaneously in a 2 x 2 design. Large basin studies may study only a few BMPs or dozens of different BMPs across a multitude of land uses.
- Experimental design varied widely among studies. Calibration periods, pre-existing monitoring, replicates, controls, post-BMP monitoring, and other factors vary among the studies.
- Due to the nature of agricultural practice, many of the studies have significant changes to multiple variables (e.g., fertilizer, crop type, irrigation, rainfall, etc.) during the study period, which presents challenges when interpreting study results.
- Many of the studies report time averaged data by month, season or year. Often, only grab samples are collected or reported (i.e., limited event-based composite sample data are available).
- Some of the studies focus on BMP effects on groundwater and/or soil water, in addition to surface water. In some cases, surface water is not the primary study focus.

These general observations are useful for refining the content and scope of the WERF/NCGA Database design.

5 LITERATURE REVIEW FINDINGS: EXISTING DATABASES AND STUDY COMPILATIONS

To maximize efficiency in the current literature review effort and to avoid "reinventing the wheel", the literature review included an effort to document key existing agricultural BMP performance databases, which have been created for various purposes with varying levels of detail. These existing databases and/or study compilations are summarized below. Most of these efforts are broader in nature than the current WERF/NCGA Database effort and typically function as annotated bibliographies with performance information at a summary level. The number of relevant studies from each database or compilation ranged from a few studies to a few dozen studies expected to be applicable to the current WERF/NCGA Database effort. Out of the database efforts reviewed, the Virginia Tech BMP database (Section 5.5) appears to have used an approach most similar to the WERF/NCGA Database effort, as described below; however, it is no longer actively maintained.

5.1 AGRICOLA

The USDA Water Quality Information Center (WQIC) operates a digital dynamic library for the National Agricultural Library (NAL) online catalog (AGRICOLA) for papers and books spanning broad agricultural disciplines. Users can either search the database using AGRICOLA's classification system and pre-set default criteria, or conduct broad independent searches. For example, the dynamic library for conservation practices (i.e., BMPs) is pre-set to only include papers published after 2000. A user accessing the AGRICOLA database, however, can change this search parameter to a different date if desired. AGRICOLA only provides bibliographic information, and sometimes may contain abstracts and electronic links to access the studies online. Even though underlying data sets are not provided in this database, it is still a good resource for identifying papers of interest and was used as a key tool in the Project Team's literature review.

AGRICOLA classifies BMPs into conservation practice subcategories, which are then further subcategorized into the type of water quality parameters studied. The water quality related subcategories include: general, erosion and sedimentation, nitrogen, pathogens, pesticides, phosphorus, and fish and wildlife. The general conservation practice subcategories include:

- Conservation Buffers
- General
- Ally Cropping
- Filter Strips
- Grassed Waterways
- Riparian Buffers
- Vegetative Barriers
- Windbreaks and Shelterbelts Conservation Tillage
- General
- Mulch Tillage
- No Tillage/Strip Tillage
- Ridge Tillage
- Cover Crops
- Drainage
- Fencing and Livestock Exclusion
- Integrated Pest Management
- Nutrient Management
- Stream Restoration

These practice subcategories will be considered when developing the structure of the WERF/NCGA Database.

5.2 NRCS Conservation Effects Assessment Project (NRCS-CEAP)

Web based resources are also accessible for specific USDA programs involving monitoring and research. These are not databases per se, but represent sources of multiple studies that may be relevant to the current BMP Database effort. In particular, the NRCS Conservation Effects Assessment Project (NRCS-CEAP) was initiated in 2003 and has several small watershed investigation programs for studying BMP effectiveness. These include:

- USDA Agricultural Research Station (USDA-ARS) Benchmark Watershed Studies: 14 long-term studies
- National Institute of Food and Agriculture (NIFA) Competitive Grant Watershed Studies (formerly known as CSREES): 13 studies conducted over 3 years
- NRCS Special Emphasis Watershed Studies: 11 studies conducted over 3 years

For more information on these programs, see:
www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/ceap/?&cid=nrcs143_014160.

Important lessons learned from the "NIFA-CEAP Synthesis" project were the subject of a joint EPA-NRCS webinar in May 2012. Technical findings were summarized by Dr. Deanna Osmond of North Carolina State University and provided insight into pitfalls to avoid when analyzing agricultural data sets.

5.3 USDA STEWARDS Database

The USDA Sustaining the Earth's Watershed Agricultural Research Data Systems (STEWARDS) database provides data for the 14 USDA-ARS Benchmark Watershed Studies. It is accessed online via a geospatial user interface. Data access is facilitated through the use of an online dynamic map. Data sets are limited to those provided by researchers at USDA-ARS watershed sites.

Prior to development of the STEWARDS database, ARS watershed data had been managed and disseminated independently at each research location, hindering accessibility and utility of these data for policy-relevant, multi-site analyses. In response to the need for better public accessibility, and as part of the CEAP project, STEWARDS was developed to provide access to soil, water, climate, land-management, and socio-economic data from 14 watersheds. ARS describes the key components of STEWARDS as follows:

1) a centralized site with Web/SQL/ArcGIS servers and application software, including a database management system (DBMS) and a geospatial data access portal;
2) data: including measurement data, imagery/GIS, and metadata;
3) users; and
4) research watershed sites that are data sources.

5.4 USDA MANAGE Database

USDA's "Measured Annual Nutrient Loads from Agricultural Environments" (MANAGE) database was developed to be a readily accessible, easily queried database of site characteristic and field scale nutrient export data. The original version of MANAGE was an electronic database which contained nutrient load data and corresponding site characteristics of agricultural land uses from 40 studies. The current version of MANAGE includes nitrogen (N) and phosphorus (P) load data from 15 additional agricultural runoff studies, along with N and P concentration data for all 55 studies. The database now contains 1,677 cumulative years of monitoring data (i.e., watershed years) for various agricultural land uses (703 for pasture/rangeland; 333 for corn; 291 for various crop rotations; 177 for wheat/oats; and 4 – 33 for barley, citrus, vegetables, sorghum, soybeans, cotton, fallow, and peanuts).

Representative practices evaluated in the MANAGE database include tillage, contour farming, filter strips, terraces, and waterway practices and fertilizer management.

5.5 Virginia Tech BMP Database

In 2002, Virginia Tech researchers developed a BMP database for EPA's Chesapeake Bay Program. This database was developed from 1999-2002 by Gene Yagow, Theo Dillaha, Jim Pease, Dave Kibler, and Darrell Bosch. Dr. Gene Yagow provided a copy of the database to the Project Team in May 2012, granting permission to incorporate aspects of the Virginia Tech BMP database into the current WERF/NCGA Database effort, where appropriate. The goal of the Virginia Tech project team was to develop a database from published research for assessing the impact of BMP implementation on nutrient loads and concentrations, as well as cost-effectiveness of these BMPs.

The Virginia Tech project team worked to define common attributes among BMP research studies that would allow for comparisons between the context of the studies and the study's water quality pollutant measurements. Many different experimental designs, approaches, and study objectives were identified in the reviewed articles. The objectives of these studies are not always to quantify the impact of a specific BMP. Many of the studies are related to BMP design variation; therefore, the studies evaluate a number of only slightly different treatments, trying to optimize one parameter for designing a BMP (e.g. filter strip width, or sediment pond detention time). Other studies simply present the water quality impact related to a certain land use or management practice without a control. The studies included in the Virginia Tech database, however, are essentially those between a control, either in space or time, and a definable BMP.

The Virginia Tech BMP database includes 596 papers related to agricultural BMPs. Information contained in database entries corresponding to these papers includes:

- 316 database entries that are limited to bibliographic data and were excluded from further analysis due to lack of data or scope applicability.

- 112 database entries that consisted of only bibliographic data, as a result of scope limitations at the time the project was conducted.

- 168 references that included underlying raw data sets and were evaluated in more detail. These data sets were summarized statistically and are stored in the Microsoft Access database provided by Virginia Tech.

The Virginia Tech database is composed of approximately 80 data elements (data entry fields) which are standardized in five tables. The five tables are: 1) Articles, 2) Primary Authors, 3) Study Sites, 4) BMPs, and 5) Measurements. Attachment 3 provides a description of these data elements and generally includes bibliographic data, geospatial data, BMP data, cost data, and monitoring parameter data. Four categories of BMPs classify 61 BMP types that are entered into the database based on NRCS code number. These BMPs are further divided into these general categories:

- Cropland
- Livestock
- Riparian
- Urban

Studies from the Virginia Tech database expected to be relevant to the current WERF/NCGA Database effort have been added to the table in Attachment 1 with Virginia Tech identified as the database source. Limitations of the Virginia Tech database are that the effort focused primarily on nutrients and the database has not been maintained with more recent research from the last decade. However, the studies included in the Virginia Tech database and aspects of the database design are useful for inclusion in the current WERF/NCGA Database effort.

5.6 EPA Agricultural BMP Effectiveness Database

In the early 2000's, EPA began developing an agricultural BMP database using Oracle database software; however, this database was placed on hold prior to public release. Per communication with Katie Flahive, the EPA lead for the project, the literature review component of EPA's database development efforts was incorporated into *Guidance for Federal Land Management in the Chesapeake Bay Watershed, Chapter 2 Agriculture* (EPA 841-R-10-002; May 12, 2010). Multiple tabular summaries of agricultural BMP performance are provided in this report, along with an over 30-page reference list. In regard to crops, information is provided on cropland agriculture source controls, cropland infield controls, and edge-of-field trapping and treatment. Although the intent of the current WERF/NCGA Database effort would be to provide more detailed underlying information enabling more detailed statistical analysis, the compilation of studies developed by EPA is expected to be an important information source to further evaluate. An example of the type of summary provided by EPA is shown on the following page.

The Project Team has also requested information relating to the approach used by EPA for developing the database structure, but only limited information was available at the time this literature review was completed. However, EPA provided information on the selection criteria for studies that were included in their literature review. Many of these criteria are consistent with screening criteria applied as part of the development of the International Stormwater BMP Database. EPA's criteria included:

- Is the source of the data Agricola, Federal Agency Report, or author-submitted? Is there proper bibliographic information for this study?
- Does this study quantitatively measure the effectiveness of one or more agricultural Conservation Practices/BMPs pollution for water quality? Does this study include and present changes in concentration or loading and effectiveness percentages for one or more pollutant?
- Does the study contain field results that quantitatively measure the effect on water quality (not lab, not modeling)?
- Is this a primary source, and not a comparison of results from other primary sources?
- Does this study describe the Conservation Practices/BMPs in quantifiable terms, with measurements and specifications about the site and location given?
- For proprietary devices, is an independent third party involved with the study?

Example Table Excerpt from EPA (2010)

Reference (as cited by Merriman et al. 1980	State	BMP name	Field plot	3-8	B	TP %	TN %	Total sediment
Bingham et al. 1980	NC	Contour Buffer Strip (3 m)	Field plot	3-8	B	52.77%	18.6%	
Bingham et al. 1980	MO	Contour Buffer Strip (3 m)	Field plot	3	B	7.91%	14.53%	
Udawatta et al. 2002	MO	Contour Buffer Strip (4.5 m)	Small watershed	3	D	26%	20%	19%
Udawatta et al. 2002	MO	Hedgerow Planting	Field plot	3-8	D	26%	20%	19%
Meyer et al. 1999	MS	Hedgerow Planting	Lab plot	3-8	C			76%
Meyer et al. 1995	GA	Hedgerow Planting	Field	3	B			80%
Sheridan et al. 1999	GA	Riparian Forest Buffer	Field	0-3	N/A			95%
Sheridan et al. 1999	GA	Riparian Forest Buffer	Field	0-3	N/A			74%
Sheridan 2005	GA	Riparian Forest Buffer	Farm	0-3	N/A			68%
Blanco-Canqui et al. 2004	GA	Riparian Forest Buffer	Farm	3	D	56%	37%	
Dillaha et al. 2004	MO	Vegetated Filter Strip (VFS)	Field plot	3-8	D			95%
Dillaha et al. 1988	VA	VFS	Field plot	3-8	C	2%	1%	31%
Srivastava et al. 1996	AR	VFS	Field plot	3-8	C	65.5%	67.2%	
Dillaha et al. 1996	AR	VFS	Field plot	8	C	36%	43.9%	
Dillaha et al. 1988	VA	VFS	Field plot	8-15	C	63%	64%	87%
Feagley et al. 1992	AR	VFS	Field plot	N/A	D			78.49%
Chaubey et al. 1995	TX	VFS (15.2 m)	Field plot	3-8	C	86.8%	75.7%	
Sanderson et al. 2001	TX	VFS (16.4 m)	Field plot	N/A	C	47%		
Chaubey et al. 2001	TX	VFS (16.4 m)	Field plot	N/A	C	76%		
Chaubey et al. 1995	AR	VFS (21.4 m)	Field	3-8	C	91.2%	80.5%	
Daniels and Gilliam. 1996	MO	VFS (3 m)	Field	3-8	B	55%	40%	53%
Chaubey et al. 2004	MO	VFS (4 m)	Field plot	3-8	D		77%	91%
Chaubey et al. 1995	AR	VFS (4 m)	Field plot	3-8	C	39.6%	39.2%	
Mendez et al. 2001	VA	VFS (4 m)	Field plot	N/A	N/A	50%	50%	
Mendez et al. 1999	VA	VFS (4.3 m)	Field plot	3-8	C		55.6%	81.9%
Dillaha et al. 1989	VA	VFS (4.6 m)	Field plot	8	C	85%	84%	83%
Dillaha et al. 1989	VA	VFS (4.6 m)	Field plot	15	C	73%	73%	86%
Dillaha et al. 1988	VA	VFS (4.6 m)	Field plot	15-25	C	52%	69%	76%
Dillaha et al. 1989	VA	VFS (4.6 m)	Field	3-8	C	49%	47%	53%
Chaubey et al. 1995	AR	VFS (6 m)	Field	3-8	B	65%	48%	68%
Chaubey et al. 1995	AR	VFS (6.1 m)	Field plot	3-8	C	58.4%	53.5%	

5.7 EPA Section 319 Program Data Sources

The EPA 319 program supports non-point source control projects that may include monitoring components. Several sources of 319 information are described below. Additional effort beyond the current scope of work would be needed to extract data from these sources for use in the WERF/NCGA Database effort.

5.7.1 EPA 319 Program National Monitoring Program Projects

The EPA Section 319 Program National Monitoring Program (NMP) was initiated in 1991. It encompasses 27 surface water projects and one ground water project for the purposes of tracking BMP effectiveness. Five of the 27 surface water projects focus on mining or urban BMPs. These projects are tracked using the Non-point Source Management System software developed by the EPA. Based on initial efforts to obtain this software (via emails to EPA staff), it appears that it is not publically available. Software accessibility could be further researched during Phase 2 of this effort.

5.7.2 EPA 319 Success Story Database

There are 368 projects listed in the EPA 319 Success Story database. These projects include watersheds that have undergone non-point source restoration using funding from Section 319 of the Clean Water Act. The database is searchable by location. Data are presented narratively. Raw data are sometimes provided in tables, charts, or graphs.

5.7.3 EPA 319 Grants Reporting and Tracking System (GRTS)

The GRTS database contains thousands of projects supported by Section 319 of the Clean Water Act. Data are searchable by location. While most of the focus of this database is for tracking grants, over 1,500 studies have pollutant data available of varying types (measured and/or modeled).

5.7.4 Rural Clean Water Program (RCWP)

This program was initiated in 1980 and was used to evaluate BMPs in 21 watersheds nationwide. The RCWP was administered by the USDA and EPA, and was a precursor to the modern day EPA 319 program.

5.8 MP Miner

The MP Miner (Management Practices Miner) database and website (http://mpminer.waterboards.ca.gov/mpminer/) are a compendium of documented non-point source pollution management practices compiled by Tetra Tech for the California EPA State Water Resources Control Board. The version of MP Miner reviewed by the Project Team included 20 agricultural BMPs subdivided into six subcategories. The six BMP categories include:

- Basins

- Channels
- Buffers
- Areal Practices (vegetative covers, cover crops and agroforestry)
- Source Management (pest management, nutrient management, and irrigation)
- Combination (studies that incorporate many BMPs or comprehensive planning)

The current online version of the database appears to have some additional categories of information, with agricultural BMPs divided into the categories of erosion and sediment control, animal waste, nutrient management, pesticide management, grazing management, irrigation and water management, and education and outreach.

Summary-level information is provided based on percent removal ranges, along with bibliographical information. Some site characteristic data elements are also included, such as soil type, vegetative cover, soil series, average slope percentage, drainage area, and depth to groundwater.

5.9 State Agricultural BMP Databases and Compilations

Due to the limited scope of this Phase 1 effort, an exhaustive review of local state programs was not conducted; however, several state or watershed-based resources were identified in this initial literature review. Representative examples include:

- **WATERSHEDSS (Water, Soil, and Hydro - Environmental Decision Support System):** WATERSHEDSS is an online, interactive tool developed by the North Carolina State University Water Quality Group. It hosts a watershed evaluation and assessment tool for landowners, provides educational information regarding agricultural BMPs, and hosts a large searchable bibliography of relevant research papers.

- **Neuse River Virtual Field Reference Database:** This database is specific to the Neuse River Basin in North Carolina. Navigation is based on a simple "map-view" interface that allows users to select which watershed to view. Reported data include location, description, land cover, vegetation, ecology, crown density, basal area measurements, and photographs. While this database does not study BMPs directly, its user interface may be of interest with regard to a framework for future database development work.

- **Ohio State Extension Service Agricultural BMP Fact Sheet:** The Ohio State University Extension Service has published an Agricultural Best Management Practices Fact Sheet (AEX-464-91) based on the USDA-NRCS Agriculture Information Bulletin No. 598. This fact sheet summarizes the effects of 30 different BMPs on surface water and ground water quality, derived from a 1990 USDA report. The effects are ranked qualitatively in three groups (A, B, C) or as "unknown" in regard to nine water quality parameter categories (salinity, temperature, sediment, soluble nutrients, absorbed nutrients, soluble pesticides, absorbed pesticides, oxygen demanding substances and pathogens).

Other compilations of this nature are expected to be available from universities with agricultural programs and cooperative extension services. Although these were not evaluated state-by-state, the overall literature search is expected to have captured at least some of the key state-related publications. During Phase 2 of this project, it may be appropriate to further review state and regional data sources, particularly mid-western and southern states that have significant agricultural operations.

5.10 Canadian Programs (WEB and Others)

The Watershed Evaluation of Beneficial Management Practices (WEB) program is similar to the USDA-CEAP program, but is sponsored by Agriculture and Agri-Food Canada. This study includes nine watersheds in Canada.

Additionally, the "Archive of Agri-Environmental Programs in Ontario Before 2000" is a Canadian website with agricultural BMP performance data (http://agrienvarchive.ca/). Last updated July 2012, this website archives 626 published documents covering numerous agricultural research programs in Ontario, Canada. From 1986 to 1997, a series of federal-provincial initiatives were conducted that focused on agricultural sustainability while reducing pollution in the Great Lakes Basin in the Province of Ontario. The overall funding for these programs approached $100 million. This archive includes at least 12 separate programs, including:

- Canada-Ontario Agriculture Green Plan
- Clean Up Rural Beaches Program (CURB)
- Ontario Ministry of the Environment funded projects
- Great Lakes Water Quality Program (GLWQ)
- Land Management Assistance Program (LMAP)
- Land Stewardship Program (LSP)
- National Soil Conservation Program (NSCP)
- Soil and Water Environmental Enhancement Program (SWEEP)
- Pollution from Land Use Activities (PLUARG)
- Stratford/Avon River Environmental Management Project (SAREMP)
- Thames River Implementation Committee (TRIC)
- Ontario Research Enhancement Program (OREP)

5.11 Mexican Decision Support (MEDS)

This program is similar to USDA-CEAP and Canadian WEB studies. MEDS began in 2006 under the Mexican National Institute for Forestry, Agriculture, and Animal Husbandry Research (INIFAP). Due to the English/Spanish language barrier, an initial assessment of INIFAP by the Project Team did not result in the identification of published reports from this project.

6 WATERSHED MODELS

Many agricultural models either explicitly or indirectly incorporate BMPs and may be sources of BMP design parameter guidance useful for development of the WERF/NCGA Database. Many of these models are tested, calibrated, or verified with field data that may be applicable to this database. As part of Phase 1 of this effort, these models have been reviewed for design parameters that should be considered as part of WERF/NCGA BMP Database development. Although this review is described in a separate Task 1 deliverable and is not repeated herein, representative models and supporting materials provided by USDA ARS staff that have been reviewed by the Project Team as potential resources include:

- Soil and Water Assessment Tool (SWAT) (Note: there is also an on-line SWAT Literature Database for Peer-Reviewed Journal Articles (accessible at https://www.card.iastate.edu/swat_articles/index.aspx)
- Agricultural Non-Point Source Pollution Model (AGNPS) and its successor AnnAGNPS
- Universal Soil Loss Equation (USLE) (and its revised/modified successors)
- Kinematic Runoff and Erosion Model (KINEROS2)

7 CONCLUSIONS AND NEXT STEPS

This literature review identified multiple sources of agricultural BMP study information that will be useful in developing and populating a centralized agricultural BMP database. Next steps for use of this information include:

- Key design parameters for BMPs as described in the NRCS standard codes will be used to help guide development of design related entries for groups of agricultural BMPs.

- The Virginia Tech database data elements will be reviewed for potential inclusion in the beta release of the WERF/NCGA Database.

- The top dozen studies identified in this literature review will be used as examples of information likely to be reported with high quality studies.

- During Phase 2 of this project, individual studies obtained in support of this literature review may be suitable to begin populating the WERF/NCGA Database. In some cases, additional follow up with the original researcher may be needed to obtain more detailed supporting data.

- During Phase 2 of this project, the databases and data compilations described in Section 5 are expected to be useful in identifying BMP performance studies in other agricultural sectors. Additionally, state universities and cooperative extensions, as well as regional organizations, may provide additional studies beyond those included in this Phase 1 literature review.

8 ATTACHMENTS

Attachment 1. Literature Summary

Attachment 2. NRCS Standard Practice Code Spreadsheet

Attachment 3. Virginia Tech BMP Database Data Elements

Review Number	Reference (author, year)	Report Title	Other Database Source (if applicable)	Sponsoring Program	Location (s)	Crop(s)	Practices Implemented/ Evaluated	Quantitative Practice Data? (y/n)	Quantitative Watershed Data? (y/n)	Quantitative Event-Based Data (y/n)?	# of Events/ Study Duration	Study Technique (upstream/ downstream, control-reference, before/after, influent/effluent)	Data Tabulated or Electronically Available? (y/n)	Consider for More Detailed Review? (y/n)	Comments	Abstract (*using cut & paste*)
11	Abaci, O. 2009	Long-term effects of management practices on water-driven soil erosion in an intense agricultural sub-watershed: monitoring and modeling			IA	corn, soybean	tillage	N	Y	N	2-year		Y	N		Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
102	Alberts et al., 1985	Dissolved N and P in runoff from watersheds in conservation and conventional tillage			IA	corn	conventional, contour, terrace	Y	Y	Y	10-year	experiment/control	N	Y	Yearly means presented graphically.	Dissolved N and P concentrations in surface and subsurface flows were measured from three corn-cropped watersheds in southwestern Iowa from 1974 through 1983. One watershed was tilled conventionally while the other two were till-planted, all on the contour. One of the till-planted watersheds was terraced, with underground pipe drains to remove excess water from the terrace channels. Each of the watersheds was fertilized at recommended N and P levels for optimum corn production. Losses of NO3-N, NH4-N, and PO4-P in surface runoff were low, representing less than 2% of the annual fertilizer application. However, NO3-N and NH4-N concentrations in surface runoff from the till-planted watersheds sometimes exceeded water quality standards. PO4-P in surface runoff from each of the watersheds always exceeded the water quality standard, and was especially high from the till-planted watersheds. NO3-N losses in subsurface flow represented more than 85% of the total NO3-N losses in both subsurface and surface flows. The highest annual NO3-N loss in subsurface flow was 74.4 kg/ha (66.4 lbs/acre) from the nonterraced, till-planted watershed in 1983. NO3-N concentrations in subsurface flow from this till-planted watershed have exceeded the water quality standard since 1977.
115	Allan et al., 1997	Piedmont N.C. Wet Retention Basins: Performance factors, sedimentation dynamics, and seepage losses			NC	None listed	Retention Ponds	Y	N	Y	1-year	inflow/outflow	Y	No, urban study	Thesis	In this study an examination of environmental factors potentially affecting the ability of small ponds to perform as water quality improvement facilities has been undertaken within a 240 square mile (622 square km) region of the North Carolina Piedmont, largely within the urban - suburban region of Charlotte, N.C. The study has involved 10 sequential sets of analyses. The first was a remote sensing and GIS-based analysis of the relationships between watershed attributes and turbidity within ponds during interstorm or dry periods. The second and third were analyses of bulk sedimentation (in 20 basins) and sedimentary facies (in five ponds). The fourth was a study of the physical and chemical limnology of a suite of 20 ponds. The fifth and sixth were investigations of P, N and Zn chemistry of pond sediment. The seventh through tenth involved a multicomponent analysis of pond performance during a full year climatic cycle with additional detailed analyses of a number of storm events. The benefits of small ponds to serve as water quality improvement facilities is likely limited (without dredging) to ~50 years. Approximately 1% of the existing ponds are likely to need remediation or improvement each year, if the current estimate of a net 12% benefit to TSS removal by the ponds is maintained. The efficacy of ponds for pollutant removal is species-dependent. From 20% to 98% of TSS, BOD, COD, total P and some metals such as Pb and Cr are likely to be removed. Ponds have limited efficacy (40%) in removing other components such as C1, TKN and ortho P. Stratification in ponds during summer months produces anoxic, hypolimnionic waters which can dynamically exchange adsorbed constituents within sediment reservoirs with storm pulses of more dilute epilimnionic water. This can result in short periods of downstream TDS levels higher than under nonimpounded conditions.
96	Angle et al., 1984	Nutrient losses in runoff from conventional and no-till corn watersheds			MD	corn	conventional, no-till	Y	N	Y	32	experiment/control	Y	Y	Excellent event data	A study was initiated to determine the quantity of nutrients and sediment in runoff from conventional and no-till corn (Zea mays L.) watersheds. Runoff was collected with H-type flumes and Coshocton wheels. Parameters measured in runoff included NH4+-N, NO3-N, total N, ortho-PO4, total soluble P, total P, suspended sediment, and soluble solids. There was a significant difference in total runoff between the conventional and no-till watersheds. Over nine times more runoff originated from the conventional-till watershed when compared with the no-till watershed in 1982. A large difference between the two watersheds in suspended sediment content was also observed. Yearly sediment losses of 370 and 9 kg/ha from the conventional and no-till watersheds, respectively, were found for 1982. There was also a significant difference in the loss of soluble solids between the two watersheds. For 1982, there was over a 29-fold greater loss of soluble solids from the conventional-till watershed than from the no-till watershed. Losses of NH4+-N, NO3-N, and total N from each watershed were very low, although large differences were observed between the two watersheds. In 1980, 271, 638, and 1199 g/ha of NH4+-N, NO3-N, and total N, respectively, were lost from the conventional-till watershed, while 2, 47, and 87 g/ha, respectively, of the above parameters were lost from the no-till watershed. The loss of all forms of P from each watershed was also very small. During 1982, 161 g/ha of total P were lost from the conventional-till watershed while only 8 g/ha were lost from the no-till watershed. The loss of ortho-PO4 and total soluble P was not significantly different between the two tillage treatments.
161	Angle et al., 1993	Soil Nitrate Concentrations under Corn as Affected by Tillage, Manure, and Fertilizer Applications	Va. Tech/Yagow	MD Dept. of Ag.	MD	corn	tillage, fertilizer, manure	Y	N	N	4-year	experiment/control	Y	Y	Good, yearly means presented	A 3-yr study was conducted to examine combination effects of tillage (no-till, conventional-till), manure, and inorganic fertilizer (ammonium nitrate) on leaching of nitrates from the root zone of corn (Zea mays L.). Soil cores were collected every spring to a depth of 210 cm and analyzed for NO3-N. Leaching of NO3-N significantly increased as fertilizer N rates increased, especially when rates exceeded the crop's potential to assimilate N. The concentration of soil nitrate (averaged over depth and tillage) in Year 3 of the study under the unfertilized control plots was 2.5 mg NO3-N kg−1, whereas the concentration under plots fertilized with 260 kg N/ha was 8.7 mg NO3-N kg−1. Soil nitrate concentrations were consistently lower under no-tillage when compared with conventional-tillage. Tillage differences were greatest when high rates of N were added to soil. These results indicate that the use of no-tillage cultivation may reduce the leaching of nitrates beyond the crop root zone.
116	Baldwin et al., 1986	Effects of Tillage on Quality of Runoff Water	Va. Tech/Yagow		KY	bluegrass	conventional, chisel-plow, no-till	Y	N	Y	11	experiment/control	Y	Y	Excellent.	Generally, the first year's data from this study showed little statistically significant difference in water quality parameters due t o tillage. At least part of this can be attributed to the homogeneity of these plots in their first year of tillage following many years i n bluegrass sod. The data does indicate certain trends. Runoff from NT tended t o be highest i n concentrations throughout much of the season, but the total amount of greatest in runoff from CT. Total runoff volume and sediment for the season were also greatest from CT. Runoff from CP was most often highest in concentrations of both water-soluble P and atrazine and often carried higher total amounts of atrazine. Because of the higher volume of runoff, the greatest total amount of water-soluble P was removed from the CT plots. The pH values generally were highest f o r CP and lowest for CT runoff. Our NO- and P results were similar to those reported by Romkens e t al. (1973) ahd angle et al. (1984), although significant differences between tillage treatments were few. With subsequent cropping years, these p l o t s are expected t o become much more characteristic of their respective tillage systems in regard to surface condition, soil structure , organic matter and surface pH, a l l of which have been indicated as influencing runoff volume and its composition and sediment delivery.
186	Basso et al., 2005	Impact of compost, manure and inorganic fertilizer on nitrate leaching and yield for a 6-year maize–alfalfa rotation in Michigan			MI	Corn, alfalfa	fertilizer management	Y	N	N	6-year	experiment/control	Y	Y	Good, bi-annual means presented	An accurate estimate of nitrate (NO3N) leaching from agricultural land is critical to environment impact studies. Although NO3N are almost always present in groundwater, their continued increase in managed agricultural land can lead to nitrate concentrations in groundwater above acceptable human health standards. The amount of NO3N leached during the growing season may be minimal compared to leaching losses that occur between the harvest of one crop and the planting of the next. In this study we compared the effect of inorganic N and raw and composted animal manure on crop productivity and N leaching under field conditions in a maize-alfalfa system using undisturbed drainage lysimeters in Michigan. The cropping system rotation consisted of 3 years of continuous maize (Zea mays L.) and 3 years of continuous alfalfa (Medicago sativa L.). One cropping system consisted of a maize crop grown in the 1994-1996 seasons and alfalfa in the 1997-1999 seasons. The other cropping system was alfalfa (1994-1996) then maize (1997-1999). Four N treatments were imposed on the cropping systems. Treatment 1 was a check, no N fertilizer; Treatment 2 was manure; Treatment 3 was compost; Treatment 4 was inorganic fertilizer. No significant differences in yields of maize and alfalfa were found between N treatments in the 6-year rotation, although the no N treatment in maize had consistently lower yields. The highest amount of NO3N leaching was measured in the manure treatment with a mean annual value of 55 kg NO3N/ha in maize-alfalfa rotation and 59 kg NO3N/ha in alfalfa-maize, followed by compost (35 kg NO3N/ha in alfalfa-maize and 30 kg NO3N/ha in maize-alfalfa), inorganic N (33 kg NO3N/ha in alfalfa-maize and 25 kg NO3N/ha in maize-alfalfa) and no N (27 kg NO3N/ha in alfalfa-maize and 25 kg NO3N/ha in maize-alfalfa). The highest rates of NO3N losses were also observed in the manure treatment with a mean value for the 6-year rotation of 0.14 kg NO3N mm−1 in alfalfa-maize and 0.35 kg NO3N mm−1 in maize-alfalfa.
170	Bergstrom et al., 2001	Ryegrass Cover Crop Effects on Nitrate Leaching in Spring Barley Fertilized with NH4NO3		Swedish Council for Forestry and Ag. Research	Sweden	barley	cover crop	Y	N	N	2-year	experiment/control	N	Y	Good, but no runoff data	Cover crops are a management option to reduce NO3 leaching under cereal grain production. A 2-yr field lysimeter study was established in Uppsala, Sweden, to evaluate the effect of a perennial ryegrass (Lolium perenne L.) cover crop interseeded in barley (Hordeum vulgare L.) on NO3-N leaching and availability of N to the main crop. Barley and ryegrass or barley alone were seeded in mid-May 1992, in lysimeters (0.3-m diam. × 1.2-m depth) of an undisturbed, well-drained, sandy loam soil. Fertilizer N was applied at the same time as labeled 15NH4 15NO3 (10 atom % 15N) at a rate of 100 kg N/ha In 1993, barley was reseeded in May in the lysimeters but with nonlabeled NH4NO3 and no cover crop (previous year's cover crop incorporated just prior to seeding). Barley yields and total and fertilizer N uptake in Year 1 (1992) were unaffected by cover crop. Total aboveground N uptake by the ryegrass was 28 kg/ha at the time of incorporation the following spring. Recovery of fertilizer-derived N in May 1993 was about 100%; 53% in soil, 46% in barley, <2% in ryegrass, and negligible amounts in leachate. In May 1994, the corresponding figures were: 32% in soil, <3% in barley, and, again, negligible amounts in leachate. The cover crop reduced concentrations of NO3-N in the leachate considerably (<5 mg/L, compared with 10 to 18 mg/L without cover crop) at most sampling times from November 1992 to April 1994, and reduced the total amount of NO3-N leached (22 compared with 8 kg/ha).

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162	Bingham et al., 1980	Effect of Grass Buffer Zone Length in Reducing the Pollution from Land Application Areas	Va. Tech/Yagow		NC	manure land-application	grass buffer strip	Y	N	N	1-year	experiment/control	Y	N	Land-application of manure treatment study	A field study was conducted to determine the effect of length of grass buffer zones in reducing pollutant concentration in rainfall runoff from land application areas. Evaluation of pollutant concentrations in runoff at various distances downslope from an area where caged layer poultry manure was applied regularly indicated that for the conditions of this experiment a buffer area length to waste area length ratio of 1.0 was usually required to reduce concentrations to those measured in runoff from a similar plot receiving no manure. Less buffer area would be needed if concentrations greater than background conditions were acceptable.
163	Bjorneberg et al., 1998	Alternative N Fertilizer Management Strategies Effects on Subsurface Drain Effluent and N Uptake	Va. Tech/Yagow	CSRS-USDA	IA	corn, soybean	tillage, fertilizer	Y	N	N	3-year	control/experiment	Y	Y	Good, yearly means presented	Demonstrating positive environmental benefits of alternative N fertilizer management strategies, without adversely affecting crop growth or yield, was a major goal for the Midwest Management Systems Evaluation Areas (MSEA) program. Our project objectives within this program were to quantify the effects of split- and single-N fertilization strategies on NO3-N concentration and loss in subsurface drain effluent and N accumulation and yield of corn (Zea mays L.) and soybean [Glycine max (L.) Merr.]. The study was conducted on glacial till derived soils in northeast Iowa from 1993 through 1995 using no-till and chisel plow tillage treatments. One-third of the 2,611 effluent samples had NO3-N concentrations greater than 10 mg/L . Split applying fertilizer N based on pre-sidedress soil nitrate test (PSNT) results significantly increased corn yield for both tillage treatments in the extremely wet 1993 without increasing NO3-N loss in drain effluent. Increased grain yield also resulted in significantly more N removal. When fertilizer N was applied based on the PSNT, no-till and chisel treatments had similar NO 3-N losses and concentrations. Average flow-weighted NO3-N concentrations in drain effluent were not increased when larger amounts of fertilizer were applied based on PSNT. However, prior crop and tillage practices and differences in drain flow volume caused significant differences in NO3-N losses and concentrations. These results suggest that spatial differences in flow volume are a major factor determining NO3-N loss in drainage effluent. Significant differences suggest that combining no-tillage practices with split N fertilizer management strategies can have positive environmental benefits without reducing corn yield
89	Blattel et al., 2005	Abatement of groundwater phosphate in giant cane and forest riparian buffers	AGRICOLA	State of Illinois	IL	corn, soybean	vegetative buffer	Y	N	Y	1-year	inflow/outflow	N	Y	Means presented monthly. Groundwater	Forest and grass riparian buffers have been shown to be effective best management practices for controlling nonpoint source pollution. However, little research has been conducted on giant cane Arundinaria gigantea (Walt. Muhl.), a formerly common bamboo species, native to the lower midwestern and southeastern United States, and its ability to reduce nutrient loads to streams. From May 2002 through May 2003, orthophosphate or dissolved reactive phosphate (DRP) concentrations in ground water were measured at successive distances from the field edge through 12 m of riparian buffers of both giant cane and mixed hardwood forest along three streams draining agricultural land in the Cache River watershed in southern Illinois. Giant cane and mixed hardwood forest did not differ in their DRP sequestration abilities. Ground water DRP concentrations were significantly reduced (14%) in the first 1.5 m of the buffers, and there was an overall 28% reduction in DRP concentration by 12 m from the field edge. The relatively low DRP reductions compared to other studies could be attributed to high DRP input levels, narrow (12 m) buffer lengths, and/or mature (28 to 48 year old) riparian vegetation.
164	Blevins et al.,1990	Tillage Effects on Sediment and Soluble Nutrient Losses from a Maury Silt Loam Soil	Va. Tech/Yagow		KY	corn	tillage	Y	N	N	4-year	control/experiment	Y	Y	Good, yearly means presented	As the role of nonpoint-source contamination of surface waters becomes more evident, increasingly more attention is focused on the effects of agricultural practices on soil erosion and water quality. Tillage systems are known to affect the amount of water moving over the surface and through the soil. This study compared the contributions of three tillage systems used in corn (Zea mays L.) production with (i) sediment losses and surface runoff and (ii) the potential for nonpoint-source surface water pollution from N and P fertilizers and triazine herbicides. Tillage treatments were no-tillage, chisel-plow tillage, and conventional tillage (moldboard plow plus secondary tillage). The study site was on a Maury silt loam (Typic Paleudalfs). Over the 4-yr period, conventional tillage runoff volume was 576.7 kL/ha, chisel-plow 205.7 kL/ha, and no-tillage 239.9 kL/ha. Total soil loss from conventional tillage was 19.79 Mg/ha, chisel plow 0.71 Mg/ha, and no-tillage 0.55 Mg/ha. Amounts of NO-3, soluble P, and atrazine leaving the plots in surface runoff were greatest from conventional tillage and about equal from chisel-plow and no-tillage. The magnitudes of the losses in surface runoff water were small for all chemicals measured.
171	Blowes et al., 1994	Removal of agricultural nitrate from tile-drainage effluent water using in-line bioreactors			Canada	corn	bioreactors				2-year	inflow/outflow	Y	Y	Good, but few tables	Two 200-L fixed-bed bioreactors, containing porous-medium material of coarse sand and organic carbon (tree bark, wood chips and leaf compost), were used to treat NO3 contamination from agricultural runoff. Flow from a farm-field drainage tile containing NO3-N concentrations of 3-6 mg/L was successfully treated in the reactors (NO3-N < 0.02 mg/L) at a rate of 10-60 L/day over a 1-yr period. Treatment occurs by anaerobic denitrification promoted by the added solid-phase organic carbon. Because the reactor design is simple, economical to construct and maintenance free, it may provide a practical solution to the problem of treating redox-sensitive contaminants, such as NO3, in agricultural runoff.
172	Borin et al., 2005	Effectiveness of buffer strips in removing pollutants in runoff from a cultivated field in North-East Italy			Italy	Winter wheat, corn, soybean	buffer strip	Y	N	Y	4-year	experiment/control	Y	Y	Good, yearly means presented	Buffer strips are an efficient and economical way to reduce agricultural nonpoint source pollution. Local researches are necessary to gain information on buffer performance, with particular emphasis on narrow buffers. The effect of a 6 m buffer strip (BS) in reducing runoff, suspended solids and nutrients from a field growing maize, winter wheat and soybean was assessed in a field experiment conducted in North-East Italy during 1998-2001. The BS was composed of two rows of regularly alternating trees (Platanus hybrida Brot.) and shrubs (Viburnum opulus L.), with grass (Festuca arundinacea L.) in the inter-rows. The BS reduced total runoff by 78% compared to no-BS, in which cumulative runoff depth was 231 mm over 4 years. With no-BS runoff appeared to be influenced mostly by total rainfall, while with BS maximum rainfall intensity was more important. The filtering effect of the BS reduced total suspended solids (TSS), particularly after the second year, when the median yearly concentrations ranged from 0.28 to 0.99 mg/Land were smaller than 0.14 mg/L, with no-BS and with BS respectively. The combination of lower concentrations and runoff volumes significantly reduced TSS losses from 6.9 to 0.4 t/ha over the entire period. A tendency to increased concentrations of all forms of N (total, nitrate and ammonium) while passing through the BS was observed, but total N losses were reduced from 17.3 to 4.5 kg/ha in terms of mass balance. On the contrary, P concentrations were unmodified (soluble P), or lowered (total P) by the BS, reducing total losses by about 80%. The effect on total P, composed mainly of sediment-bound forms, was related to particulate settling when passing through the BS. A numerical index (Eutrophic Load Index), integrating water quality and runoff volumes, was created to evaluate the eutrophication risk of runoff with or without the BS. It showed that the BS effect was mostly due to a reduction of runoff volumes rather than improving the overall water quality.
6	Boyd, P.M. 2003	Pesticide Transport with Surface Runoff and Subsurface Drainage through a Vegetative Filter	MPMINER	Academia	Iowa	Row crops, specific crop not in abstract	filter strip	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	tbd	Full text not available	Vegetative filter strips (VFS) have become an established best management practice during the last 25 years. This study examined the effectiveness of VFS of brome grass in central Iowa for reducing the mass transport of sediment and pesticides (atrazine, acetochlor, and chlorpyrifos) with surface runoff under natural rainfall conditions. Measurements of pesticide concentrations in water from a single subsurface drain under the plots were also made. Overall results showed that many factors affect pesticide transport, such as rainfall timing and intensity, hydrology, source to VFS area ratios, and the adsorption properties of pesticides in VFS inflow. Two primary mechanisms (inflow water infiltration and sediment deposition) had a significant effect on pesticide passage through VFS. Sediment deposition increased with decreased flow volume and velocity, and was considerably higher for the 15:1 area ratio plots than for the 45:1 plots; this in turn aided in the reduction of transport of pesticides adsorbed to sediment. Reductions in atrazine and acetochlor transport were primarily controlled by the infiltration efficiency of the VFS, as they are moderately adsorbed, and the major portion of these pesticides moved in solution in the surface runoff water phase. Chlorpyrifos was highly adsorbed to the sediment, making sediment deposition in the VFS equally, if not more, important than infiltration for mass removal. The herbicides (atrazine and acetochlor) had low to moderate adsorption characteristics and moved primarily in the runoff water phase. Data collected for the subsurface drainage from the tile line showed that there were measurable concentrations of the moderately adsorbed herbicides in the tile flow at the time surface runoff was taking place; however, concentrations of the more strongly adsorbed chlorpyrifos were below detection. The statistical difference was most prominent in the event with the smallest runoff volume. This showed that at lower flow rates, VFS can effectively reduce runoff, sediment, and pesticide transport from cropland.
13	Bracmort, K. 2006	Modeling Long-Term Water Quality Impact of Structural BMPs		USDA	IN	corn, pasture, soybean	grassed waterway, terrace, field border, grade stabilization	Y	N	N		model calibration	N	N	May be difficult to use for database	Structural best management practices (BMPs) that reduce soil erosion and nutrient losses have been recommended and installed on agricultural land for years. A structural BMP is expected to be fully functional only for a limited period after installation, after which degradation of the BMP is likely to lead to a reduction in the water quality improvement provided by the BMP. Assessing the impact of BMPs on water quality is of widespread interest, but no standard methods exist to determine the water quality impact of structural BMPs, particularly as the impact changes through time. The objective of this study was to determine the long-term (~20 year) impact of structural BMPs in two subwatersheds of Black Creek on sediment and P loads using the Soil and Water Assessment Tool (SWAT) model. The BMPs were represented by modifying SWAT parameters to reflect the impact the practice has on the processes simulated within SWAT, both when practices are fully functional and as their condition deteriorates. The current condition of the BMPs was determined using field evaluation results from a previously developed BMP condition evaluation tool. Based on simulations in the two subwatersheds, BMPsin good condition reduced the average annual sediment yield by 16% to 32% and the average annual P yield by10% to 24%. BMPs in their current condition reduced sediment yield by only 7% to 10% and P yield by 7% to 17%.

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52	Bracmort, K., 2004	Estimating the Long-Term Benefits and Costs of BMPs in an Agricultural Watershed			IN	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	tbd	Not enough info in abstract to evaluate	Federal conservation agencies are recognizing the need to account for the millions of dollars spent nation-wide on conservation programs focused on implementing best management practices (BMPs), some of which have been in existence for decades. A cost-benefit analysis for many of these programs is difficult due to the limited water quality and cost data available, and because attempts to quantify the water quality benefits obtained from BMP implementation is problematic. A cost-benefit analysis was performed on a large watershed management project that installed hundreds of BMPs in the mid-1970s, the Black Creek Project. Water quality improvement for sediment and total P reduction due to BMP implementation was estimated in 2000 dollars using off-site benefit estimates, fertilizer nutrient costs and water quality trading values. The benefits received from the BMPs did not outweigh the costs for implementing and maintaining the BMPs. Benefits not captured in this economic analysis include lessons learned and used outside the watershed by the conservation community, gully erosion, erosion deposited within the watershed, N reduction, wildlife habitat improvement, human and aquatic ecosystem health, aesthetics, downstream impacts, intangible impacts and the needs of future generations. This study shows that the tools needed to compute an accurate comparison of benefits and costs concerning water quality are lacking. Economic analysis of conservation planning should continue, but should not be the sole determining factor when deciding if a conservation project is worthwhile.
117	Brandi-Dohrn et al., 199	Nitrate Leaching under a Cereal Rye Cover System	Va. Tech/Yagow	many	OR	corn, rye, broccoli	cover crop	Y	N	N	3-year	experiment/control	Y	Y	Good. Yearly means presented	Winter cover crops hold potential to capture excess NO3- and reduce leaching by recycling nutrients. The objective of this study was to compare winter NO3-N leaching losses under winter-fallow and a winter cereal rye (Secale cereale L.) cover crop following the harvest of sweet corn (Zea mays L.) or broccoli (Brassica oleracea var. italica Plenck). Leachate was sampled with passive capillary wick samplers that apply a suction of 0 to 5 kPa to the soil-pore water and intercept leachate in a pan of known area. Without disturbing the over-laying soil profile, 32 samplers (0.26 m2) were installed at a depth of 1.2 m in a Willamette loam (fine-silty mixed mesic Pachic Ultic Argixeroll). The randomized complete-block split plot design of this cover crop-crop rotation study (initiated in 1989) has cropping system (winter fallow vs. winter cereal rye) as main plots and three N application rates, ranging from 0 to 280 kg N ha-1 yr-1, as subplots. At the recommended N rate for the summer crops, NO3 leaching losses were 48 kg N ha-1 under sweet corn-winter-fallow for winter 1992-1993, 55 kg N ha-1 under broccoli-winter-fallow for winter 1993-1994, and 103 kg N ha-1 under sweet corn-winter-fallow for winter 1994-1995, which were reduced to 32, 21, and 69 kg N ha-1, respectively, under winter cereal rye. For the first two winters, most of the variation (61%) in NO3- leaching was explained by N rate (29%), cereal rye N uptake (17%), and volume of leachate (15%). Seasonal, flow-weighted concentrations at the recommended N rate were 13.4 mg N/L under sweet corn-winter-fallow (1992-1993), 21.9 mg N/L under broccoli-winter-fallow, and 17.8 mg N/L under sweet corn-winter-fallow (1994-1995), which were reduced by 39, 58, and 22%, respectively, under winter cereal rye.
118	Brown et al., 1981	Ponding Surface Drainage Water for Sediment and Phosphorus Removal	Va. Tech/Yagow		ID	corn, beans, alfalfa, grain	pond	Y	Y	N	5-year	inflow/outflow	Y	Y	Good. Yearly means presented	SEDIMENT and P (P) removal efficencies of a sediment-retention pond with a capacity of about 3400 m" receiving surface water runoff from 4050 ha of irrigated land, were measured for five years. Average daily flow through the pond, during the irrigation runoff period, was 347 Lis, with a pond retention time of 2.7 h. The pond removed 65 to 76% of the sediment, and 25 to 33% of the total P entering the pond. Sediment and P removal efficiencies depended upon the flow rate and the sediment concentration of surface return flow entering the pond. Sediment and P were most efficiently removed when the stream flow was 340 to 453 L/s and the sediment concentration was in the range of 20 to 750 mg/L. Sediment removed from the pond was used to cover protruding basalt to improve and expand a golf course.
74	Bryant 2012	Using flue gas desulfurization gypsum to remove dissolved P from agricultural drainage waters		UMD & USDA-ARS	MD	corn, soybean	gypsum filter	Y	N	Y	31	inflow/outflow	Y	Y	Excellent candidate	High levels of accumulated P (P) in soils of the Delmarva Peninsula are a major source of dissolved P entering drainage ditches that empty into the Chesapeake Bay. The objective of this study was to design, construct, and monitor a within-ditch filter to remove dissolved P, thereby protecting receiving waters against P losses from upstream areas. In April 2007, 110 Mg of flue gas desulfurization (FGD) gypsum, a low-cost coal combustion product, was used as the reactive ingredient in a ditch filter. The ditch filter was monitored from 2007 to 2010, during which time 29 storm-induced flow events were characterized. For storm-induced flow, the event mean concentration efficiency for total dissolved P (TDP) removal for water passing through the gypsum bed was 73 ± 27% confidence interval (α = 0.05). The removal efficiency for storm-induced flow by the summation of load method was 65 ± 27% confidence interval (α = 0.05). Although chemically effective, the maximum observed hydraulic conductivity of FGD gypsum was 4 L s(-1), but it decreased over time to <1 L s(-1). When bypass flow and base flow were taken into consideration, the ditch filter removed approximately 22% of the TDP load over the 3.6-yr monitoring period. Due to maintenance and clean-out requirements, we conclude that ditch filtration using FGD gypsum is not practical at a farm scale. However, we propose an alternate design consisting of FGD gypsum-filled trenches parallel to the ditch to intercept and treat groundwater before it enters the ditch.
80	Burner et al., 2005	Herbage Nitrogen Recovery in a Meadow and Loblolly Pine Alley	AGRICOLA	USDA	AR	loblolly pine, meadow	alley cropping	Y	N	N	2-year	control/experiment	N	N	Focuses mainly on crop productivity	Herbage in conventional pasture and agroforestry systems is managed for microclimate and spatial differences inherent to these systems, but managers have scarce data on which to base their decisions. Our objective was to measure herbage N fertilizer recovery at two sites, an unshaded meadow and a shaded alley in 10-yr-old loblolly pine [Pinus taeda (L.)]. The test was conducted on a Leadvale silt loam soil (fine-silty, siliceous, thermic Typic Fragiudult) near Booneville, Arkansas in 2002 and 2003, with tall fescue (Festuca arundinacea Schreb.) the predominant herbage species. Fertilizer N was broadcast as split-applications at six rates (100 kg/ha increments from 0 to 500 kg/ha/yr). The meadow and pine alleys had sufficient herbage yield for rotational livestock production. Cumulative herbage yield (CHY) in the meadow was much more responsive to added N than pine alley herbage, but average cumulative fertilizer N recoveries were only 38% and 12%, respectively. A shallow fragipan, low available soil P < 6 mg/kg, and depletion of soil water in July to September (both sites), and low solar irradiance (pine alley), were likely contributors to low fertilizer N recovery and herbage productivity. Because of poor herbage yield response and substantial accumulation of soil mineral N (62 to 237 kg/ha) in pine alleys fertilized with > 200 kg N ha/yr, only maintenance levels of fertilizer N (< 100 kg/ha) should be applied to similar sites. For these same reasons, yearly applications of fertilizer N > 300 kg/ha/yr are not recommended for meadows similar to the study site.
14	Butler, G., 2007	An Alabama BMP Database for Evaluating Water Quality Impacts of Alternative Management Practices	Alabama Ag BMP Database	USEPA	AL	corn, cotton, soybean, and others	tillage, fertilizer	N	N	N			N	N	Cited data would be useful, may be difficult to obtain	Best management practices (BMPs) are often used to control nonpoint source (NPS) pollutants from agricultural, forested, and urban watersheds. NPS models are used to estimate pollutant loads, devise NPS abatement plans, and develop and implement Total Maximum Daily Load (TMDL) plans. Accuracy of NPS model prediction depends on, among other things, the accuracy of input data, which includes accurate description of BMPs. Although detailed BMP description can be obtained by using extension manuals and talking to experts, a comprehensive BMP database for use by watershed modelers and water resource managers are usually unavailable. In the absence of regionally appropriate BMP database, simplified assumptions are often used. This practice can introduce input data uncertainty in models, which can lead to poor model predictability and mistrust in models. To alleviate this problem, a comprehensive database of commonly used agricultural and forestry BMPsin Alabama was developed. Using this database, various NPS pollution abatement measures can be evaluated using the SWAT(Soil and Water Assessment Tool) or other distributed parameter, continuous simulation NPS model. Specific objectives were:(1) to develop a database of commonly used BMPs in agriculture and forestry for the State of Alabama and (2) to create an ArcView 3.X GIS (Geographic Information System) extension to load the database into the SWAT model. The complete database containing hundreds of BMPs and supporting documents are available at http://www.eng.auburn.edu/users/srivapu. The database provides environmental professionals with detailed information on management of agricultural and forested lands. This type of detailed information is currently unavailable in Alabama and many other states. Using them database with the SWAT model, environmental professionals will be able to evaluate the site-specific effectiveness of MPs and conduct more accurate assessments of NPS pollutant loads, TMDLs, pollutant trading, and BMP implementation plans. Overall, this will allow environmental professionals to make more confident BMP recommendations and manage watersheds more effectively. Additionally, the methodology presented can be used by other states to develop region-specific MP databases.
15	Cassell, E., 1993	Dynamic Simulation Modeling for Evaluating Water Quality Response to Agricultural BMP Implementation		USDA	Simulated	None, simulation	Manure application management	N	N	N	None, simulation	model calibration	N	N	Not appropriate, simulation study	Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
16	Centner, T., 1999	The Adoption of Best Management Practices to Reduce Agricultural Water Contamination		German fund	Literature Review	None, literature review	Various studies	N	N	N	None, literature review	Literature Review	N	N	Literature Review without underlying data	Nonpoint source water pollution generated by agricultural production is considered a major environmental issue in the United States and Europe. One strategy in the United States has been to adopt various measures, called best management practices (BMPs), to reduce water pollution. Our research addresses legal institutions and the applied use of BMPs, and discusses compensatory payments to reduce N fertilization levels. Models employed in Georgia and Baden-Wuerttemberg evaluate institutional constraints of payments to reduce N usage, penalties for excessive leaching, and financial incentives for meeting minimum mineralized N levels. By modeling net returns, preferred economic strategies for producers are identified. Results show that while BMPs can reduce agricultural nonpoint contamination, pollution abatement may be costly to producers. Thus, reduced pollution probably will require some type of government intervention.

Review Number	Reference (author, year)	Report Title	Other Database Source (if applicable)	Sponsoring Program	Location (s)	Crop(s)	Practices Implemented/ Evaluated	Quantitative Practice Data? (y/n)	Quantitative Watershed Data? (y/n)	Quantitative Event-Based Data (y/n)?	# of Events/ Study Duration	Study Technique (upstream/ downstream, control-reference, before/after, influent/effluent)	Data Tabulated or Electronically Available? (y/n)	Consider for More Detailed Review? (y/n)	Comments	Abstract (*using cut & paste*)
140	Chichester et al., 1992	Sediment and Nutrient Loss from Clay Soils as Affected by Tillage			TX	corn, sorghum, wheat	no-till, conventional till	Y	N	N	6-year	experiment/control	Y	Y	Good. Yearly means presented	Agricultural source pollution of water resources has been a source of concern in recent years. Research is needed to define mechanisms of chemical and sediment loss in runoff from agricultural land, and to develop management practices that minimize transport of these pollutants. This study was designed to compare the effect of no-till (NT) and conventional chisel-till (CT) soil management on runoff water volumes, sediment loss, and N and P loss from small watersheds on a clay soil. Three NT and three CT watersheds located on Houston Black clay vertisol soil (fine, montmorillonitic, thermic, Udic Pellusterts) in east central Texas were used for the study. Wheat (Triticum aestivum L.), corn (Zea mays L.) and sorghum [Sorghum bicolor (L.) Moench] were grown rotationally on the watersheds from 1984 to 1989. Runoff amounts, sediment loss, and N and P losses were measured for each rainfall event that produced runoff. Runoff volume was not changed by tillage system and sediment loss and N and P losses in runoff were less, on average, from NT than from CT. Runoff averaged 1.3 ML ha-1 annually for both CT and NT. Average annual quantities for sediment and nutrient losses were: 160 kg/ha and 1575 kg/ha for sediment, 3.8 kg/ha and 8.1 kg/ha for N, and 0.8 kg/ha and 1.5 kg/ha for P for NT and CT, respectively. These results indicate that the loss of sediment and nutrients from agricultural lands could be minimized by using NT on clay soils
119	Coale et al., 1994	Phosphorus in Drainage Water from Sugarcane in the Everglades Agricultural Area as Affected by Drainage Rate	Va. Tech/Yagow		FL	sugarcane	drainage rate	Y	N	Y	9	experiment/control	Y	Y	Excellent	Sugarcane (interspecific hybrids of Saccharum spp.) is grown on 78% (156,000 ha) of the cultivated organic soils of the Everglades Agricultural Area (EAA) of southern Florida. Recently, the EAA has come under scrutiny because of concerns with the impact of nutrient-rich drainage water from organic soils on the ecology of adjoining bodies of water and wetlands. The objectives of our research were to determine the effects of field drainage rate on P concentration and off-field P loads in drainage water from sugarcane grown on organic soils of the EAA and to determine the effect of field drainage rate on sugarcane productivity and sugar yield. The research site was on a Terra Ceia muck soil (euic, hyperthermic Typic Medisaprist) on a commercial sugarcane farm located in the EAA. The treatments were fast and slow field drainage rates. Nine drainage events were monitored between Nov. 1988 and Aug. 1990. Average drainage water total P (TP) and total dissolved P (TDP) concentrations were significantly higher for the slow drainage rate treatment. In order to minimize off-farm P loading, main-farm canal water should be discharged off-farm while field drainage water is retained on-farm. Field drainage rate should be fast and drainage event duration should be as short as possible. Plant-cane crop yield and yield component data were not collected. The first-ratoon crop total aerial dry weight and harvested sugarcane and sugar yields were not affected by drainage rate.
165	Cook et al., 1996	Reducing Diffuse Pollution through Implementation of Agricultural Best Management Practices: A Case Study	Va. Tech/Yagow		NC	corn, soybean, wheat, tobacco, cotton, cucumber, sweet potato	nutrient, pest and animal waste management; soil conservation practices	Y	Y	N	4-year	before/after	Y	Y	Good, yearly means presented	A system of agricultural best management practices (BMPs) was implemented on a 2,100 ha watershed in Duplin County, North Carolina, USA, for the purpose of improving water quality. The BMPs included: Nutrient, pest, and animal waste management; and soil conservation practices. Both surface and ground water were continually analyzed to assess the water quality impacts. Nutrient management plans have been developed for over 80% of the cropland. Pest management plans have been developed for over 60% of the cropland. Over one-half of all plans have been implemented. Poultry mortality composting and improved swine waste management have decreased the potential adverse effects of animal operations. A constructed wetland shows promise as a pre-treatment of swine waste prior to land application. Stream monitoring shows decreasing amounts of nitrate- and ammonium-N in the surface waters of the watershed. Ground water monitoring shows relatively high concentrations of nitrate in areas of intensive swine and poultry operations. Ground water monitoring of pesticides reveals low levels of alachlor, atrazine, and metolachlor even though large amounts of these chemicals are used on crops. The successful implementation of agricultural BMPs appears to be having a positive effect on water quality. Both stream and ground water monitoring will be continued for several years to assess more definitively the changes in water quality.
168	Cooper et al., 1990	Nutrient trapping efficiency of a small sediment detention reservoir	Va. Tech/Yagow	USDA-ARS	MS	livestock	detention pond	Y	Y	N	4-year	inflow/outflow	Y	N	Livestock-only watershed	Weekly measurements of water quality parameters were taken over a 5 year period from four sites in Morris Pond, a 1.09 ha reservoir in the loess hills of Mississippi's Goodwin Creek drainage basin. Catchment of the 30 year old reservoir, constructed for flood and sediment control, consisted of 17.8 ha of permanent pasture and 14.6 ha of cultivated and mixed-cover land. Inflow in winter and spring increased reservoir concentrations of P (from nondetectable to 1 mg/l), nitrate-N (from nondetectable to 1 mg/l), and suspended sediments (from 30 to > 300 mg/l). Storm-related inflow was the driving force behind short-term limnological and water quality cycles in Morris Pond. Multiple chlorophyll peaks indicated rapid phytoplankton response to runoff-related nutrient loading in this shallow (2.5 m normal max. depth)reservoir. Chlorophyll a ranged from < 10 mg/m3 in winter to < 100 mg/m3 in summer. Nutrient and suspended sediment concentrations in inflow were significantly correlated (P < 0.001) with precipitation and storm runoff and were significantly (P < 0.05) higher than normal seasonal pond concentrations. Nutrient trapping efficiency during storms averaged above 70% for P and N comlbs flushed into the pond. This buffering capability of agricultural impoundments makes them excellent tools for managing intensive agricultural runoff and downstream water quality
18	Corwin, D., 2006	Monitoring management-induced spatio-temporal changes in soil quality through soil sampling directed by apparent electrical conductivity		U. Cal	CA	livestock grazing	none	N	N	N	2-year	before/after	N	N	Not directly relevant to water quality	Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
79	Cullum et al., 2007	Runoff and soil loss from ultra-narrow row cotton plots with and without stiff-grass hedges	AGRICOLA	USDA	MS	cotton	alley cropping, no-till	Y	N	Y	4-year	control/experiment	Y	Y	Good	Grass hedges and no-till cropping systems reduced soil losses on standard erosion plots in ultra-narrow row (20 cm) cotton during a 4-year study (1999-2002). No-till cotton with grass hedges, no-till cotton without grass hedges, conventional-till cotton with grass hedges, and conventional-till cotton without grass hedges produced 4-year average annual soil losses of 1.8, 2.9, 4.0, and 30.8 t ha_1, respectively, and produced 4-year average runoff amounts of 267, 245, 353, and 585 mm, respectively. The annual ratio of soil loss for no-till ultra-narrow row cotton plots with grass hedges to those without hedges averaged 0.62. The annual ratio of soil loss for conventional-till plots with grass hedges to without hedges was 0.13. Averaged over all plots (with and without grass hedges), no-till plots had 86% less soil loss than conventional-till plots. No-till plots without grass hedges had 90% less soil loss than conventional-till plots without grass hedges. Grass hedges effectively reduced soil loss on erosion plots with similar cropping practices as compared to plots without hedges. Along with the reduced soil losses from no-till system as compared to conventional till system, the no-till ultra-narrow row cotton system resulted in an average 0.2 t ha_1 yield increase as compared to the conventional-till system. Reduced soil loss and increased crop yield are both positive factors that the user should consider when adopting this cotton system. Other studies of contoured grass hedges on field-sized areas are being conducted to determine their applicability on larger areas with greater concentrations of runoff.
54	Cunningham, J., 2003	An Assessment of the Quality of Agricultural Best Management Practices Implemented in the James River Basin of Virginia			VA	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	N	May need to obtain full text to evaluate--appears to be qualitative rather than quantitative	Survey-like assessment tools were developed to quantify the quality of agricultural best management practices (BMPs). BMP quality is defined as the adherence to design, site selection, implementation, and maintenance criteria as specified by state and federal agencies promoting BMP implementation. Quality assessments made with the tools are based upon visual observations of BMPs rather than traditional assessment methods such as water quality monitoring. BMP quality scores have the potential to be used as a surrogate measure for BMP performance" without the extensive water quality monitoring associated with performance quantification. The tools presented here are part of a proof of concept study that involved assessment tool development and preliminary testing. Statistical analyses indicate that there is no strong significant difference (p<0.05) in quality between cost-shared and non cost-shared practices sampled.
19	Dabney, S., 1998	Cover crop impacts on watershed hydrology			Various	variety	Cover crops	Y	N	Y	None, literature review	Literature Review	N	Y	Should consider obtaining original studies	Cover crops alter many aspects of the hydrologic cycle. They increase evapotranspiration while growing and can enhance water infiltration into soil, slow runoff rates, and reduce soil erosion in both conventional-till and no-till systems throughout the year. However, the difference between the results of plot and watershed studies demonstrate that caution should be taken in extrapolating plot data to watershed scales. As scale increases, so does the influence of hydraulically-controlling subsurface soil horizons. Unfortunately, most of the available cover crop research comes from relatively small plats and very few watershed studies have been initiated in recent years. Perennial cover crops offer the potential for altering the porosity of subsurface soil horizons so as to increase future soil productivity and reduce future runoff amounts and rates.
20	Dabney, S., 2007	Using Winter Cover Crops to Improve Soil and Water Quality		USDA	Various	variety	Cover crops	Y	N	Y	None, literature review	Literature Review	N	Y	Should consider obtaining original studies	This article reviews literature about the impacts of cover crops in cropping systems that affect soil and water quality and presents limited new information to help fill knowledge gaps.Cover crops grow during periods when the soil might otherwise be fallow. While actively growing, cover crops increase solar energy harvest and carbon flux into the soil, providing food for soil macro and microrganisms, while simultaneously increasing evapotranspiration from the soil. Cover crops reduce sediment production from cropland by intercepting the kinetic energy of rainfall and by reducing the amount and velocity of runoff. Cover crops increase soil quality by improving biological, chemical and physical properties including: organic carbon content, cation exchange capacity, aggregate stability, and water infiltrability. Legume cover crops contribute a nitrogen (N) to subsequent crops. Other cover crops, especially grasses and brassicas, are better at scavenging residual N before it can leach. Because growth of these scavenging cover crops is usually N limited, growing grass/legume mixtures often increases total carbon inputs without sacrificing N scavenging efficiency. Cover crops are best adapted to warm areas with abundant precipitation. Water use by cover crops can adversely impact yields of subsequent dryland crops in semiarid areas. Similarly, cooler soil temperatures under cover crop residues can retard early growth of subsequent crops grown near the cold end of their range of adaptation. Development of systems that reduce the costs of cover crop establishment and overcome subsequent crop establishment problems will increase cover crop utilization and improve soil and water quality.

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166	Daniels et al., 1996	Sediment and Chemical Load Reduction by Grass and Riparian Buffers	Va. Tech/Yagow		NC	Not listed, only "cultivated fields"	grass/forest riparian buffer	Y	N	N	2-year	inflow/outflow	Y	Y	Good, wide variety of data presented	Vegetated filter strips help reduce non-point source pollution from agricultural areas. Even though they are an accepted and highly promoted practice, little quantitative data exist on their effectiveness under field conditions. The objective of this research was to determine the amount of nutrients and sediment removed by natural and planted filters. This was achieved by collecting and analyzing runoff at field edges and at various locations in vegetated buffers. Total weight of sediment and nutrients in runoff from North Carolina agricultural fields showed that the grass and riparian filter strips studied reduced runoff load by 50 to 80%. Total sediment decrease through the filters was about 80% for both grass and riparian vegetation. The reduction in the chemical load depended on the nutrient and its form. Filters reduced total P load by 50%, but 80% of the soluble PO_4-P arriving at the field edge frequently passed through the filters. The filters retained 20 to 50% of the $NH_4$and approximately 50% of the total Kjeldahl N and NO_3. High-volume flows commonly overwhelmed both grass and riparian filters next to cultivated fields. Forested ephemeral channels had little vegetation and were effective sediment sinks during the dry season but were ineffective during large storm events because there was little resistance to flow. When possible, drainageways should be designed to hold sediment and to disperse the discharge into a riparian area.
21	D'Arcy, B., 2001	The role of best management practices in alleviating water quality problems associated with diffuse pollution			Various	variety	Various practices	Y	N	Y	None, literature review	Literature Review	N	Y	Should consider obtaining original studies	This paper introduces the concept of best management practices for the control of diffuse pollution. It considers where they are appropriate, and how the concept of a best management practice approach differs from the conventional means of controlling pollution by regulating each point source, in relation to established environmental quality standards and available dilution.
12	Daroub, S. 2011	Best Management Practices and Long-Term Water Quality Trends in the Everglades Agricultural Area			FL	sugarcane, winter vegetables	variety	N	Y	N	28-year	before/after	Y	Y	Good, very broad study	The Everglades Agricultural Area (EAA) in South Florida, part of the historical Everglades, was initially drained in the early 20tbcenturyfor agriculture and flood protection. The organic soils have been subject to subsidence caused by organic matter oxidation. Soils are deeper east of Lake Okeechobee compared to soils south of the lake. The area is mostly planted to sugarcane and other crops such as rice, vegetables, and sod. Concerns about quality of water leaving the EAA led to a regulatory program for mandatory best management practices (BMP) since 1995 to reduce P (P)loads out of the EAA by 25% compared to historical levels. The program is highly successful, with 100% grower participation and exceeding P load reduction required by law. Trend analysis conducted on selected EAA farms, sub basins, and whole basin show, in general, decreasing trends in P concentrations, drainage flow, and loads. Differences are noted between farms and sub basins due cofactors that include rainfall distribution, water management practices, irrigation water quality, soil type/depth, and cropping systems. Water management practices were the dominant factors affecting P loads out of the EAA. Water management research that targets farms with deeper soils is recommended to achieve additional P load reductions. Other practices to improve BMP performance include minimizing generation and transport of sediments from farm.
22	Delgado, J., 2008	Numeric Modeling to Study the Fate of Nitrogen in Cropping Systems and Best Management Case Studies			FL and MN	citrus, potato	fertilizer, cover crop	Y	N	N	2-year	Experimental Farm		Y	Stormwater not tracked--N leaching measured in shallow groundwater	Nitrogen(N) availability for crop uptake is dependent on various factors that influence the transformation of N sources and transport of N forms in soils. The fate and transport of N is site-specific, therefore evaluation of N dynamics under each condition is neither practical nor feasible. Simulation models which are adequately calibrated and tested can be used to estimate the fate and transport of N as well as crop responses under different production systems. These evaluations provide some guidelines as how to manage N and water efficiently to maximize the N uptake efficiency and minimize the losses. Thus, they contribute to the development of N and water best management practices. In this chapter, we discuss recent information on experimentally measuring the water and nutrient transport in soils as well as performing estimations using simulation models. The development and application of different simulation models for different production systems have been summarized. Some case studies on N and water best management practices are also discussed.
1	Deterling, D., 1994	How Farmers are Helping the Environment	WATERSHEDSS			n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	N	Full text not available	Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
5	Devlin, D. 2002	Best Management Practices for Phosphorus	MPMINER	Academia	KS	Not listed, only "crop fields"	Conservation tillage	Unknown, full text unavailable	Unknown, full text unavailable	Unknown, full text unavailable	Unknown, full text unavailable	Unknown, full text unavailable	Unknown, full text unavailable	N	Full text not available	Recent studies conducted at Kansas State University's East Central Kansas Experiment Field have indicated that P best management practices are very effective at reducing P runoff from crop fields. No-till farming methods reduced soil erosion by 75% compared to a conventional (chisel-disk) tillage system. Total P losses under no-till were reduced by approximately 40% compared to conventional tillage. Total P consists primarily of insoluble P attached to soil particles or as freestanding inorganic comlbs. Researchers also found no-till actually had higher losses of soluble P in runoff water than did the conventional system. Soluble P is more readily utilized by algae than is insoluble P attached to soil particles, and it may be a better indicator of pollution problems than amounts of total P in surface water. To reduce losses of soluble P under no-till systems, the researchers found P fertilizers should be deep banded or placed near the seed. Deep banding P fertilizers reduced P runoff losses by 50% compared to broadcast fertilizer applications. The combination of reduced tillage and P placement below the soil surface will be effective in reducing P losses into surface waters.
120	Drury et al., 1993	Influence of Tillage on Nitrate Loss in Surface Runoff and Tile Drainage	Va. Tech/Yagow	SWEEP	Canada	corn, bluegrass	no-till, ridge till, conventional	Y	N	Y	24, 3-year	experiment/control	Y	Y	Good. Yearly means presented. Event data graphically	A study was conducted to determine the effect of conservation (notillage and ridge tillage) and conventional (moldboard plow) tillage systems on NO-3 loss through surface runoff and tile drainage. Nitrate concentrations and total volume of surface runoff and tile drainage from conventional tillage (CT), no-tillage (NT), and ridge tillage (RT) all planted in continuous corn (Zea mays L.), and Kentucky bluegrass (BG, Poa pratensis L.) treatments, were measured for 3 yr, 1989 to 1991. All corn tillage treatments received a total of 178.6 kg N/ha annually during the growing season. The volume of water drained through the tiles in the corn tillage systems always exceeded the volume in surface runoff, typically by factors of 2 to 4. Tile drainage was greatest from the CT treatments, least from BG, and approximately equal from RT and NT treatments in 1989 and 1990. Concentrations of NO-3in tile water from CT, RT, and NT treatments exceeded the maximum recommended safe limit for drinking water (10 mg N/L) in 79% of the leaching events, with flow-weighted concentrations between 12 and 17 mg N/L in 1989 and 1990. Flow-weighted NO-3concentrations were only 1.2 and 2.6 mg N/L from BG in 1989 and 1990, respectively. The total NO-3 lost in tile water in 1989 was 18, 14, 14, and 1 kg N/ha from the CT, RT, NT, and BG treatments, respectively, whereas in 1990 there were 29, 20, 20, and 3 kg N/halost from the CT, RT, NT, and BG treatments, respectively. Nitrate losses in surface runoff were lower than in tile drainage, with maximums of 2.6 kg N/ha for the RT and NT treatments in 1989 and 5.5 kg N/ha for the RT treatment in 1990. In 1989 and 1990, both RT and NT treatments had greater yields and N uptake in grain than the CT treatment. A serious drought in 1991 limited corn yield, N uptake in grain, and NO-3 loss.
121	Drury et al., 1996	Influence of Control Drainage-Subirrigation on Surface and Tile Drainage Nitrate Loss	Va. Tech/Yagow	Great Lakes Water Quality Preservation Fund	Canada	corn	tillage, tile drains	Y	N	N	4-year	experiment/control	Y	Y	Good. Data averaged by BMP	Controlled drainage-subirrigation (CDS), conservation tillage, and corn (Zea mays L.) production practices were evaluated as methods of reducing NO3- loss through tile drainage. Controlled drainage-subirrigation was used to manage water from precipitation and subirrigation. Samples of tile drainage (5801) and surface runoff (3274) water were collected with autosamplers during each runoff event over a 3-yr period. Annual tile drainage volumes were reduced 24% with CDS compared with the drainage (DR) treatments. Flow weighted mean NO3- concentration of tile drainage water was reduced 25% from 10.6 mg N/L for the DR treatments to 7.9 mg N/L for the CDS treatments. The average annual NO3- loss was reduced 43% from 25.8 kg N ha-1 for the DR treatment to 14.6 kg N ha-1 for the CDS treatments. Eighty-eight to 95% of the NO3- losses from all treatments occurred in the noncrop period (1 Nov.-31 Apr.). Conservation tillage in combination with CDS reduced annual NO3- losses 49% (11.6 kg N ha-1) when compared with the conventional moldboard plow tillage and DR treatment. Annual NO3- loss through surface runoff was increased to 1.9 kg N ha-1 with the CDS treatments compared with 1.4 kg N ha-1 with the DR treatment, this loss was minor compared with losses incurred through tile drainage. Controlled drainage-subirrigation is a technological advancement in soil and water management as it enables farmers to minimize the effect of dry summers on crop growth and reduce NO3- contamination of drainage water.
173	Drury et al., 2009	Managing Tile Drainage , Subirrigation, and Nitrogen Fertilization to Enhance Crop Yields and Reduce Nitrate Loss			Canada	corn, soybean	controlled drainage/subirrigation	Y	N	N	4-year	experiment/control	Y	Y	Good, yearly means presented	Improving field-crop use of fertilizer N is essential for protecting water quality and increasing crop yields. The objective of this study was to determine the effectiveness of controlled tile drainage (CD) and controlled tile drainage with subsurface irrigation (CDS) for mitigating off-field nitrate losses and enhancing crop yields. The CD and CDS systems were compared on a clay loam soil to traditional unrestricted tile drainage (UTD) under a corn (Zea Mays L.)-soybean (Glycine Max. (L.) Merr.) rotation at two N (N) fertilization rates (N1: 150 kg N/ha applied to corn, no N applied to soybean; N2: 200 kg N/haapplied to corn, 50 kg N/ha applied to soybean). The N concentrations in tile flow events with the UTD treatment exceeded the provisional long-term aquatic life limit (LT-ALL) for freshwater (4.7 mg N/L) 72% of the time at the N1 rate and 78% at the N2 rate, whereas only 24% of tile flow events at N1 and 40% at N2 exceeded the LT-ALL for the CDS treatment. Exceedances in N concentration for surface runoff and tile drainage were greater during the growing season than the non-growing season. At the N1 rate, CD and CDS reduced average annual N losses via tile drainage by 44 and 66%, respectively, relative to UTD. At the N2 rate, the average annual decreases in N loss were 31 and 68%, respectively. Crop yields from CDS were increased by an average of 2.8% relative to UTD at the N2 rate but were reduced by an average of 6.5% at the N1 rate. Hence, CD and CDS were effective for reducing average nitrate losses in tile drainage, but CDS increased average crop yields only when additional N fertilizer was applied.

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84	Duchemin et al. 2009	Reduction in agricultural non-point source pollution in the first year following establishment of an integrated grass/tree filter strip system in southern Quebec	AGRICOLA	CARD	Canada	corn	vegetative strips	Y	N	Y	19	control/experiment	N	Y	Means presented. Not events	Vegetative buffer strips represent a possible approach for filtering the pollutants transported in runoff before the water reaches watercourses. Nevertheless, the effectiveness of these filter strip systems is often low in the first year after establishment because of the limited vegetation cover. The goal of this project was to evaluate the initial effectiveness of an integrated grass/tree strip system in filtering runoff and drainage water from grain corn fields fertilized with liquid swine manure. The experimental site consisted of four random blocks each comprising three plots (i.e. treatments T1-T2-T3). The effectiveness of the grass treatment (T2) and the grass/poplar tree treatment (T3), compared with the control plot with no vegetative strip (T1), was determined for each water quality parameter (total suspended solids (TSS), P, N, Escherichia coli) based on the total annual loads exported from the plots. The results obtained in the first year after the experimental layout was established in 2004 indicate that the grassed strips T2 reduced runoff water (R) volumes by 40%, TSS by 87%, total P by 86%, dissolved P by 64%, NH by 57%, NO by 33% and E. coli by 48% whereas the grass/tree strips T3 reduced runoff volumes by 35%, TSS by 85%, total P by 85%, dissolved P by 57%, NH by 47%, NO by 30% and E. coli by 57%. The drainage water (D) volumes measured for the plots containing vegetative strips (T2 and T3) increased by 16% and 8%, respectively, compared with the control plot (T1). The increased drainage water volume also corresponded to increased total P of 418%, dissolved P of 23% and E. coli of 24% for treatment T2; and increases of 347%, 27% and 18%, respectively, for treatment T3. By contrast, the NH and NO loads in drainage water were reduced by 8% and 63% in T2 and by 11% and 68% in T3. Overall, taking into account the total loads exported in runoff and drainage water (R + D), the vegetative filter strips system T2-T3 reduced water volumes by about 15%, TSS by 85%, total P by 75%, dissolved P by 30%, NH by 50%, NO by 60% and E. coli by 25% in agricultural non-point source pollution associated with liquid swine manure spread in the corn plots. The addition of young (two-years-old) poplars in treatment T3 did not bring about a significant increase in the filtering capacity of the grassed strip system in this first year of monitoring.
10	Duriancik, L. 2008	The first five years of the Conservation Effects Assessment Project	CEAP										N	N		Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
23	Easton, Z., 2007	Combined Monitoring and Modeling Indicate the Most Effective Agricultural Best Management Practices			NY	variety	fertilizer, drainage, buffers	Y	Y	N	7-year	before/after	N	Y	Study area includes row crops, but does not isolate row crop data	Although water quality problems associated with agricultural nonpoint source (NPS) pollution have prompted the rapid and widespread adoption of BMPs, there have been few realistic efforts to assess their combined effectiveness…
167	Ebbert et al., 1998	Relation between Irrigation Method, Sediment Yields, and Losses of Pesticides and Nitrogen	Va. Tech/Yagow		WA	alfalfa, wheat, corn, beans, potatoes, apples	irrigation	Y	Y	N	2-year	upstream/downstream	Y	Y	Good, monthly means presented	Yields of suspended sediment from watersheds in the Quincy and Pasco Basins of Washington State have been reduced by the use of sprinkler irrigation on cropland previously in furrow irrigation. Mean daily yields of suspended sediment from nine watersheds sampled during April and May 1994 ranged from 0.4 kg/ha of irrigated cropland in a watershed with no furrow irrigation to 19 kg/ha in a watershed where 58% of irrigated cropland was in furrow irrigation. About 67% of the variation in the yields can be attributed to irrigation method. Temporal trends also indicated that use of sprinkler irrigation reduced sediment yields. Mean daily yields of suspended solids from one of the watersheds decreased from 0.3 kg/ha in 1975 to <0.2 kg/ha in 1988, corresponding with a decrease from about 65% to <50% in the use of furrow irrigation. Sampling in two watersheds suggests that the use of sprinkler irrigation reduces runoff losses of pesticides and N. For 10 of 13 pesticides and N, runoff losses from a watershed with mostly furrow irrigation exceeded runoff losses from a watershed with mostly sprinkler irrigation.
24	Ebbert, J. 1998	Relation between irrigation method, sediment yields, and losses of pesticides and N			WA	corn, alfalfa, bean, potato, etc.	sprinkler (vs. furrow) irrigation	Y	Y	N	5-year	watershed comparison	Y	Y	No storm specific data.	Yields of suspended sediment from watersheds in the Quincy and Pasco Basins of Washington State have been reduced by the use of sprinkler irrigation on cropland previously in furrow irrigation. Mean daily yields of suspended sediment from nine watersheds sampled during April and May 1994 ranged from 0.4 kg/ha of irrigated cropland in a watershed with no furrow irrigation to 19 kg/ha in a watershed where 58% of irrigated cropland was in furrow irrigation. About 67% of the variation in the yields can be attributed to irrigation method. Temporal trends also indicated that use of sprinkler irrigation reduced sediment yields. Mean daily yields of suspended solids from one of the watersheds decreased from 0.3 kg/ha in 1975 to <0.2 kg/ha in 1988, corresponding with a decrease from about 65% to <50% in the use of furrow irrigation. Sampling in two watersheds suggests that the use of sprinkler irrigation reduces runoff losses of pesticides and N. For 10 of 13 pesticides and N, runoff losses from a watershed with mostly furrow irrigation exceeded runoff losses from a watershed with mostly sprinkler irrigation.
122	Edwards et al., 1997	Effect of BMP Implementation on Storm Flow Quality of Two Northwester Arkansas Streams	Va. Tech/Yagow	Many	AR	pasture, forest	nutrient management, pasture/hayland management, waste utilization, dead poultry composting, waste storage	Y	Y	Y	5-year	before/after	Y	Y	Good. Yearly means presented	Storm flow quality of the two main tributaries to Lincoln Lake in Northwest Arkansas was monitored from September, 1991 to April, 1994 to determine the effects of best management practices (BMPs) implemented in the Lincoln lake watershed. Significant decreases (from 24-75% per year) in both concentrations and mass transport of nitrate N, ammonia N, total Kjeldahl N, and chemical oxygen demand occurred concurrently with BMP implementation. The decreases in N and chemical oxygen demand concentrations are attributed to BMP implementation, and the BMP most responsible for these decreases is most likely nutrient management.
25	Edwards, D. 1997	Effect of BMP Implementation on Storm Flow Quality of Two Northwestern Arkansas Streams		KY Ag. Ex. Station, EPA	AR	mostly pasture, some other agriculture	nutrient management, waste utilization, waste storage	Y	Y	Y/N	3-year	before/after	N	tbd	Good data analysis, however row crops are not isolated (or emphasized)	The effectiveness of management practices in improving quality of runoff from agricultural land areas has been reported based primarily on results from plot- and field-scale studies. There is limited information available on watershed scales, particularly when the dominant agricultural land use is pasture. The objective of this study was to determine whether a program of Best Management Practice (BMP) implementation in the Lincoln Lake watershed of northwestern Arkansas was effective in reducing storm stream flow concentrations and mass transport of nitrate N (NO3-N), ammonia N (NH3-N), total Kjeldahl N (TKN), ortho-P (PO4-P), total P (TP), chemical oxygen demand (COD), and total suspended solids (TSS). Storm flow quality of the two main tributaries to Lincoln Lake was monitored from September 1991 to April 1994. Significant decreases (from 23 to 75% per year) in both concentrations and mass transport of NO3-N, NH3-N, TKN, and COD occurred concurrently with BMP implementation. The decreases in N and COD concentrations and mass transport are attributed to BMP implementation, and the BMP most responsible for these decreases is most likely nutrient management.
92	Elliot et al, 2010	Conventional and Conservation Tillage: Influence on Seasonal Runoff, Sediment, and Nutrient Losses in the Canadian Prairies		WEBs	Canada	wheat, flax, canola, oats, barley	conservation tillage	Y	N	Y	8-year	experiment/control	N	Y	Excellent. Data presented for yearly averages	Conservation tillage has been widely promoted to reduce sediment and nutrient transport from agricultural fields. However, the effect of conservation tillage on sediment and nutrient export in snowmelt-dominated climates is not well known. Therefore, a long-term paired watershed study was used to compare sediment and nutrient losses from a conventional and a conservation tillage watershed in the Northern Great Plains region of western Canada. During the treatment period, dissolved nutrient concentrations were typically greater during spring snowmelt than during summer rainfall events, whereas concentrations of sediment and particulate nutrients were greatest during rainfall events. However, because total runoff was dominated by snowmelt, most sediment and nutrient export occurred during snowmelt. Overall, conservation tillage reduced the export of sediment in runoff water by 65%. Similarly, concentrations and export of N were reduced by 41 and 68%, respectively, relative to conventional tillage. After conversion to conservation tillage, concentrations and exports of P (P) increased by 42 and 12%, respectively, with soluble P accounting for the majority of the exported P, especially during snowmelt. Our results suggest that management practices designed to improve water quality by reducing sediment and sediment-bound nutrient export from agricultural fields and watersheds can be less effective in cold, dry regions where nutrient export is primarily snowmelt driven and in the dissolved form. In these situations, it may be more appropriate to implement management practices that reduce the accumulation of nutrients in crop residues and the surface soil.
26	Ergas, S., 2010	Performance of Nitrogen-Removing Bioretention Systems for Control of Agricultural Runoff		UNH (academia)	CT	silage	bioretention system	Y	N	Y	1-year	control/experiment	N	tbd	Study does not examine row crops	This research evaluated N-removing bioretention systems for control of nutrients, organics, and solids in agricultural runoff. Pilot-scale experiments were conducted with bioretention systems.
2	Fall, C., 1988	An Investigation of the St. Johns Water Control District: Reservoir Water Quality and Farm Practices.	WATERSHEDSS		FL	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	N	Full text not available	Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
160	Ferrara et al., 1983	Stormwater Quality Characteristics in Detention Basins	Va. Tech/Yagow	USGS	NJ	Urban	detention	Y	N	Y	3 events	inflow/outflow	Y	N	Urban study	The use of stormwater detention basins for the dual purpose of flood control and mitigation of pollutant runoff loads has been promoted. However, only limited data and methods for analysis and prediction of pollutant removal in detention basins exist. This paper presents the results of a stormwater quality sampling program conducted to describe the particle size distribution and the time variable influent and effluent concentrations of chemical oxygen demand, total P, total kjeldahl N, and solids during various storm events. Concentrations in three separate particle size ranges for each of the four parameters was determined. The basin is shown to be generally effective in reducing solids, chemical oxygen demand (COD), and total P. Total kjeldahl N (TKN) concentrations and loadings were generally increased. The effectiveness of the detention basin in reducing pollutant loads appears to be related to two factors, namely, equalization and sedimentation. Dry weather water quality in the detention basin determines the importance of the former, whereas the particle size distribution for each pollutant determines the degree of sedimentation

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111	Fiener et al., 2005	Managing erosion and water quality in agricultural watersheds by small detention ponds		German Federal Ministry of Education and Research	Germany	corn, potato, winter wheat	ponds	Y	N	Y	8-year	inflow/outflow	N	Y	Averages reported	Terrace-contouring systems with on-site water detention cannot be installed in areas of complex topography, small parceling and multi-blade moldboard plow use. However, field borders at the downslope end may be raised at the deepest part where runoff overtops to create detention ponds, which can be drained by subsurface tile outlets and act similar to terrace-contouring systems. Four of suchdetentionponds were monitored over 8 years. Monitored effects included the prevention of linear erosion down slope, the sediment trapping from upslope, the enrichment of major nutrients in the trapped and delivered sediments, the amount of runoff retained temporarily, the amount of runoff reduced by infiltration, the decrease in peak runoff rate and the decrease in peak concentrations of agrochemicals due to the mixing of different volumes of water within the detention ponds. The detention ponds had a volume of 30-260 m3/ha and trapped 54-85% of the incoming sediment, which was insignificantly to slightly depleted (5-25%) in organic carbon, P, N and clay as compared to the eroding topsoil, while the delivered sediment was strongly enriched (+70-270%) but part of this enrichment already resulted from the enrichment of soil loss. The detention ponds temporarily stored 200-500 m3 of runoff. A failure was never experienced. Due to the siltation of the pond bottom, the short filled time (1-5 days) and the smallwatercovered area, infiltration and evaporation reduced runoff by less than 10% for large events. Peak runoff during heavy rains was lowered by a factor of three. Peak concentrations of agrochemicals (Terbutylazin) were lowered by a factor of two. The detention ponds created by raising the downslope field borders at the pour point efficiently reduced adverse erosion effects downslope the eroding site. They are cheap and can easily be created with on-farm machinery. Their efficiency is improved where they are combined with an on-site erosion control like mulch tillage because sediment and runoff input are reduced. Ponds had to be dredged only after the first year when on-site erosion control was not fully effective.
27	Fiener, P., 2003	Effectiveness of Grassed Waterways in Reducing Runoff and Sediment from Agricultural Watersheds		German Federal Ministry of Education and Research	Germany	corn, potato, winter wheat	grassed waterways	Y	Y	N	7-year	control/experiment	N	Y	Large sample size, row crop and BMP evaluation	Grassed waterways (GWWs) drain surface runoff from fields without gullying along the drainageway. Secondary functions include reducing runoff volume and velocity and retaining sediments and harmful substances from adjacent fields. Grass cover (sward)-damaging sedimentation in the GWW is commonly reduced by frequent mowing, but in doing so the effectiveness of the waterway relative to the secondary functions is reduced. Our objectives were to (i) evaluate whether the maintenance of a GWW can be reduced if on-site erosion control is effective, (ii) measure the effectiveness of such a GWW, and (iii) analyze the underlying mechanisms. A long-term (1994-2000) landscape experiment was performed in four watersheds, where two had GWWs for which maintenance was largely neglected. An intensive soil conservation system was established on all fields. Runoff and sediment delivery were continuously measured in the two watersheds with GWWs and in their paired watersheds that were similar, but without GWWs. Runoff was reduced by 90 and 10% for the two sets of paired watersheds, respectively. The different efficiencies of the GWWs resulted from different layouts (doubled width and flat-bottomed vs. v-shaped drainageway). The GWWs reduced sediment delivery by 97 and 77%, respectively, but the sward was not damaged by sedimentation. Grain sizes > 50 µm were settled due to gravity in both GWWs. Smaller grain sizes were primarily settled due to infiltration, which increased with a more effective runoff reduction. In general, the results indicated a high potential of GWWs for reducing runoff volume and velocity, sediments, and agrochemicals coming from agricultural watersheds. Abbreviations: GWW, grassed waterway.
185	Fink et al., 2004	Seasonal and storm event nutrient removal by a created wetland in an agricultural watershed			OH	row crops	wetland treatment	Y	N	N	2-year	inflow/outflow	Y	Y	Good, bi-annual means presented	This study examines the effectiveness of a 1.2-ha created/restored emergent marsh at reducing nutrients from a 17.0 ha agricultural and forested watershed in the Ohio River Basin in west central Ohio, USA, during base flow and storm flow conditions. The primary source of water to the wetland was surface inflow, estimated in water year 2000 (October 1999-September 2000) to be 646 cm/year. The wetland also received a significant amount of groundwater discharge at multiple locations within the site that was almost the same in quantity as the surface flow. The surface inflow had 2-year averages concentrations of 0.79, 0.033, and 0.16 mg/L for nitrate + nitrite (as N), soluble reactive P (SRP), and total P (TP), respectively. Concentrations of nitrate-nitrite, SRP, and TP were 40, 56, and 59% lower, respectively, at the outflow than at the inflow to the wetland over the 2 years of the study. Concentrations of SRP and TP exported from the wetland increased significantly ($\alpha = 0.05$) during precipitation events in 2000 compared to dry weather flows, but concentrations of nitrate-nitrite did not increase significantly. During these precipitation events the wetland retained 41% of the nitrate-nitrite, 74% of the SRP, and 28% of the TP (by mass). The wetland received an average of 50 g N m^2 per year of nitrate-nitrite and 7.1 g m^2 per year of TP in 2000. Retention rates for the wetland were 39 g N m^2 per year of nitrates and 6.2 g P m^2 per year. These are close to rates suggested in the literature for sustainable non-point source retention by wetlands. The design of this wetland appears to be suitable as it retained a significant portion of the influent nutrient load and did not lose much of its retention capacity during heavy precipitation events. Some suggestions are given for further design improvements.
56	Frankenberger, J., 2005	On-Farm Monitoring to Assess the Impacts of Drainage Water Management			IN	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	N	Appears unlikely to be useful	Subsurface tile drainage of crop land is a major source of the nitrate load to surface water in the Midwest. Drainage water management (also known as controlled drainage) can reduce nitrate losses from drained fields while maintaining drainage intensity during critical periods of the crop growth cycle. Impacts of the practice on nitrate loss, soil quality, and farm profitability are being studied through paired-field trials on three private farms and a Purdue University farm. Drain flow and nitrate concentration are being monitored in each paired field to quantify nitrate load reductions due to drainage water management. Potential impacts on agricultural sustainability are also being assessed by measuring management practice impacts on soil physical properties, earthworms, plant growth, plant N content, yield, and profitability of both conventional and managed drainage for each paired site. This paper presents site selection, design and installation of the flow monitoring system, and an overview of soil and crop measurements to be made.
28	Gabel, K., 2012	Assessment of the effectiveness of best management practices for streams draining agricultural landscapes using diatoms and macroinvertebrates		Watershed Agricultural Council	NY	85% dairy, 15% row crops	riparian planting, streamside fencing, barnyard improvements, manure storage	Y	Y	N	1 fall, 1 spring	control/experiment	N	N	Does not isolate row crops. Individual BMPs not evaluated	In this study, a bioassessment was conducted to determine the effectiveness of best management practices (BMPs) implemented in farms in the Upper Delaware River watershed, NY (USA). Diatom and macroinvertebrate communities were analyzed across 17 low-order streams, designated as reference, BMP, or non-BMP. Streams lacking improvements (non-BMP) had significantly greater specific conductance, pH, TDP, NH4-N, and NO3-N than did reference streams. Diatom model affinity (DMA) values were significantly greater in reference and BMP streams than in non-BMP streams; non-BMP streams bordered on a ''severely impacted'' rating. The Trophic Diatom Index (TDI) varied two-fold among stream classes, with non-BMP[BMP[reference. TDI and DMA values were highly correlated, and both varied significantly with conductance, TDP, NH4-N, and NO3-N. Macroinvertebrate taxa, EPT richness, and Simpson's diversity did not differ significantly among stream classes. Macroinvertebrate metrics (HBI, Bioassessment Profile,% Model Affinity) varied by stream class, but none indicated greater water quality in BMP sites. Nonetheless, each correlated significantly with conductance and TDP in the directions predicted by each model. Our data suggest that diatoms are more sensitive to moderate increases in nutrients, conductivity, and pH in high gradient agricultural streams, and may be more useful in assessing stream management practices.
113	Garbrecht, 2008	Multi-year precipitation variations and watershed sediment yield in a CEAP benchmark watershed	AGRICOLA	USDA-ARS	OK	pasture, row-crops	land-conversion, low-till techniques	N	Y	N	66-year	before/after	N	N	Data presented graphically. No BMP specified in detail. Mainly an observation study.	A case study was conducted on the Fort Cobb Reservoir watershed in central Oklahoma to investigate impacts and implications of persistent multi-year precipitation variations on watershed runoff and sediment yield. Several persistent multi-year precipitation variations, called wet and dry periods, occurred in central Oklahoma between 1940 and 2005. The difference in mean annual precipitation between wet and dry periods was 33% of the long-term mean, or 1.5 standard deviations. As a result of non-linear hydrologic linkages between precipitation, runoff and sediment yield, corresponding variations in watershed runoff and sediment yield were comparatively larger. The difference in mean annual runoff between wet and dry periods was 100% of the long-term mean, or 2.1 standard deviations. Sediment yield was estimated using a sediment-discharge relationship. The difference in mean annual sediment yield between wet and dry periods was 183% of the long-term mean, or 1.7 standard deviations. The sensitivity of runoff and therefore of sediment yield to wet and dry periods suggests that measures of conservation program effectiveness depend on climatic conditions used in their evaluation, and that great care should be taken to select a climate record representative of prevailing climate conditions. Furthermore, it was inferred that the calibration of simulation models used in the conservation effects assessment may be biased if performed with climatic data representing either just a wet or a dry period. In the presence of multi-year precipitation variations, a thorough model validation for both wet and dry periods is recommended to ensure accurate simulation results over the full range of prevailing climatic conditions.
29	Garbrecht, J., 2009	Watershed sediment yield reduction through soil conservation in a West-Central Oklahoma watershed		USDA	OK	cropland, grassland	conservation tillage, terrace planting	Y	Y	N	3-5 year	before/after	N	Y		Soil conservation practices on the Fort Cobb Reservoir watershed in West-Central Oklahoma were limited before the 1950s. However, extensive soil conservation measures were implemented in the second half of the 20th century to protect agriculturally fertile but erosion-prone soils. Fortuitously, the U.S. Geological Survey (USGS) collected instantaneous suspended-sediment and discharge measurements on major tributaries within the watershed in 1943-1948 and again in 2004-2007, called pre- and post-conservation periods respectively. These measurements offered the opportunity to compare channel suspended-sediment yield before and after implementation of conservation practices. A separate suspended sediment-discharge rating curve was developed for the pre- and post-conservation period. Average annual suspended-sediment yield at a U.S. Geological Survey gauging station near the watershed outlet was estimated by evaluating each sediment-discharge rating curve with the 18- year long daily discharge record at that gauging station. Average annual suspended-sediment yield was estimated to be 760 [Mg/yr/km2] and 108 [Mg/yr/km2] for the pre- and post-conservation periods, respectively. The substantial reduction in suspended-sediment yield was related to land use and management changes and the wide range of conservation practices implemented in the second half of the 20th century. Even though it generally is difficult to identify impacts of upstream conservation practices on sediment yield at the watershed outlet during the short time-span of a particular conservation project, targeted and widespread conservation efforts in the Fort Cobb Reservoir watershed have led, over 60 years, to a sizable and measurable reduction in watershed sediment yield. Published in 2009 by John Wiley & Sons, Ltd.

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123	Gaynor et al., 1995	Soil and Phosphorus Loss from Conservation and Conventional Till age in Corn Production	Va. Tech/Yagow	SWEEP	Canada	corn	tillage, tile drain	Y	N	Y	3-year	experiment/control	Y	Y	Good. Yearly means presented	Conservation tillage is encouraged in southwestern Ontario by concern for soil erosion and compaction. The contribution of agriculture to eutrophication of the Great Lakes by P is also at issue. Soil loss and ortho-P transport were measured from a conventional and two conservation tillage treatments (zero and ridge tillage) from January 1988 to 30 Sept. 1990 to evaluate their impact on meeting Great Lakes water quality objectives for P. Sediment concentration from the poorly drained, Brookston clay loam (clayey, mixed, mesic Typic Haplaquolls), cropped to corn (Zea mays L.) was 2.1 times larger in surface runoff than tile discharge (0.20 g/L) but tile discharge contributed 44 to 65% of the soil loss probably from preferential flow. Conservation tillage reduced average soil loss 49% from conventional tillage (899 kg/ha). Conservation tillage increased ortho-P concentrations in runoff 2.2 times from conventional tillage (0.25 mg/L). Orthophosphate transport decreased in the order zero>ridge>conventional tillage. Average ortho-P loss was 1.7 to 2.7 times greater from conservation than conventional tillage (559 g/ha/yr). Subsurface drainage accounted for 55 to 68% of the ortho-P transported. Transport of total soluble P and total P (sum of sediment-attached P and soluble P, only measured in 1990) increased 2.2 and 2.0 times, respectively, with conservation than conventional tillage. Dissolved P accounted for 84 to 93% of the P transported from the three tillage treatments. Sediment-attached P constituted 7 to 16% of total P loss. Conservation tillage effectively reduced soil erosion but increased P loss.
30	Gebirrye, T., 1990	Investigating Scale, Rainfall-Runoff Sequences and BMP Effects of Phosphorus, Runoff and Sediment Yield			OK	Pasture	Strip-cropping, terrace, forestation	Y	N	N	62-days	experiment/control	N	N	Row crops are not highlighted	Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
17	Georgia Soil and Water Conservation Commission, 2007	Best Management Practices for Georgia Agriculture		USDA	GA	Variety	Variety	N	N	N	n/a, literature review	Literature review	n/a, literature review	Y	Underlying data would be useful. No raw data provided.	State-wide guide for agricultural BMP's, so no abstract provided
174	Gharabaghi et al., 2001	Sediment-Removal Efficiency of Vegetative Filter Strips			Canada	None (experimental application of pollutants)	Filter Strips	Y	N	N	58 events	experiment/control	N	N	No crops, simulated runoff	Field experiments on vegetative filter strips (VFS) showed average sediment-removal efficiency varied from 50 to 98% as flow path length increased from 2.44 to 19.52 m. Almost all of the easily-removable aggregates (i.e. aggregates larger that 40 mm in diameter) can be captured within the first five meters of the filter strip. However, the remaining small-size aggregates are very difficult to remove by filtering flow through grass media, as even relatively low levels of turbulent energy in the water is sufficient to keep the finer sediments in suspension. The only effective mechanism for removal of small-size sediments is infiltration. Experiments with appreciable infiltration (low to moderate flow rates on the longer plot lengths), showed removal efficiencies of 90% or higher. The sediment-removal efficiency of the filter strip does not increase much by increasing the width of the filter strip beyond ten meters. Improved efficiency of VFS can be achieved through the installation of a drainage system to increase infiltration.
31	Gharabaghi, B., 2006	Effectiveness of Vegetative Filter Strips in Removal of Sediments from Overland Flow		Ontario Cattlemen's Council	Canada	Not provided	vegetated filter strip	Y	N	N	6-year	control/experiment	N	tbd	Experimental design, single BMP evaluation, not necessarily row crop	Many forms of natural heritage manifested as streams, rivers, ponds, lakes and wetlands play an integral role in maintaining natural beauty, health and a high quality of life. Agricultural intensification in southern Ontario has contributed to elevated sediments, nutrient and bacteria levels in water bodies. Vegetative filter strips (VFS) are control measures that can partially remove sediments and pollutants adhered to sediments from overland runoff before entering water bodies. The objective of this study was to determine the effect of vegetation type, width of the filter strip, runoff flow rate and inflow sediment characteristics on effectiveness of the VFS in removing pollutants from runoff. The results show that sediment removal efficiency increased from 50 to 98% as the width of the filter increased from 2.5 to 20 m. In addition to the width of the filter strip, grass type and flow rate were also significant factors. This study indicates that the first five (5) meters of a filter strip are critical and effective in removal of suspended sediments. More than 95% of the aggregates larger than 40 pm in diameter were trapped within the first five meters of the filter strip.
175	Gilliam et al., 1979	Drainage Control to Diminish Nitrate Loss from Agricultural Fields			NC	Tobacco?	drainage control	Y	N	N	3 months	before/after	N	Y	Good. But all data in charts	In an attempt to reduce NO3-N movement to drainage waters, flashboard riser-type water level control structures were installed in tile mains or outlet ditches at two locations to raise the water table to increase denitrification during the winter. A large reduction in NO3-N movement through tile lines occurred (from 25-40 to 1-7 kg/ha) in moderately well-drained soils because of reduction in effluent volume. In the moderately well-drained soils, there was no indication of increased denitrification in the field. In poorly drained soils, drainage control had no influence upon soil profile oxidation-reduction potentials but resulted in approximately.a 50% reduction in NO3−N movement through drainage ditches. This reduction was due to increased water movement into and through deeper soil horizons (below 1 m). The NO3-N concentrations and low Eh values in all profiles below 1 m indicate that the NO3−N which moved to this depth underwent denitrification.
47	Gitau, M., 2004	Farm Level Optimization of BMP Placement for Cost Effective Pollution Reduction			NY	corn, hay and pasture	nutrient management, riparian forest buffers, contour strip cropping	N	N	N	none, modeling study	modeling/predictive	n/a, modeling study	N		With best management practices (BMPs) being used increasingly to control agricultural pollutant losses to surface waters, establishing the environmental effectiveness of these practices has become important. Additionally, cost implications of establishing and maintaining environmentally effective BMPs are often a crucial factor in selecting and adopting BMPs. This article considers both water quality and economic concerns and presents a methodology developed for determining cost-effective farm- or watershed-level scenarios through optimization. This optimization technique uniquely incorporates three existing tools: a genetic algorithm (GA), a watershed-level nonpoint-source model (Soil and Water Assessment Tool, SWAT), and a BMP tool. The GA combines initial pollutant loadings from SWAT with literature-based pollution reduction efficiencies from the BMP tool and with BMP costs to determine cost-effective watershed scenarios. The methodology was successfully applied to a 300 ha farm within the Cannonsville Reservoir watershed, a P (P) restricted reservoir within New York City's water supply system. An average reduction in dissolved P of 60% over the lifetime of the BMPs was set as the pollutant target. A baseline scenario was established to represent practices on the farm before BMP implementation. The most cost-effective scenario for the farm, under the presented methodology, achieved a cost-effectiveness of 0.6 kg dissolved P reduction per dollar spent per year. Additionally, the methodology determined alternative scenarios for the farm, which met the pollution reduction criterion cost-effectively. The methodology, as developed, is extendable to multi-farm or watershed-level evaluations
97	Glenn et al., 1986	Atrazine and simazine in runoff from conventional and no-till corn watersheds			MD	corn	conventional, no-till	Y	N	Y	19	experiment/control	Y	Y	Excellent event data	A study was initiated to compare the surface runoff of atrazine and simazine from adjacent conventional tillage (CT) and no-tillage (NT) corn watersheds that were otherwise identical. Runoff was collected in H-type flumes and Coshocton wheels. Atrazine [2-chloro-4-(ethylamino)-6-(isopropylamino) -s-triazine] and simazine [2-chloro-4,6-bis(ethylamino)-s-triazine] were applied at 2.2 kg a.i./ha to both watersheds annually from 1979 to 1982. There was less runoff of water, atrazine and simazine from the NT watershed compared to the CT watershed each year that a major runoff event occurred during the growing season. Between 1979 and 1982, total volume of runoff was 27% less from the NT compared to the CT watershed. Most of the herbicide loss in surface runoff occurred during the first runoff event after application. The concentration of simazine in runoff was much less than that of atrazine. The greatest runoff of herbicides occurred in 1979 when 1.6 and 1.1% of the atrazine applied moved from the CT and NT watershed, respectively, and 0.52 and 0.36% of the simazine applied moved from the CT and NT watershed, respectively.
48	Goel, P., 2004	Pollutant Removal by Vegetative Filter Strips Planted with Different Grasses			Canada	None (experimental application of pollutants)	filter strip	Y	N	Y		inflow/outflow	Y	N	field experiment (may be based on irrigation test, need to verify)	Over the last few years, increasing occurrence of deadly pathogens and presence of various pollutants (nutrients, pesticides, other chemicals, and sediments) above the prescribed limit in water systems, clearly indicate alarmingly deteriorating quality of water resources. As a result, farming systems that are known to be the main non-point or diffuse pollution source are being reviewed microscopically. Vegetative Filter Strip (VFS) is considered to be one of the best management practices (BMPs) for effective control sediment and nutrient transport over agricultural lands. Many laboratory and field scale studies have also indicated the limited usefulness of VFS to control movement of bacteria in surface runoff. However, design of VFS under field conditions still remains a challenge due to variation in upland hydrological parameters and factors effecting movement of pollutants through VFS such as type of vegetation cover and density, width of strip, and land slope. Determination of trapping efficiency of VFS for bacteria is more complex due to the complex interaction of various factors governing the die-of and re-growth of bacteria under field condition, and release of bacteria from soil reserve. An extensive field experiment is being conducted at the research farm of University of Guelph in Southern Ontario, Canada, to evaluate to effectiveness of VFS under different vegetation cover, ground slope, width of filter strip, and in various seasons. Concentration of sediment reduced an average by 88.3% and almost 94.3% sediment mass was trapped in various filter strips. Higher trapping efficiencies for mass were observed for sediment bound nutrients (94.5% and 93.9% for N and P, respectively) compared to soluble forms (57.0% and 77.3% for N and P, respectively). Results for bacteria (Total Coliforms, Fecal Coliforms, and E. Coli) through VFSs were encouraging but not conclusive. In the present paper, experiment and results of the study are presented and discussed in details.

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93	Gordon et al., 2011	Impact of modified tillage on runoff and nutrient loads from potato fields in Prince Edward Island		Canada/PEI water supply expansion program	Canada	potato	conventional tillage, row shaper tillage, basin tillage	Y	N	Y	45	experiment/control	N	Y	Good. Means presented.	Potato production accounts for 24% of the cultivated land-use in PrinceEdwardIsland, Canada. The island often experiences prolonged dry periods interspersed with excessive rainfall events throughout the growing season. Thus, water retention is important for maximum crop production while sediment and nutrient loading to surface water systems are also concerns. Therefore, agronomic practices that reduce the environmental impact of potato production are being sought. Basin tillage (BT) is a potential option in which small dams are created in the furrows (row middles), resulting in basins that enhance infiltration, reduce runoff, minimize contaminant loads, and increase yields. This on-farm study compared BT against two types of 'conventional' hilling treatments with replicated plots on four field sites over two growing seasons. Field sites had sandy loam soils with topography slopes ranging from 3% to 5%. Within each field, nine 25 m long and 3.66 m wide (4 rows) plots were established, including three plots of each hilling treatment (CT = conventional tillage; RS = row shaper tillage; BT = basin tillage). Runoff volume, nutrient (phosphate, ammonium, nitrate) and suspended solids loads were measured using collection barrels on the down slope end of each furrow. Basin tillage had 78% and 75% less runoff than CT and RS, respectively ($P < 0.05$). Runoff differences between BT and CT were significant at all sites while runoff differences between BT and RS were significant at three of four sites. Reductions for each parameter (on a mass basis) averaged across all sites were: sediment 89%, nitrate 45%, ammonium 38%, and phosphate 15%; although, treatment effect was not significant for some mass loads in some fields. No significant effect on marketable potato yield was observed at any site; soil water was not limiting in either growing season. Overall, basin tillage was effective at reducing runoff and nutrient losses without affecting yield and appears to be an effective tool for decreasing environmental risks.
176	Grigg et al., 2003	Drainage System Impacts on Surface Runoff, Nitrate Loss, and Crop Yield on a Southern Alluvial Soil			LA	Corn	drainage control	Y	N	N	1-year	experiment/control	Y	Y	Good, only summary data presented	Excess rainfall and subsequent surface runoff is a challenge to farmers of the Lower Mississippi River Valley region. In 1993, we established an experimental field site in Baton Rouge, Louisiana, consisting of 16 hydraulically isolated plots (0.2 ha) on a Commerce soil (Aeric Fluvaquents). Our objective was to determine drainage system impacts on surface runoff, subsurface drainage effluent, nitrate loss, and corn (Zea mays L.) yield. We evaluated the following drainage systems (four replications) in 1995 and 1996: surface drainage only (SUR), controlled subsurface drainage at 1.1 m below the soil surface (DCD), and shallow water table control at a 0.8 m depth via controlled-drainage/subirrigation (CDSI). Planting date, fertility management, and minimum tillage were consistent across treatments. When compared to SUR, DCD and CDSI did not reduce surface runoff or nitrate loss in runoff. This is in contrast to previous research showing that subsurface drainage systems decreased runoff on this soil, the difference being that we did not use deep tillage. Our results suggest that subsurface drainage systems should be coupled with deep tillage to reduce nutrient loss in runoff from this alluvial soil. DCD and CDSI controlled the shallow water table, but the increased annual effluent from subsurface drainage increased nitrate loss compared to SUR. DCD and CDSI had no affect on corn yield under these rainfall conditions. With respect to nitrate loss and crop yield in this region, typical SUR drainage may be the best management practice (BMP) in the absence of effective runoff mitigation, such as deep tillage.
49	Grismer, M., 2004	Vegetative Filter Strip for Nonpoint Source Pollution Control in Agriculture			Review	NA	filter strip	N	N	N				N	Possibly use to ID other studies	Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
124	Guillard et al., 1999	The Pre-Sidedress Soil Nitrate Test and Nitrate Leaching from Corn	Va. Tech/Yagow		CT	corn	pre-sidedress soil nitrate test	Y	N	Y	2-year	experiment/control	Y	Y	Good. Yearly means presented	The pre-sidedress soil nitrate test (PSNT) is recommended in many states as a best management practice (BMP) for corn (Zea mays L.). A 2-yr study was conducted in Connecticut on a Woodbridge fine sandy loam soil (coarse loamy, mixed, mesic Aquic Dystrochrept) to determine NO3-N concentrations and losses in soil water from corn managed with three different N fertilization regimes: (i) PRE, 196 kg N/ha applied preplant; (ii) PSNT-1, 90 kg N/ha applied at preplant and any remaining N needs estimated by the PSNT (0 kg/ha in 1995 and 45 kg/ha in 1996); and (iii) PSNT-2, no preplant N and all N needs estimated by the PSNT (34 kg/ha in 1995 and 123 kg/ha in 1996). Percolate was collected with zero-tension pan lysimeters. Flow-weighted NO3-N concentrations from the PRE treatment were 22.3 mg/L in 1995 and 17.4 mg/L in 1996; the PSNT treatments were <8.0 mg/L. Losses of NO3-N as a% of N applied in 1995 were 20%, 10%, and 12% for PRE, PSNT-1, and PSNT-2, respectively, and 31%, 21%, and 21%, respectively, in 1996. Greatest leaching losses occurred after corn harvest. Corn yields were not significantly ($P > 0.05$) different among N treatments. These findings suggest that a well calibrated soil N test can reduce excess fertilization and the potential for NO3 contamination of ground water.
9	Guimera, J., 1995	Nitrate Leaching and strawberry production under drip irrigation management	MPMINER	Government	Spain	strawberry	irrigation	Y	N	N	1-year	control/experiment	Y	Y	Good, monthly means presented	The aim of the present study is the understanding of N leaching and uptake in an experimental crop. The experiment was carried out in one of the European aquifers most polluted by agricultural practices (Maresme area, Barcelona, Spain) and performed on a widespread crop in the area. The study aimed to determine the effect of continuous fertigation regimes through drip irrigation on N uptake and leaching as well as on the yield of strawberries. Irrigation regimes were imposed by watering when suction was - 0.01 MPa (wet) and -0.07 MPa (dry) in the root zone. The nutrient solution was the same for both treatments. Foliage and fruit N concentration did not differ between the treatments, but N uptake was higher in the wet treatment; as a result, plant production and biomass increased. Nitrate N (NO3-N) leachates under the root zone were 1535 and 471 kg N ha- 1, respectively; N uptake was 12% and 23% of the total applied. The wet irrigation regime resulted in significantly increased yields. Experimental conditions revealed a slow transit time through the vadose zone. Management practices should be improved to account for crop needs and thus, improve N uptake efficiency and reduce N leaching.
125	Hall et al.,1993	Effects of agricultural nutrient management on N fate and transport in Lancaster County, Pennsylvania	Va. Tech/Yagow		PA	corn, tobacco, rye, Sudan grass, fruits, vegetables	nutrient management	Y	Y	Y	6-year	before/after	Y	Y	Good. Yearly means presented	Nitrogen inputs to, and outputs from, a 55-acre site in Lancaster County, PA, were estimated to determine the pathways and relative magnitude of loads of N entering and leaving the site, and to compare the loads of N before and after the implementation of nutrient management. Inputs of N to the site were manure fertilizer (averaging 93% of average annual N additions), commercial fertilizer (4%), N in precipitation (2%), and N in groundwater inflow (1%). Outputs of N from the site were N in harvested crops (averaging 37% of average annual N removals from the site), loads of N in surface runoff (<1%), volatilization of N (25%), and loads of N in groundwater discharge (38%). Virtually all of the N leaving the site that was not removed in harvested crops or by volatilization was discharged in the groundwater. Applications of manure and fertilizer N to 47.5 acres of cropped fields decreased about 33%, from an average of 22,700 lbs/yr (480 lbs/acre/yr) before nutrient management to 15,175 lbs of N/yr (320 lbs/acre/yr) after the implementation of nutrient management practices. Nitrogen loads in groundwater discharged from the site decreased about 30%, from an average of 292 lbs of N/million gal of groundwater before nutrient management to an average of 203 lbs of N/million gal as a result of the decreased manure and commercial fertilizer applications. Reductions in manure and commercial fertilizer applications caused a reduction of approximately 11,000 lbs (3,760 lbs/yr; 70 lbs/acre/yr) in the load of N discharged in groundwater from the 55-acre site during the 3-yr period 1987-1990.
100	Hansen et al., 2000	Snowmelt runoff, sediment, and P losses under three different tillage systems			MN	corn	3 till techniques	Y	N	Y	8	experiment/control	N	Y	Good. Yearly means presented	In cold climates, snowmelt runoff often exceeds rainfall runoff during the year. Conservation tillage practices may be effective in reducing runoff during the cropping season but not during the snowmelt period. A plot study was conducted on a cropped hill slope to assess how tillage practices affectsnowmeltrunoff and the associated losses of sediment, P (P), and chemical oxygen demand (COD). Tillage systems were fall moldboard and chisel plowing with spring disking, and a ridge till system utilizing only the tillage associated with summer row cultivation. Tillage and planting were done up and down the slope. Ridge tilled plots had higher fall residue cover, retained more snow, had less surface roughness, and consequently produced more runoff than the moldboard plow treatment. The amount of runoff from chisel plowed plots was similar to runoff from ridge tilled plots despite a relatively rough surface and moderate amount of residue cover. Phosphorus losses in runoff were higher for the ridge till and chisel plow systems than for the moldboard plow system. For all tillage systems, soluble P represented a major portion (75%) of the total P loss in snowmelt runoff. Although erosive losses in snowmelt were low, the Plosses were substantial and merit consideration in studies evaluating management systems impact on surface water quality in regions where snowmelt runoff is important.
177	Hansen et al., 2000 (2)	Nitrate Leaching as Affected by Introduction or Discontinuation of Cover Crop Use			Denmark	unclear from abstract	Cover crop	Y	N	N	4-year	experiment/control	Y	Y	Good, yearly data presented	A 24-yr-old permanent field trial with spring-sown crops was used in a nitrate N leaching study to determine (i) the effect of long-term cover crop use compared with the introduction of perennial ryegrass (Lolium perenne L.) as a cover crop on plots with a history of no previous cover crop use and (ii) the effect of discontinuing long-term use of ryegrass as a cover crop compared with no previous cover crop use. The cover crop (seed rate 8-10 kg/ha) was undersown in spring wheat (Triticum aestivum L.). The field trial was conducted on a coarse sand (Orthic Haplohumod) under temperate coastal climate conditions in Denmark. From 1993 to 1997, nitrate leaching was estimated by use of soil water samples from ceramic cups in four treatments: cover crop since 1968, cover crop since 1993, no cover crop, and cover crop until 1993. Each treatment was carried out at two N rates: 60 and 120 kg N/ha yr^{-1}. As an average of 4 yr and two N rates, leaching was 14 kg N/ha yr^{-1}or 29% higher in plots with long-term previous cover crop use than in plots without. The effect of previous long-term use of ryegrass as a cover crop lasted at least 4 yr. Thus, if the higher N mineralization due to long-term use of cover crop is not taken into consideration by adjusting the cropping system, the reduction in nitrate leaching caused by the cover crop may not be as significant in the long-term.

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154	Huggins et al., 2001	Subsurface Drain Losses of Water and Nitrate following Conversion of Perennials to Row Crops		USDA-ARS	MN	corn, soybean, alfalfa	crop rotation	y	N	N	2-year	experiment/control	Y	Y	Good, monthly means presented	Nitrate losses through subsurface drains in agricultural fields pose a serious threat to surface water quality. Substantial reductions in drainage losses of NO3-N can occur with alfalfa (Medicago sativa L.) or perennial grasses as used in Conservation Reserve Program (CRP) plantings. Conversion of perennials to annual row crops, however, could have rapid, adverse affects on water quality. We evaluated water and N use efficiency of row crops following perennials, and losses of water and NO3-N to subsurface drains. Four cropping systems: continuous corn (Zea mays L.), a corn-soybean [Glycine max (L.) Merr.] rotation, alfalfa (ALF), and CRP, were established in 1988. The ALF and CRP were converted to a corn-corn-soybean sequence from 1994 through 1996 while continuous corn (C-C) and corn-soybean (C-S) rotations were maintained. Following CRP, corn yield was 14% and water use efficiency (WUE) 20% greater as compared with C-C. Yield was 19% and WUE 21% greater for soybean following corn in CRP and ALF as compared with C-S. Residual soil NO3-N (RSN) increased 125% in first year corn following CRP and was 32% greater than C-C by 1996. High N uptake efficiencies of corn following alfalfa slowed the buildup of RSN, but levels were equal to row crop systems after 2 yr. Nitrate losses in drainage water remained low during the initial year of conversion, but were similar to row crop systems during the subsequent 2 yr. Beneficial effects of perennials on subsurface drainage characteristics were largely negated following 1 to 2 yr of corn.
46	Inamdar, S., 2001	BMP Impacts on Sediment and Nutrient Yields from an Agricultural Watershed in the Coastal Plains Region			VA		filter strip, nutrient management, tillage	Y	Y	n/a, Full text unavailable	12-year	before/after	n/a, Full text unavailable	Y	Full text not available	The goal of the Nomini Creek watershed monitoring study was to quantify the effectiveness of BMPs at the watershed scale and to determine if the improvements in water quality could be sustained over a long term period. Information on the long-term effectiveness of BMPs is critical since BMPs are being implemented under the state cost share program to reduce nonpoint source pollution (NPS) to the Chesapeake Bay. The Nomini Creek project started in 1985 and was completed in 1997. A pre versus post BMP design was used. A combination of managerial and structural BMPs was implemented. Major BMPs implemented in the Nomini Creek watershed included no-tillage, filter strips, and nutrient management. The data collected at the 1463 ha Nomini Creek watershed consisted of land use, hydrologic, water quality, soils, and geographical information. The BMPs implemented at Nomini Creek reduced average annual loads and flow-weighted concentrations of N (N) by 26% and 41%, respectively. Average annual total-N loads discharged from the watershed were reduced from 9.57 kg/ha during the pre-BMP period to 7.05 kg/ha for the post-BMP period. Largest reductions were observed for dissolved ammonium-, soluble organic-N, and particulate-N. In contrast, nitrate-N loads increased after BMP implementation. Increase in nitrate exports was likely due to ammonification and nitrification, and subsequent leaching of particulate-N species that were conserved on the field. In comparison to N, reductions in P (P) loads and concentrations were not significant. BMP implementation resulted in a mere 4% reduction for total-P with a corresponding 24% reduction in flow-weighted concentration. The average annual total-P loads exported from the watershed were 1.31 and 1.26 kg/ha for the pea€“ and post-BMP periods, respectively. Reductions in total-P loads were due to decreases in particulate-P. Exports of Rothay-P and dissolved organic-P increased after BMP implementation. It is likely that some of this post-BMP increase in dissolved P fractions was associated with dissolution and leaching of particulate-P, and higher rainfall runoff activity in the watershed during the post-BMP period. In comparison to nutrients, there was no significant change in suspended solids discharged from the watershed. Overall, the findings of this study indicate that the BMPs were effective in reducing the losses of some forms of nutrients, such as ammonium-N and particulate-P, from the Nomini Creek watershed, but additional BMPs are necessary to achieve significant reductions in all forms of N and P.
60	Izuno, F., 1995	Agricultural BMPs for Phosphorus Reduction in South Florida			FL	sugarcane, rice, cabbage and radish	crop rotation, drainage rates, fertilizer	Y	N	Y	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	Y	Appears to have useful data collected under controlled conditions	Four sets of eight or twelve 0.7 ha plots, designed for soil and hydraulic uniformity, were used to screen potential Best Management Practices (BMPs) for reducing total P (TP) concentrations and loadings in the Everglades Agricultural Area (EAA) of south Florida. The four production systems and their alternatives (treatments) studied were: (1) sugarcane (interspecific hybrids of Saccharum sp.) versus drained fallow plots; (2) fast versus slow drainage rates for sugarcane; (3) rice (Oriza sativa L.) in rotation following radishes to serve as a P filter crop versus traditional flooding fallow; and (4) banding P (P) fertilizer at 50% of the soil-test recommendation rate for cabbage (Brassica oleracea L.) versus full-rate broadcast applications. The study showed that there were no differences in P concentrations in drainage water between sugarcane and drained fallow fields. Annual P loading to the plots in rainfall and irrigation water (0.63 kg TP) exceeded the P loading of drainage waters (0.52 kg TP for sugarcane and 0.59 kg TP for drained fallow plots). Slow drained sugarcane plots exhibited significantly higher TP concentrations than the fast drained plots. However, TP loads were significantly higher (0.97 kg) for fast drained plots than for the slow drained plots (0.67 kg). Rice as a P filter crop following radishes reduced TP concentrations and loadings. Finally, banding P fertilizer at a reduced rate for cabbage reduced TP concentrations compared to those for broadcasted P at the full recommended level. Total P loadings in drainage water were 1.17 kg for banded and 1.38 kg for broadcast treatments. A total of 1.30 kg TP entered the plots in rainfall and irrigation water. All treatment TP loadings leaving the plots in drainage water were close in magnitude to TP loadings to the plots, even under heavy fertilization. This indicates that the EAA system is currently a net assimilator of P.
126	Johengen et al., 1989	Evaluating the Effectiveness of Best Management Practices to Reduce Agricultural Nonpoint Source Pollution	Va. Tech/Yagow	RCWP	MI	unclear from abstract	till techniques, crop rotation, cover crops, crop residue, nutrient management, grassed waterways, retention basins, erosion weirs, waste management	Y	Y	N	6-year	before/after	N	N	data not in an accessible format.	The Saline Valley project is one of 20 national projects sponsored by the U.S. Department of Agriculture (USDA) under the Rural Clean Water Program (RCWP) to evaluate methods of controlling agricultural non-point source pollution. The goals of this project were (1) to evaluate whether a voluntary approach using cost-share incentives would produce adequate participation by local farmers and (2) to reduce P loads from the area by 40%. Water quality has been monitored since 1981 using weekly grab samples and flow measurements. Trends in empirical relationships between concentration and discharge at three sampling stations were used to examine the effectiveness of best management practices (BMP). These relationships were highly variable among the sub-basins and years, and did not appear to correlate with areal estimates of BMP implementation. Overall, low participation within the project area hindered the ability to quantify changes in water quality resulting from BMP implementation and prevented the project from meeting its P reduction goals.
91	Jordan et al., 1993	Nutrient interception by a riparian forest receiving inputs from adjacent cropland	AGRICOLA	NSF	MD	corn	riparian buffer	Y	N	N	1-year	inflow/outflow	N	Y	Data presented graphically. Annual Average. Groundwater	To investigate the ability of riparian forest to intercept nutrients leaving adjacent cropland, we examined changes in the chemistry of groundwater flowing from a corn (Zea mays L.) field through a riparian forest. This study provided a comparison to previous studies of a different forest. We sampled groundwater from a transect of wells, and used a Brû tracer to confirm that groundwater moved laterally along the transect through the forest. As groundwater flowed through the forest, NO-3 concentrations decreased from about 8 mg/L at the edge of the corn field to <0.4 mg/L halfway through the forest. Dissolved organic N and NH+4 increased by less than 0.1 mg/L, and dissolved organic C did not change with distance. Sulfate remained constant with distance until midway through the forest, where it began to increase. Chloride concentration rose until midway through the forest, then fell. Values of pH increased from under 5 at the edge of the corn field to over 7 at the stream bank, perhaps as a result of the NOû3 consumption. Most of the change in NO-3 occurred abruptly at the edge of a floodplain within the forest. There the water table was closest to the surface and soil Eh below the water table was less than û90 mV. Such strongly reducing conditions may have promoted denitrification in the floodplain. In contrast, soil Eh on the adjacent hill slope was above 500 mV, too high to support denitrification. There were only slight seasonal changes in groundwater chemistry. We also studied the net annual accretion of sediment in the riparian forest by measuring changes in the elevation of the soil surface. There was little or no accretion in the forest, but along a path of overland storm flow there was net erosion. Thus, nutrient retention by this forest, in contrast with the forest we previously studied, was entirely a below ground process. Functional differences within sections of this forest and among different riparian forests suggest a need for research on the factors that control nutrient retention.
153	Kaluli et al., 1999	Subirrigation systems to minimize nitrate leaching		Natural Sciences and Engineering Research Council of Canaa	Canada	corn, ryegrass	subirrigation, intercropping	Y	N	N	2-year	experiment/control	Y	Y	Good, seasonal means presented	Nitrate leaching from corn production systems and the subsequent contamination of ground and surface waters is a major environmental problem. In field plots 75 m long by 15 m wide, the writers tested the hypothesis that subirrigation and intercropping will reduce leaching losses from cultivated corn and minimize water pollution. Nitrate leaching under subirrigation at a depth of either 0.7 m or 0.8 m below the soil surface was compared with leaching under free drainage. The cropping systems investigated were corn (Zea mays L.) monoculture and corn intecropped with annual italian ryegrass (Lolium multiflorum Lam. cv. Barmultra). The effects of three fertilizer application rates (0, 180, and 270 kg N/ha) on leaching were investigated in the freely drained plots. The greatest annual loss of NO3--N in tile drainage water (21.9 kg N/ha) occurred in freely draining, monocropped plots fertilized with 270 kg N/ha. Monocropped plots fertilized with 270 kg N /ha, with subirrigation at 0.7 m depth, resulted in annual nitrate losses into tile draining of 6.6 kg N/ha, 70% less than under free drainage. Annual soil denitrification rates (60 kg N /ha) with subirrigation at 0.7 m were about three-fold greater than under free drainage. Intercropping under free drainage resulted in a 50% reduction in tile drainage loss of NO3--N compared with monocropping. Off-season (November 1, 1993,to May 31, 1994) tile drainage losses of NO3--N (7.8 kg N /ha) from freely draining monocropped plots accounted for 30% of the annual tile drainage losses.

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178	Kaspar et al., 2007	Rye Cover Crop and Gamagrass Strip Effects on NO3 Concentration and Load in Tile Drainage		CSREES	IA	Corn, soybean	Cover crop	Y	N	N	5-year	experiment/control	Y	Y	Good, yearly means presented	A significant portion of the NO_3 from agricultural fields that contaminates surface waters in the Midwest Corn Belt is transported to streams or rivers by subsurface drainage systems or "tiles." Previous research has shown that N fertilizer management alone is not sufficient for reducing NO_3 concentrations in subsurface drainage to acceptable levels; therefore, additional approaches need to be devised. We compared two cropping system modifications for NO_3 concentration and load in subsurface drainage water for a no-till corn (*Zea mays* L.)-soybean (*Glycine max* [L.] Merr.) management system. In one treatment, eastern gamagrass (*Tripsacum dactyloides* L.) was grown in permanent 3.05-m-wide strips above the tiles. For the second treatment, a rye (*Secale cereale* L.) winter cover crop was seeded over the entire plot area each year near harvest and chemically killed before planting the following spring. Twelve 30.5 × 42.7-m subsurface-drained field plots were established in 1999 with an automated system for measuring tile flow and collecting flow-weighted samples. Both treatments and a control were initiated in 2000 and replicated four times. Full establishment of both treatments did not occur until fall 2001 because of dry conditions. Treatment comparisons were conducted from 2002 through 2005. The rye cover crop treatment significantly reduced subsurface drainage water flow-weighted NO_3concentrations and NO_3 loads in all 4 yr. The rye cover crop treatment did not significantly reduce cumulative annual drainage. Averaged over 4 yr, the rye cover crop reduced flow-weighted NO_3 concentrations by 59% and loads by 61%. The gamagrass strips did not significantly reduce cumulative drainage, the average annual flow-weighted NO_3concentrations, or cumulative NO_3 loads averaged over the 4 yr. Rye winter cover crops grown after corn and soybean have the potential to reduce the NO_3 concentrations and loads delivered to surface waters by subsurface drainage systems.
144	Kladivko et al., 2004	Nitrate Leaching to Subsurface Drains as Affected by Drain Spacing and Changes in Crop Production System	Va. Tech/Yagow	Purdue	IN	corn, soybean, wheat	drains, cover-crop, tillage, nutrient management	Y	N	N	15-year	experiment/control	Y	Y	Good. Yearly means presented	Subsurface drainage is a beneficial water management practice in poorly drained soils but may also contribute substantial nitrate N loads to surface waters. This paper summarizes results from a 15-yr drainage study in Indiana that includes three drain spacings (5, 10, and 20 m) managed for 10 yr with chisel tillage in monoculture corn (Zea mays L.) and currently managed under a no-till corn-soybean [Glycine max (L.) Merr.] rotation. In general, drainflow and nitrate N losses per unit area were greater for narrower drain spacings. Drainflow removed between 8 and 26% of annual rainfall, depending on year and drain spacing. Nitrate N concentrations in drainflow did not vary with spacing, but concentrations have significantly decreased from the beginning to the end of the experiment. Flow-weighted mean concentrations decreased from 28 mg L(-1) in the 1986-1988 period to 8 mg L(-1) in the 1997-1999 period. The reduction in concentration was due to both a reduction in fertilizer N rates over the study period and to the addition of a winter cover crop as a "trap crop" after corn in the corn-soybean rotation. Annual nitrate N loads decreased from 38 kg ha(-1) in the 1986-1988 period to 15 kg ha(-1) in the 1997-1999 period. Most of the nitrate N losses occurred during the fallow season, when most of the drainage occurred. Results of this study underscore the necessity of long-term research on different soil types and in different climatic zones, to develop appropriate management strategies for both economic crop production and protection of environmental quality.
179	Kovacic et al., 2000	Effectiveness of Constructed Wetlands in Reducing Nitrogen and Phosphorus Export from Agricultural Tile Drainage			IL	Corn, soybean	wetland treatment	Y	N	N	3-year	inflow/outflow	Y	Y	Good, yearly means presented	Much of the nonpoint N and P entering surface waters of the Midwest is from agriculture. We determined if constructed wetlands could be used to reduce nonpoint N and P exports from agricultural tile drainage systems to surface waters. Three treatment wetlands (0.3 to 0.8 ha in surface area, 1200 to 5400 m3 in volume) that intercepted subsurface tile drainage water were constructed in 1994 on Colo soils (fine-silty, mixed, superactive, mesic Cumulic Endoaquoll) between upland maize (Zea mays L.) and soybean [Glycine max (L.) Merr.] cropland and the adjacent Embarras River. Water (tile flow, precipitation, evapotranspiration, outlet flow, and seepage) and nutrient (N and P) budgets were determined from 1 Oct. 1994 through 30 Sept. 1997 for each wetland. Wetlands received 4639 kg total N during the 3-yr period (96% as NO3-N) and removed 1697 kg N, or 37% of inputs. Wetlands decreased NO3−N concentrations in inlet water (annual outlet volume weighted average concentrations of 4.6 to 14.5 mg N/L) by 28% compared with the outlets. When the wetlands were coupled with the 15.3-m buffer strip between the wetlands and the river, an additional 9% of the tile NO3−N was apparently removed, increasing the N removal efficiency to 46%. Overall, total P removal was only 2% during the 3-yr period, with highly variable results in each wetland and year. Treatment wetlands can be an effective tool in reducing agricultural N loading to surface water and for attaining drinking water standards in the Midwest.
32	Kroger, R., 2011	Spatial and Temporal Changes in Total Suspended Sediment Concentrations in an Oxbow Lake After Implementing Agricultural Landscape Management Practices		MS DEQ	MS	Not listed	grade stabilization, slotted pipes, sediment basins	Y	Y	Y	2-year	before/after	N	tbd	Not as useful due to lack of crop identification	The Wolf-Broad oxbow lake (417 ha) was evaluated by the Mississippi Department of Environmental Quality and included on the Mississippi 303(d) list of impaired waterbodies for total suspended solids (TSS). A study was undertaken for 2 years to evaluate and document changes to TSS (mg/L) and overall lake turbidity (NTU) through best management practice implementation. These two objectives were analyzed with routine monthly surface sampling events of turbidity (Eureka Manta 2, automated data sonde) as well as 20 random samples per sampling trip for TSS from June 2008 to June 2010. Results from a non-parametric Kruskal-Wallis analysis indicated a significant month-by-year effect on turbidity and TSS (chi-squared=76.08, p=0.001), but reach (chi-squared=2.45, p=0.784) and depth by reach (chi-squared=2.44, p=0.784) did not show significant effects on turbidity. There were no significant correlations between TSS concentrations and turbidity and 2 days and 7 days summed or mean rainfall for the duration of the evaluation. Spearman correlation analysis for TSS indicated significant correlations between TSS and mean two-day (r2=0.62, p=0.002) and seven-day (r2=0.51, p=0.014) wind speeds. All other variables used in the analysis did not show significant correlation with TSS (p>0.05). This suggests that wind conditions, rather than rainfall, predict the greatest variability in TSS and turbidity in Wolf Lake. These documented correlations between lake water column TSS, turbidity and wind highlight the difficulties of demonstrating success of management practices in the short temporal period between project initiation and completion. Unmanageable environmental conditions (wind speed and direction) and limited temporal monitoring scales (1 1/2 years post-BMP implementation) limit the possibility of demonstrating successful water-quality improvement within a 303(d) listed waterbody such as Wolf Lake.
112	Kuhnle et al., 2006	Goodwin Creek Experimental Watershed – Effect of Conservation Practices on Sediment Load	AGRICOLA	USDA-ARS	MS	timber, pasture, row-crops	conversion of land to uncultivated	Y	Y	N	26-year	before/after	N	tbd	Data presented graphically. BMP is change in land-use. Not sure if that is pertinent.	The Goodwin Creek Experimental Watershed, a benchmark watershed in the USDA-ARS Conservation Effects Assessment Project (CEAP), drains 2132 ha in the north central part of the state of Mississippi, USA. The watershed is characterized as having high sediment yield (13.2 t/ha/yr) and unstable channel substrate and banks. The effectiveness of management practices applied to the watershed will be evaluated as part of CEAP, and new practices and strategies for continued reduction in sediment loading will be explored using watershed computational models. Land use on the watershed has changed from 26 to 6% cultivated with corresponding increases in timber (26-38%) and pasture (48-55%) lands over the period of record. Annual concentrations of sediment have decreased from about 5000 ppmw in 1982 to about 2000 ppmw at the present. Sediment source tracking using naturally occurring radionuclides has indicated that channel processes are one of the main sources of sediment to the streams of the watershed. In addition to the reduction in sediment, a significant reduction has occurred in the relation between runoff and precipitation in the first part (April-July) of the land use year. Simulations using AnnAGNPS have been shown to favorably compare to the relative trends of the measured rates of runoff and sediment concentration except for periods of cultivation on agricultural lands. Enhancements or applications with advanced channel erosion models are needed to better reflect ephemeral gully and channel erosion.
82	Lafrance et al., 2010	Impact of Grass and Grass with Poplar Buffer Strips on Atrazine and Metolachlor Losses in Surface Runoff and Subsurface Infiltration from Agricultural Plots	AGRICOLA	NSERC	Canada	grass	buffer strip	Y	N	Y	3	control/experiment	Y	Y	Good. Few events	In many areas of intensive corn production, atrazine and metolachlor are among the most commonly found herbicides in surface and ground water. This 2-yr study compared the impact of grass and grass+tree buffer strips on the exported masses of atrazine, metolachlor, and a degradation product of atrazine, desethylatrazine (DEA). The experimental system consisted of four replicate plots in a three-way completely randomized design (no buffer zone, grass buffer zone, and grass+tree buffer strips). The field plots were 5 m wide and 30 m long and grown in corn. The grass and grass+tree buffer strips were 5 m and had the same grass vegetation except for eight young hybrid poplars. Over the 2-yr study, surface runoff and subsurface infiltration water (under the buffer strip) were collected after the initial three rainfall events after herbicide application. Dissolved atrazine, metolachlor, and DEA were analyzed by gas chromatography/mass spectrometry. The presence of buffer strips decreased the exported masses of atrazine and metolachlor in surface runoff. A three-way ANOVA with treatment (type of buffer strip), water (surface runoff or subsurface infiltration), and time between herbicide application and rainfall event as factors showed a significant reduction (40-60% in 2004 and 75-95% in 2005) in the total (surface runoff+infiltrated water) exported masses of atrazine and metolachlor in the presence of buffer strips. Rainfall events after herbicide application were different between the 2 yr and greatly affected the flow distribution (e.g., subsurface infiltration) and the leached herbicide concentrations. No significant difference in the capacity to reduce herbicide exports was observed between grass and grass+tree buffer strip treatments; the poorly developed young poplar biomass at the time of the study may partly explain this observation.
127	Lalonde et al., 1996	Effects of controlled drainage on nitrate concentrations in subsurface drain discharge	Va. Tech/Yagow	Many	Canada	corn, soybean	controlled water table	Y	N	Y	2-year	experiment/control	Y	Y	Good. Yearly means presented	A water table management field study was conducted on a Bainesville silt loam soil during 1992 and 1993. The water table levels studied were conventional free outlet subsurface drainage (FD), and controlled water tables (CWT) of 0.50 and 0.25 m above the drain level. The three treatments were replicated thrice resulting in nine plots, each measuring 115 m long by 18.69 m wide. A subsurface drain was installed 1.0 m deep in the centre of each plot. Drain discharge, nitrate concentrations in drainage effluent, rainfall and water table elevations were measured during the two growing seasons. The plots were cropped with grain corn (Zea mays L.) in 1992, and soybean (Glycine max (L.) Mill.) in 1993. Controlled drainage had a significant effect on drain discharge quantity and quality. In 1992, the 0.25 and 0.50 m CWT treatments reduced drain flow by 58.7% and 65.3% respectively; and in 1993, by 40.9% and 95%, respectively, compared with the FD treatment. In 1992, there was a 75.9% and 68.9% reduction of nitrate concentration in drain flow with the 0.25 and 0.50 m CWT, respectively, compared with FD. In 1993, the reductions were 62.3% and 95.7% for the 0.25 and 0.5 m CWT, respectively. While it was impossible to maintain the water tables consistently at 0.5 and 0.25 m throughout the growing season, these results show that there are significant environmental benefits with controlled drainage.

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33	Lam, Q., 2011	The impact of agricultural Best Management Practices on water quality in a North German lowland catchment			Germany		conservation tillage, crop rotations, cover crops	Y	Y	Y	2-year	before/after	N	Y	Includes cost estimates for BMPs with effectiveness evaluation	Research on water quality degradation caused by point and diffuse source pollution plays an important role in protecting the environment sustainably. Implementation of Best Management Practices (BMPs) is a conventional approach for controlling and mitigating pollution from diffuse sources. The objectives of this study were to as- sess the long-term impact of point and diffuse source pollution on sediment and nutrient load in a lowland catchment using the ecohydrological model Soil and Water Assessment Tool (SWAT) and to evaluate the cost and effectiveness of BMPs for water quality improvement in the entire catchment. The study area, Kielstau catchment, is located in the North German lowlands. The water quality is not only influenced by the pre- dominating agricultural land use in the catchment as cropland and pasture, but also by six munici- pal wastewater treatment plants. Diffuse entries as well as punctual entries from the wastewater treatment plants are implemented in the model set-up. Results from model simulations indicated that the SWAT model performed satisfactorily in simulating flow, sediment, and nutrient load in a daily time step. Two approaches to struc- tural and nonstructural BMPs have been recom- mended in relation to cost and effectiveness of BMPs in this study. These BMPs include exten- sive land use management, grazing management practice, field buffer strip, and nutrient manage- ment plan. The results showed that BMPs would reduce fairly the average annual load for nitrate and total N by 8.6% to 20.5%. However, the implementation of BMPs does not have much impact on reduction in the average annual load of sediment and total P at the main catch- ment outlet. The results obtained by implement- ing those BMPs ranged from 0.8% to 4.9% and from 1.1% to 5.3% for sediment and total phos- phorus load reduction, respectively. This study also reveals that reduction only in one type of BMP did not achieve the target value for water quality according to the European Water Frame- work Directive. The combination of BMPs im- proved considerably water quality in the Kielstau catchment, achieving a 53.9% and a 46.7% load reduction in nitrate and total N load, re- spectively, with annual implementation cost of 93,000 Euro.
128	Langdale et al., 1985	Conservation practice effects on P losses from Southern Piedmont watersheds	Va. Tech/Yagow	USDA-ARS	GA	corn, barley, soybean, wheat, clover, sorghum	tillage techniques	Y	N	Y	4-year	experiment/control	Y	Y	Good. Yearly means presented	Conservation and conventional tillage systems were used on small, upland watersheds in the Southern Piedmont to determine P contributions to nonpoint-source water pollution. Six tillage/cropping systems were studied on three watersheds over a 10-year period. Each tillage/cropping system was repeated every 2 to 4 years over a range of conservation practices and related to both C and P factors of the USLE. Total P runoff losses varied from 0.1 to 4.0 kg/hayr−1 and consistently related to soil loss within each tillage system, irrespective of watershed landscape and the conservation practice imposed, The soluble-P fraction, PO4-P, and total dissolved P increased dramatically from about 10% to 40% of total P as multiple croppping and the use of conservation tillage intensafied with respect to crop residue cover. Although higher concentrations of both soluble P and total P were usually associated with conservation tillage, total P losses declined 50% or more while soluble P losses were nearly equal to or less than those measured for conventional tillage. These reductions in total P were the result of lower runoff volume with conservation tillage.
129	Langland et al., 1995	Hydrology and the effects of selected agricultural best-management practices in the Bald Eagle Creek Watershed, York County, Pennsylvania, prior to and during nutrient management : Water-Quality Study for the Chesapeake Bay Program	Va. Tech/Yagow		PA	Corn	Fertilizer and nutrient management	Y	Y	N	5-year	before/after	Y	Y	Thesis	The USGS, in cooperation with the Susquehanna River Basin Commission and the Pennsylvania Department of Environmental Resources, conducted a study as part of the EPA's Chesapeake Bay Program to determine the effects of nutrient management of surface-water quality by reducing animal units in a 0.43-square-mile agricultural watershed in York County. The study was conducted primarily from October 1985 through September 1990 prior to and during the implementation of nutrient-management practices designed to reduce nutrient and sediment discharges. Intermittent sampling continued until August 1991. The Bald Eagle Creek Basin is underlain by schist and quartzite. About 87% of the watershed is cropland and pasture. Nearly 33% of the cropland was planted in corn prior to nutrient management, whereas 22% of the cropland was planted in corn during the nutrient-management phase. The animal population was reduced by 49% during nutrient management. Average annual applications of N and P from manure to cropland were reduced by 3,940 lbs (39%) and 910 lbs (46%), respectively, during nutrient management. A total of 94,560 lbs of N (538 lbs per acre) and 26,400 lbs of P (150 lbs per acre) were applied to the cropland as commercial fertilizer and manure during the 5-year study. Core samples from the top 4 feet of soil were collected prior to and during nutrient management and analyzed from concentrations of N and P. The average amount of nitrate N in the soil ranged from 36 to 135 lbs per acre, and soluble P ranged from 0.39 to 2.5 lbs per acre, prior to nutrient management. During nutrient management, nitrate N in the soil ranged from 21 to 291 lbs per acre and soluble P ranged from 0.73 to 1.7 lbs per acre. Precipitation was about 18% below normal and streamflow was about 35% below normal prior to nutrient management, whereas precipitation was 4% above normal and streamflow was 3% below normal during the first 2 years of nutrient management. Eighty-four% of the 20.44 inches of streamflow was base flow prior to nutrient management and 54% of the 31.14 inches of streamflow was base flow during the first 2 years of the nutrient-management phase. About 31% of the measured precipitation during the first 4 years of the study was discharged as surface water; the remaining 69% was removed as evapotranspiration or remained in ground-water storage. Median concentrations of total N and dissolved nitrate plus nitrite in base flow increased from 4.9 and 4.1 mg/L as N, respectively, prior to nutrient management to 5.8 and 5.0 mg/L, respectively, during nutrient management. Median concentrations of ammonia N and organic N did not change significantly in base flow. Median concentrations of total and dissolved P in base flow did not change significantly and were 0.05 and 0.03 mg/L as P, respectively, prior to the management phase, and 0.05 and 0.04 mg/L, respectively, during the management phase. Concentrations and loads of dissolved nitrite plus nitrate in base flow increased following wet periods after crops were harvested and manure was applied. During the growing season, concentrations and loads decreased as nutrient utilization and evapotranspiration by corn increased. About 4,550 lbs of suspended sediment, 5,300 lbs of N, and 70.4 lbs of phosphorous discharged in base flow in the 2 years prior to nutrient management. During the first 2 years of nutrient management about 2,860 lbs of suspended sediment, 5,700 lbs of N, and 46.6 lbs of P discharged in base flow.
3	Lant, C.L., 1995	The 1990 Farm Bill and Water Quality in Corn Belt Watersheds: Conserving Remaining Wetlands and Restoring Farmed Wetlands	WATERSHEDSS		n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	N	Full text not available	Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
87	Lee et al., 2003	Sediment and nutrient removal in an established multi-species riparian buffer	AGRICOLA	USDA, EPA, and others	IA	corn, soybean	vegetative buffer	Y	N	Y	19/6	control/experiment	Y	Y	Means presented for 19 events. 6 events presented individually.	Riparian buffers are widely recommended as a tool for removing nonpoint source pollutants from agricultural areas especially those carried by surface runoff. A field plot study was conducted to determine the effectiveness of an established multi-species buffer in trapping sediment, N, and P from cropland runoff during natural rainfall events. Triplicate plots were installed in a previously established buffer with a 4.1 by 22.1 m (14 × 73 ft.) cropland source area paired with either no buffer, a 7.1 m (23 ft) switchgrass (Panicum virgatum L. cv. Cave-n-Rock) buffer, or a 16.3 m (53.5 ft) switchgrass/woody buffer (7.1 m swithgrass/9.2 m woody) located at the lower end of each plot. The switchgrass buffer removed 95% of the sediment, 80% of the total-N (N), 62% of the nitrate-N (NO3-N), 78% of the total-P (P), and 58% of the phosphate-P (PO4-P). The switchgrass/woody buffer removed 97% of the sediment, 94% of the total-N, 85% of the NO3-N, 91% of the total-P, and 80% of the PO4-P in the runoff. There was a significant negative correlation between the trapping effectiveness of the buffers and the intensity and total rainfall of individual storms. While the 7 m (23 ft) switchgrass buffer was effective in removing sediment and sediment-bound nutrients, the added width of the 16.3 m (53.5 ft) switchgrass/woody buffer increased the removal efficiency of soluble nutrients by over 20%. Similar or even greater reductions might have been found if the 16.3 m (53.5 ft) buffer had been planted completely to native warm-season grasses. In this buffer, combinations of the dense, stiff, native warm-season grass and woody vegetation improved the removal effectiveness for the nonpoint source pollutants from agricultural areas.
34	Lee, M., 2010	Evaluation of non-point source pollution reduction by applying Best Management Practices using a SWAR model and QuickBird high resolution satellite imagery		Sustainable Water Resource Research Center	South Korea	corn, rice, bean, potato	filter strip, fertilizer application, riparian buffer	Y	N	Y	2-year	before/after	N	Y	Storm specific data for individual BMPs. Crops may not be isolated	This study evaluated the reduction effect of non-point source pollution by applying best management practices (BMPs) to a 1.21 km2 small agricultural watershed using a SWAT (Soil and Water Assessment Tool) model. Two meter QuickBird land use data were prepared for the watershed. The SWAT was calibrated and validated using daily streamflow and monthly water quality (total P (TP), total N (TN), and suspended solids (SS)) records from 1999 to 2000 and from 2001 to 2002. The average Nash and Sutcliffe model efficiency was 0.63 for the streamflow and the coefficients of determination were 0.88, 0.72, and 0.68 for SS, TN, and TP, respectively. Four BMP scenarios viz. the application of vegetation filter strip and riparian buffer system, the regulation of Universal Soil Loss Equation P factor, and the fertilizing control amount for crops were applied and analyzed.
130	Lembi et al., 1985	Evaluation of Nitrogen Application Technique and Tillage System on Nitrogen Runoff from an Erodible Soil	Va. Tech/Yagow		IN	Corn	Tillage, nutrient management	Y	N	Y	3 events	experiment/control	Y	Y	Thesis	Runoff studies were initiated in May 1985 on a highly erodible soil with slopes ranging from 4.6% to 13.8%. 100 sq ft plots were divided into two tillage treatments: (1) no till and (2) conventional plow system. Within each tillage treatment, three N application techniques were used: (1) surface application of ammonium nitrate pellets (33.5% N), (2) injected anhydrous ammonia, and (3) injected anhydrous ammonia stabilized with the nitrification inhibitor nitrapyrin. A fourth set of plots was let unfertilized. All application rates were at 200 lbs N per acre. Runoff of water and sediment was greater from the conventional till plots than no till plots at all three dates. Results of this and a 1984 study on these same plots suggest, however, that water runoff from no till areas can be as high or higher than from conventional areas when the soil is dry. In both years, the significant contribution of no till was the reduction of soil loss. Tillage system did not have a significant effect on the majority of N parameters measured, although the amount of N moving off the plots was generally greater from the conventional till areas than from no till areas. Nitrogen application technique had a much stronger influence on the movement of NO3-N and NH3-N than on the organic or soil-bound N. Inorganic N movement was significantly greater from surface applications. Movement of inorganic N from injected and injected stabilized plots was minimal and not significantly different from that moving off untreated control areas. (USGS)

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35	Lemke, A., 2010	Evaluating Agricultural Best Management Practices in Tile-Drained Subwatersheds of the Mackinaw River, Illinois		USDA	IL	corn, soybean	tillage practices, buffer strips	Y	Y	Y	7-year	control/experiment	N	Y	Relevant study with large amount of data	Best management practices (BMPs) are widely promoted in agricultural watersheds as a means of improving water quality and ameliorating altered hydrology. We used a paired watershed approach to evaluate whether focused outreach could increase BMP implementation rates and whether BMPs could induce watershed-scale (4000 ha) changes in nutrients, suspended sediment concentrations, or hydrology in an agricultural watershed in central Illinois. Land use was >90% row crop agriculture with extensive subsurface tile drainage. Outreach successfully increased BMP implementation rates for grassed waterways, stream buffers, and strip-tillage within the treatment watershed, which are designed to reduce surface runoff and soil erosion. No significant changes in nitrate-N (NO3 -N), total P (TP), dissolved reactive P, total suspended sediment (TSS), or hydrology were observed after implementation of these BMPs over 7 yr of monitoring. Annual NO3 -N export (39-299 Mg) in the two watersheds was equally exported during baseflow and stormflow. Mean annual TP export was similar between the watersheds (3.8 Mg) and was greater for TSS in the treatment (1626 ± 497 Mg) than in the reference (940 ± 327 Mg) watershed. Export of TP and TSS was primarily due to stormflow (>85%). Results suggest that the BMPs established during this study were not adequate to override nutrient export from subsurface drainage tiles. Conservation planning in tile-drained agricultural watersheds will require a combination of surface-water BMPs and conservation practices that intercept and retain subsurface agricultural runoff. Our study emphasizes the need to measure conservation outcomes and not just implementation rates of conservation practices.
36	Lenat, D., 1984	Agriculture and Stream Water Quality: a Biological Evaluation of Erosion Control Practices		NC Dept. of Nat. Res.	NC		tillage practices, buffer strips	Y	N	N	3	control/experiment	N	N	Studies biologic criteria only	Agricultural runoff affects many streams in North Carolina. However, there is is little information about either its effect on stream biota or any potential mitigation by erosion control practices. In this study, benthic macroinvertebrates were sampled in three different geographic areas of North Carolina, comparing control watersheds with well-managed and poorly managed watersheds. Agricultural streams were characterized by lower taxa richness (especially for intolerant groups) and low stability. These effects were most evident at the poorly managed sites. Sedimentation was the apparent major problem, but some changes at agricultural sites implied water quality problems. The groups most intolerant of agricultural runoff were Ephemeroptera, Plecoptera and Trichoptera. Tolerant species were usually filter-feeders or algal grazers, suggesting a modification of the food web by addition of particulate organic matter and nutrients. This study clearly indicates that agricultural runoff can severely impact stream biota. However, this impact can be greatly mitigated by currently recommended erosion control practices.
131	Lentz et al., 1998	Reducing Phosphorus Losses from Surface-Irrigated Fields: Emerging Polyacrylamide Technology	Va. Tech/Yagow	USDA-ARS	ID	dry bean	PAM	Y	N	Y	?	experiment/control	Y	N	irrigation study	Most P (P) losses from surface-irrigated fields can be minimized by eliminating irrigation-induced erosion. Furrow irrigation produces more erosion than other surface irrigation systems. Farmers hesitate to employ known effective practices because they are inconvenient, invasive, or uneconomical. A convenient new practice uses a high molecular weight, anionic polyacrylamide (PAM) applied to irrigation inflows. We hypothesized that, compared to control furrows, PAM treatment would reduce field losses of ortho P, total P, nitrate, and lower tailwater chemical oxygen demand (COD). Two PAM treatments were tested: I10 applied 10 mg/L PAM only during the furrow advance phase (until runoff began) , and C1 applied 1 mg/L PAM throughout the irrigation. Soil was Portneuf silt loam (Durixerollic Calciorthid) with 1.6% slope. Initial 23 L/min inflows were cut back to 15 after 1.5-6 h. Total soil loss over four irrigations was 3.06 Mg/ha for control furrows vs 0.33 (C1) and 0.24 (I10) for PAM-treated furrows. Relative to controls, the best performing PAM-I10 treatment reduced total furrow losses of sediment by 92%, total-P by 91%, ortho-P by 86%, and lowered COD by 83%, but had little influence on runoff nitrate. PAM-I10 lowered furrow stream nutrient concentrations more than did PAM-C1, but owing to disparities in runoff, the two treatments produced similar total sediment and nutrient losses. PAM is effective, convenient, and economical, and greatly reduces P and organic losses from surface irrigated fields.
8	Lin, Z., 2003	Selenium Removal by Constructed Wetlands: Quantitative Importance of Biological Volatilization in the Treatment of Selenium-Laden Agricultural Drainage Water	MPMINER		CA	unclear from abstract	wetland treatment	Y	N	N	2-year	inflow/outflow	N	Y	Good, monthly means presented	Management of selenium (Se) -contaminated agricultural drainage water is one of the most important environmental issues in California. To evaluate the feasibility of utilizing constructed wetlands to remediate Se-laden drainage water and the role of biological volatilization in Se removal, 10 flow-through wetland cells were constructed in 1996 in Corcoran, California. The monthly monitoring study from May 1997 to December 1999 showed that the vegetated wetlands were capable of significantly reducing Se from the inflow drainage water; an average of 69.2% of the total Se mass in the inflow was removed. Most of the Se was retained in sediment, and <5% of the Se was accumulated in plant tissues. Selenium volatilization was highest in the rabbitfoot grass wetland cell, where 9.4% of the Se input was volatilized over a 2-year period. Volatilization was greater in spring and summer than in fall and winter. For example, in May and June of 1998, 35 and 48%, respectively, of the Se entering the rabbitfoot grass cell was volatilized, whereas in the winter months, <5% was volatilized. The feasibility of using constructed wetlands for Se remediation, methods for the enhancement of Se volatilization, and the importance of considering potential Se ecotoxicity are discussed.
150	Lindstrom, 1986	Effects of residue harvesting on water runoff, soil erosion and nutrient loss		USDA-ARS	MN	corn	tillage	Y	N	N	4-year	experiment/control	N	Y	Good, few data points	The effect of corn (rZea mays L.) stover harvest on water funoff, soil erosion and nutrient transport under a reduced tillaage and no-till plant system was investigated in the northwestern Corn Belt (U.S.A.). Increased levels of corn stover harvest resulted in increased water runoff and soil erosion. Nutrient removal from the cropping system generally exceeded standard fertilization practices when either high levels of corn stover were harvested or soilerosion levels approached the soil loss tolerance levekl of 11.2 tons/ha year−1.
70	Line, D., 2002	Changes in Land Use/Management and Water Quality in the Long Creek Watershed			NC	Cotton, corn, soybeans, sorghum	Waste management, nutrient management, various others	Y	Y	N	8-year	before/after	Y	Y	Good, yearly means presented	Surface water in the Long Creek watershed, located in western Piedmont region of North Carolina, was monitored from 1993 to 2001. The 8,190 ha watershed has undergone considerable land use and management changes during this period. Land use surveys have documented a 60% decrease in cropland area and a more than 200% increase in areas being developed into new homes. In addition, more than 200 conservation practices have been applied to the cropland and other agricultural land that remains in production. The water quality of Long Creek was monitored by collecting grab samples at four sites along Long Creek and continuously monitoring discharge at one site. The monitoring has documented a 70% reduction in median total P (TP) concentrations, with little reductions in nitrate and total Kjel-dahl N, or suspended sediment levels. Fecal coliform (FC) and streptococci (FS) levels declined significantly downstream as compared to upstream during the last four years of monitoring. This decrease was attributed to the implementation of waste management practices and livestock exclusion fencing on three dairy operations in the watershed. Annual rainfall and discharge increased steadily until peaking in the third year of the monitoring period and varied while generally decreasing during the last four years of the project. An array of observation, pollutant concentration, and hydrologic data provide considerable evidence to suggest that the implementation of BMPs in the watershed have significantly reduced P and bacteria levels in Long Creek.
37	Logan, T., 1993	Agricultural best management practices for water pollution control: current issues			Not listed	n/a, literature review	n/a, literature review	N	N	N	n/a, literature review	n/a, literature review	N	N	Literature Review without useable data	Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
90	Logsdon et al., 2007	Groundwater nitrate following installation of a vegetated riparian buffer	AGRICOLA	Leopold Center, USDA-ARS	IA	corn, soybean	vegetative buffer	Y	N	Y	5-year	experiment/control	N	Y	Data presented graphically. Groundwater.	Buffers are often planted along streams to reduce nutrient loss from fields. The purpose of this study was to determine if a vegetated buffer could significantly decrease groundwater nitrate-N (NO3) concentrations. During 2000 and 2001, a three-part buffer was planted adjacent to a first-order stream in the deep loess region of western Iowa. Poplar and walnut trees occupied the stream-edge strip next to a strip of alfalfa and brome grass with a strip of switch grass adjacent to the crop edge. Non-parametric statistics showed significant declines in NO3 concentrations in shallow groundwater following buffer establishment, especially mid-2003 and later. The dissolved oxygen (DO) generally was >5 ppm beneath the buffer suggesting that loss of NO3 is a result of plant uptake, rather than denitrification. Results of such short-term changes in groundwater NO3 provide evidence that vegetated riparian buffers may yield water-quality benefits in less time than has previously been hypothesized.
86	Lowrance et al., 2000	Effects of a Managed Three Zone Riparian Buffer System on Shallow Groundwater Quality in the Southeastern Coastal Plain	AGRICOLA	USDA-ARS	GA	corn, peanut, millet	3-zone riparian buffer	Y	N	N	5-year	inflow/outflow	N	Y	Means presented. Not events. Groundwater	Riparian forest buffers can help improve agricultural water quality. USDA guidelines are for riparian forest buffers of three zones. Zone I is permanent woody vegetation near the stream. Trees can be harvested in Zone 2, which is upslope from Zone 1. Zone 3 is a grass filter upslope from Zone 2 at field edge. In order to test USDA guidelines, a site was established in the southeastern Coastal Plain near Tifton, Georgia, with an 8 m wide grass buffer (Zone 3) situated between a field and a mature Riparian forest. In the Zone 2 forest, mostly 50 year-old pine trees, one block was harvested by clearcut, one block was thinned, and one block was left as a mature forest control. Care was taken to minimize soil disturbance during the timber harvest operation. The Zone I forest [15 m wide (49 ft)] was Left undisturbed Shallow groundwater wells were used to monitor the effects of the managed Riparian forest buffer on N, P, and Cl concentrations. Groundwater nitrate concentrations decreased from 11 to 22 mg/L adjacent to the field to less that 2 mg/L at 5 m (16 ft) into the forest. Nitrate concentration de- creased under the grass filter strip as well as in the forest. Nitrate concentrations increased in one corner of the Riparian forest near the stream. This increase may be due to flow patterns of groundwater that bypasses the Riparian forest buffer. Chloride concentrations increased under the buffer indicating that the nitrate removal was due to biological processes such as plant uptake and denitrification rather than dilution. Concentrations of other potential pollutants such as ortho-p, ammonium, and organic N moved in very small quantities and did not show consistent spatial patterns. There was no effect due to harvesting of the Zone 2 forest on either nutrient concentrations or water table elevations. These results indicate that Zone 2 trees, along small streams in the southeastern coastal plain, can be harvested with little effect on groundwater nutrient movement to streams.

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85	Lowrance et al., 2005	Surface Runoff Water Quality in a Managed Three Zone Riparian Buffer	AGRICOLA	USDA-ARS	GA	corn, peanut, millet	3-zone riparian buffer	Y	N	N	5-year	inflow/outflow	N	Y	Means presented. Not events	Both grass buffers and forest buffers are increasingly used as conservation practices to control nonpoint source pollution from agriculture. We measured surface runoff volumes and nutrient concentrations and loads in a three zone riparian buffer systems consisting of a grass strip (zone 3) followed by a managed forest (zone 2) and an unmanaged forest (zone 1). The managed forest consisted of a clear-cut section, a thinned section and a mature section. The grass filter was between the field and all of the forest buffers. There were significant differences in the nutrient concentrations and loading entering the buffer and this affected the apparent differences among forest treatments. There were not consistent differences in nutrient concentrations among the Zone 2 forest treatments, although the clear-cut buffer was highest (significant difference) for nitrate, total Kjeldahl N (TKN) and total N at the position nearest the stream. Although the increased concentrations in the clear-cut Zone 2 were about 20%, they only accounted for a small absolute increase, about 1 mg/L. There were no differences for sediment TKN or P species among Zone 2 treatments. The average buffer (all treatments pooled) represented the conditions along a stream reach in different stages of growth. The runoff volumes at positions in the buffer had a large impact on the loads. All loads decreased significantly within the buffer but not all concentrations decreased. Concentrations of nitrate, TKN, and total N did not change significantly within the buffer. Ammonium and P species (dissolved molybdate reactive P, total P, sediment total P) decreased significantly and chloride increased significantly. The largest% reduction of the incoming nutrient load (65 to 80%) took place in the grass buffer zone because of the large decrease (68%) in flow and smaller changes in concentrations. The entire buffer system reduced loadings for all nutrient species from 27% for TKN to 63 % for sediment P. The managed forest and grass buffer combined was an effective buffer system. Although there was elevation of most N species in the clear cut, there were not large differences among the managed forest treatments. It appears that cutting of the Zone 2 forest is possible without effects on water quality.
94	McDowell et al., 1984	Plant nutrient losses in runoff from conservation tillage corn			MS	corn	conventional, reduced, and no till	Y	N	Y	3-year	experiment/control	N	Y	Good. Yearly means presented	Conservation tillage in north Mississippi, U.S.A., reduced total (sum of solution and sediment) plant nutrient losses in runoff from corn, even though solution N (N) and P (P) concentrations in runoff were greater than from conventional-till and sediments were enriched several fold in N and P. Plant nutrient losses were reduced by conservation tillage because of the significant reductions in soil loss. Soil losses from corn grown for grain were reduced more than 92% by reduced and no-till practices. Corresponding total losses of N and P were reduced about 70 and 80%, respectively. Conservation tillage reduced plant nutrient losses associated with sediments but increased solution P concentrations and losses in runoff. Solution P concentrations and losses, which were related to crop management, decreased in the following order: no-till corn (grain) >or= no-till corn (silage) > reduced-till corn (grain) > conventional-till corn (grain) > conventional-till corn (silage). Solution P concentrations and losses in runoff increased with an increase in crop residues left on the soil surface after harvest and with a decrease in annual soil loss.
169	Mielke, 1985	Performance of water and sediment control basins in northeastern Nebraska	Va. Tech/Yagow	USDA-ARS	NE	corn, oats	sediment basins	Y	N	N	5-year	experiment/control	Y	Y	Good, some event-based data reported	Water and sediment control basins formed with discontinuous, parallel terraces using riser inlets and underground pipe outlets were evaluated for soil erosion and sediment control on a loess-derived association of Ustorthents and Haplustolls in northeastern Nebraska. The structures, parallel to existing field boundaries, provided straight rows as well as erosion protection on severely dissected landscapes that were too undulating to farm using conventional terrace systems. With clean-cultivated corn, sediment trapping efficiency exceeded 97%, and the basins retained sediment near its point of origin. The small quantity of sediment discharged from the outlet contained 12% silt and 88% clay after about 2 hours of runoff. Based on sediment trapped in the basins, an 86-mm storm transported about 40 t/ha of sediment into the basins. A smaller storm (50 mm) deposited about 17 t/ha. Sediment discharged during the initial runoff from a storm was high in silt and low in clay particles.
38	Moore, L., 1998	Agricultural runoff modeling in a small west Tennessee watershed			TN	corn	none	Y	Y	N	11	modeling/predictive	Y	N	No BMPs evaluated	The application of hydrological Simulation Program in FORTRAN (HSPF) to agriculture runoff data was examined. An 18 hectare watershed planted in corn was secured along its perimeter and all runoff from the conventionally tilled field was directed to a single discharge structure equipped with an H-flume, continuous flow recorder, and automatic sampling equipment. Data on runoff, suspended solids, nitrogen forms, and atrazine over a 19-month period were used to develop a preliminary calibration of the model. Simulation of runoff and sediment was generally good, while simulation of atrazine and soluble nitrogen forms was fair.
75	Moorman et al., 2010	Denitrification activity, wood loss, and N2O emissions over 9 years from a woodchip bioreactor		CSREES	IA	corn, soybean	denitrification wall	Y	N	Y	5-year	control/experiment	Y	Y	good	Loss of nitrate in subsurface drainage water from agricultural fields is an important problem in the Midwestern United States and elsewhere. One possible strategy for reducing nitrate export is the use of denitrification bioreactors. A variety of experimental bioreactor designs have been shown to reduce nitrate losses in drainage water for periods up to several years. This research reports on the denitrification activity of a wood chip-based bioreactor operating in the field for over 9 years. Potential denitrification activity was sustained over the 9-year period, which was consistent with nitrate removal from drainage water in the field. Denitrification potentials ranged from 8.2 to 34mgNkg−1 wood during the last 5 years of bioreactor operation. Populations of denitrifying bacteria were greater in the wood chips than in adjacent subsoil. Loss of wood through decomposition reached 75% at the 90-100cm depth with a wood half-life of 4.6 years. However, wood loss was less than 20% at 155-170cm depth and the half-life of this wood was 36.6 years. The differential wood loss at these two depths appears to result from sustained anaerobic conditions below the tile drainage line at 120cm depth. Pore space concentrations of oxygen and methane support this conjecture. Nitrous oxide exported in tile water from the wood chip bioreactor plots was not significantly higher than N2O exports in tile water from the untreated control plots, and loss of N2O from tile water exiting the bioreactor accounted for 0.0062 kgN2O-N kg−1 NO3-N.
67	Morgan, K., 2006	In-Season Irrigation and Nutrient Decision Support System for Citrus Production			FL	citrus	fertilizer management							N	Study looks at groundwater contamination--IDs little horizontal movement in sandy soils	The sandy soils of central and southern Florida have low water and nutrient retention capacities. Excessive irrigation may greatly increase nutrients leaching thereby contribute to contamination of the aquifer under-lying citrus production system. These systems can be managed in such a manner that the excessive downward drainage through the soil is minimized via use of improved irrigation management and/or scheduling strategies which are also critical to maximize water use efficiency. To aid growers in water management decision making, a computer-based decision support system was developed to facilitate more efficient use of water by making use of specific site characteristics and local weather data. System requirements include information on tree age, spacing, soil water holding characteristics, and monthly irrigation set-points for specific production blocks. The user inputs irrigation duration, and/or rainfall depths by block on a daily basis. The soil profile is divided into 40 five cm layers and both irrigated and non-irrigated zones are identified. Horizontal water movement is assumed to be confined within each vertical zone due to lack of lateral movement in the sandy Entisols that prevail in the citrus production region of central Florida. To estimate crop evapotranspiration (ET), daily reference ET values from the Florida Automated Weather Network station nearest the production area are downloaded automatically. Monthly and yearly water use reports are also provided by the decision support system. Appropriate use of this system should not only reduce statewide agricultural water requirements but also N-loading of groundwater resources associated with citrus production thereby enhancing the profitability and sustainability of Florida citrus production systems.
72	Mostaghimi, S., 1988	Phosphorus Losses From Cropland As Affected by Tillage System and Fertilizer Application Method			VA	Rye	tillage, fertilizer management	Y	N	N	3 simulated rainfall events	experiment/control	Y	N	Simulated rainfall study	A rainfall simulator was used to study the effectiveness of no-till and fertilizer application method on reducing P (P) losses from agricultural lands. Simulated rainfall was applied to 12 experimental field plots, each 0.01 ha in size. The plots were divided into no-till and conventional tillage systems. Two fertilizer application methods, subsurface injection and surface application, were investigated for the two tillage systems. Phosphorus fertilizer was applied at a rate of 46 kg/ha, 24 to 48 hours before the start of rain simulation. Water samples were collected from the base of each plot and analyzed for sediment and P content. No-till was found to be very effective in reducing runoff and sediment losses. No-till reduced sediment loss and total runoff volume by 92 and 67%, respectively. Subsurface injection of fertilizer, as compared to surface application, reduced PO4 losses by 39% for no-till and by 35% for conventional tillage. The effect of tillage system on PO4 losses was not significant. Reductions in total-P (PT) losses due to no-till compared to the conventional tillage system were 89 and 91% for surface application and subsurface injection methods, respectively. Averaged across all fertilizer treatments, an equivalent of 0.9 and 8.9% of the P applied to the plots were lost from the no-till and conventional tillage plots, respectively.
39	Mostaghimi, S., 1997	Assessment of Management Alternatives on a Small Agricultural Watershed		VA Dept. of Cons. And Rec	VA	corn	Various	N	N	N	n/a, model study	modeling/predictive	Y	N	BMP data is only modeled--no measured response	The AGNPS model was used to assess the impact of management practices on the water quantity and quality from Owl Run, a 1153-ha watershed in the Piedmont Region of Virginia. Prior to this assessment, the model was calibrated using 2 years of hydrologic and water-quality data from the same watershed. It was concluded that the model is applicable to nonpoint source (NPS) impact assessment for watersheds similar to Owl Run. Better agreement was found between simulated and observed runoff volumes than between simulated and observed peak rates, sediment or nutrient yields. An annualization procedure, based on frequency analyses of storms and rainfall erosivity factors, and the joint probabilities of occurrence at different crop stages, were used to estimate annual average NPS loadings. The results were found to be close to average observed values for the watershed. The model was also used to simulate the effects of the application of seven different best management practice (BMP) scenarios on the watershed. The reduction rates in simulated pollutant loadings and the costs for BMP implementation were used to identify appropriate BMPs for the watershed.
59	Mulla, D., 2006	Evaluating the Effectiveness of Agricultural Management Practices at Reducing Nutrient Losses to Surface Waters			n/a, lit review	n/a, lit review	n/a, lit review	n/a, lit review	n/a, lit review	n/a, lit review	n/a, lit review	n/a, lit review	n/a, lit review	N	Review paper without new data-use as source for studies	Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.

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95	Munodawafa, 2007	Assessing nutrient losses with soil erosion under different tillage systems and their implications on water quality			Zimbabwe	corn	conventional, mulch ripping, tied ridging, bare fallow	Y	N	Y	3-year	experiment/control	N	Y	Yearly means	An increased public perception of the role of agriculture in non-point source pollution has stimulated the need for information on the effect of conventional and sustainable agricultural management systems onwaterquality. While information on run-off and soil erosion is readily available in Zimbabwe, there is dearth of knowledge on the relative losses of nutrients as a result of soil erosion and their effect on water quality. This study sought to quantify the amount of nutrients lost as a result of soil erosion and thus enable conclusions to be drawn on the implications on water quality. Research work was carried out in the semi-arid region of Zimbabwe under granite-derived, inherently infertile sandy soils. Soil erosion was quantified under three tillage systems conventional tillage (CT); mulch ripping (MR); tied ridging (TR) over three years. Run-off and sediments were analyzed for N, P and K. The results showed that N and K losses were significantly higher (p < 0.001) under CT (15.8 and 34.5 kg/ha yr−1, respectively) compared to the MR (2.3 and 0.6 kg/ha yr−1, respectively) and TR (2.7 and 4.3 kg/ha yr−1, respectively). Due to the immobility of P and its small quantities in these soils, P losses were also low across all treatments (<1 kg/ha yr−1), however CT had significantly higher losses (p < 0.001). The study showed that CT results in high losses of nutrients, which would in turn reduce the quality of surface waters, due to high nutrient concentrations of especially, N, which stimulates the growth of algae and other aquatic weeds. The gravity of the situation would be higher, where soils are more fertile. MR and TR were efficient in reducing soil erosion and thusnutrientlosses with run-off and sediments. Pollution of surface water sources can be greatly reduced if conservation tillage systems are used.
66	Munoz-Carpena, R., 2002	A Normalized Design Procedure to Meet Sediment TMDL with Vegetative Filter Strips			NC	None	filter strip	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	N	Simulation study--no crops involved?	This paper presents a vegetative filter strip (VFS) design procedure to meet sediment TMDL using the graphical modeling system VFSMOD-W. The core program, the vegetative filter strip model VFSMOD, simulates overland flow and sediment dynamics within the VFS based on vegetation, soil type, and topography. The inputs to run the model (rainfall hyetograph, and source area€™s runoff hydrograph and sediment load) are automatically generated by the system based on a user given design storm (in terms of return period) and application area characteristics (crop system and soil type). These inputs are generated using a combination of the NRCS curve number method, the unit hydrograph, and the modified Universal Soil Loss Equation based on topography, land use and soil type. With this tool, a design example for representative conditions in the Piedmont region of North Carolina is presented (clay and sandy-clay top soils). Simulations were conducted representing a ratio of source area to filter length from 3:1 to 258:1. Rainfall totals for return periods T=1,2,5 and 10 yrs (54-103 mm), were used to generate 6-hour storm hyetographs and runoff hydrographs from source areas with a mean slope of 2%. The optimal filter design can be obtained when setting an objective TMDL (75% sediment reduction) over the program's graphical output. Analysis of VFS performance including graphs showing sediment delivery ratios is presented to demonstrate the utility of this approach.
40	Nakao, M., 1998	Cost of Using Riparian Forest Buffer for Soil Erosional Control			OH	silviculture	buffer strips	N	N	N				N	Non-row crop study, limited water quality data	Abstract not provided since study not expected to be applicable for purposes of the WERF/NCGA effort.
4	Nelson, D., 2008	Agricultural Discharge Management Program Monitoring and Evaluation -- West Stenislaus County	MPMINER	Government	CA		vegetated ditch, retention pond, constructed wetland, polyacrylamide	Y	N	N	3-year	inflow/outflow	Y	Y	Good, overall means presented	Growers are faced with increasing regulation of tailwater discharges and need better guidance for choosing effective BMPs for their particular operations. In this study, we will integrate and coordinate the water quality monitoring within the West Stanislaus County particularly as it relates to the ongoing BMP activities, the TOC and DO TMDL management programs and pesticide monitoring. By comparing both historical and ongoing monitoring data, it is anticipated that we will be able to evaluate the impact of current BMP implementation programs in WSC and provide guidance to growers for future BMP implementation.
180	Ng et al., 2000	Controlled drainage and subirrigation influences tile nitrate loss and corn yields in a sandy loam soil in Southwestern Ontario			Canada	Corn	drainage control	Y	N	N	2-year	experiment/control	N	Y	Good, data only presented in graphs	Controlled drainage and subirrigation (CDS) are a recommended agricultural practice to improve agricultural water quality and crop productivity. An on-farm study was conducted to evaluate the influence of CDS on nitrate leaching and corn (Zea mays L.) yield in a sandy loam soil in Southwestern Ontario, Canada. A farm was divided into two 1.9 ha plots and planted with corn. One of the plots had a free tile drainage (FD) system, and the other plot was installed with a CDS system. Drainage water volumes and water quality were monitored from 1 May 1996 until 31 April 1997. The cumulative drainage water volume from the CDS treatment was 8% greater than the FD treatment over this period. The flow weighted mean nitrate concentration of the drainage water was reduced by 41% from 19.2 mg N/L for FD treatment to 11.3 mg N/L for the CDS treatment. Hence, the net effect of slightly increased drainage volumes and dramatically lower nitrate concentrations with the CDS treatment resulted in a cumulative nitrate loss of 36.8 kg N/ha compared to 57.9 kg N/ha for the FD treatment. The CDS treatment reduced total nitrate loss by 36% compared to the FD treatment. The soil moisture content (top 120 cm) in the CDS treatment was 21% greater than the FD treatment and the FD treatment had a water table depth that was 49 cm deeper (59%) than the CDS treatment. Therefore, it was not surprising that corn from the CDS treatment had 50% greater transpiration rates (47.4 mg m^2 s−1) than the FD treatment (31.7 mg m^2 s−1). Similarly, the stomatal conductance was 12% greater with the CDS treatment (0.73 cm s−1) when compared to the FD treatment (0.65 cm s−1). The average corn yields were 11.0 Mg/ha from the CDS treatment and 6.7 Mg/ha from the FD treatment which was a 64% yield increase. The CDS treatment also had higher (11%) water use efficiency than the FD treatment. Thus, the crops utilized N and water more efficiently in the CDS treatment which resulted in increased productivity and improved water quality.
108	Ng et al., 2008	Effects of contour hedgerows on water and soil conservation, crop productivity and nutrient budget for slope farmland in the Three Gorges Region of China		Hong Kong Research Grants Council	China	wheat, soybean	hedgerow	Y	N	Y	5-year/ 34 events	before/after	N	Y	Good. Yearly means presented	Soil erosion has long been recognized as a major environmental problem in the Three Gorges Region (TGR) where slope farming is commonly practiced but the local topography is hilly. In consideration of the poor socioeconomic position of local farmers, low cost hedgerows had been introduced as a soil conservation measure to the TGR in the late 1980s. A collaborative research programme was initiated by the Chinese University of Hong Kong, the Chinese Academy of Science, the Huazhong Agricultural University, and the Bureau of Soil and Water Conservation of Zigui County to study the potential of adopting hedgerows in the TGR. Six experimental plots (10 m × 2 m, gradient = 25°) were constructed at Zigui County, Hubei Province to study effects of hedgerows on erosion, nutrient loss and crop productivity. Results indicated that there were significant relationships between rainfall and runoff, and rainfall and soil loss, respectively. Conventional slope farming could not be considered a sustainable agricultural practice because it resulted in severe erosion and low crop yield. Hedgerows per se seemed not to be effective in reducing soil loss and boosting crop productivity, but performances could be greatly improved when they combined with the use of fertilizers. Current farming and fertilization practices, however, generally did not meet N demands of crops. Results and findings of this paper will contribute towards a technical reference for the promotion and adoption of hedgerows in the TGR.
41	Panagopoulos, Y., 2011	Reducing surface water pollution through the assessment of the cost-effectiveness of BMPs at different spatial scales			Greece	corn, alfalfa	fertilization, filter strip, tillage	Y	Y	N	5-year	experiment/control	Y	Y	Need to isolate measured data from modeled data	Two kinds of agricultural Best Management Practices (BMPs) were examined with respect to cost-effectiveness (CE) in reducing sediment, nitrates-N (NO3eN) and total P (TP) losses to surface waters of the Arachtos catchment in Western Greece. The establishment of filter strips at the edge of fields and a non-structural measure, namely fertilization reduction in alfalfa, combined with contour farming and zero-tillage in corn and reduction of animal numbers in pastureland, were evaluated. The Soil and Water Assessment Tool (SWAT) model was used as the non-point-source (NPS) estimator, while a simple economic component was developed estimating BMP implementation cost as the mean annual expenses needed to undertake and operate the practice for a 5-year period. After each BMP implementation, the ratio of their CE in reducing pollution was calculated for each Hydrologic Response Unit (HRU) separately, for each agricultural land use type entirely and for the whole catchment. The results at the HRU scale are presented comprehensively on a map, demonstrating the spatial differentiation of CE ratios across the catchment that enhances the identification of locations where each BMP is most advisable for implementation. Based on the analysis, a catchment management solution of affordable total cost would include the expensive measure of filter strips in corn and only in a small number of pastureland fields, in combination with the profitable measure of reducing fertilization to alfalfa fields. When examined for its impact on river loads at the outlet, the latter measure led to a 20 tn or 8% annual decrease of TP from the baseline with savings of 15V/kg of pollutant reduction. Filter strips in corn fields reduced annual sediments by 66 Ktn or 5%, NO3eN by 71 tn or 9.5% and TP by 27 tn or 10%, with an additional cost of 3.1 V/tn, 3.3 V/kg and 8.1 V/kg of each pollutant respectively. The study concludes that considerable reductions of several pollutant types at the same time can be achieved, even at low total cost, by combining targeted BMP implementation strategies only in small parts of the catchment, also enabling policy makers to take local socio-economic constraints into consideration. The methodology and the results presented aim to facilitate decision making for a cost-effective management of diffuse pollution by enabling modelers and researchers to make rapid and reliable BMP cost estimations and thus being able to calculate their CE at the local level in order to identify the most suitable areas for their implementation.
68	Park, S., 1994	BMP Impacts on Watershed Runoff, Sediment, and Nutrient Yields			VA	corn, soybeans, wheat, barley	Tillage, covercrops, revegetation, sediment retention structures	Y	Y	N	9-year	before/after	Y	Y	Need to evaluate full text	ABSTRACT: To quantify the effectiveness of best management practice (BMP) implementation on runoff, sediment, and nutrient yields from a watershed, the Nomini Creek watershed and water quality monitoring project was initiated in 1985, in Westmoreland County, Virginia. The changes in nonpoint source (NPS) loadings resulting from BMPs were evaluated by comparing selected parameters from data series obtained before, during, and after periods of BMP implementation. The results indicated that the watershed-averaged curve number, sediment, and nutrient (N and P) concentrations were reduced by approximately 5, 20, and 40%, respectively, due to BMP implementation. The nutrient yield model developed by Frere et al. (1980) was applied to the water quality parameters from 175 storms, but it failed to adequately describe the observed phenomena. Seasonal changes in nutrient availability factors were not consistent with field conditions, nor were they significantly different in the pm- and post-BMP periods. An extended period of monitoring, with intensive BMP implementation over a larger portion of the watershed, is required to identify BMP effectiveness.

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132	Patty et al., 1997	The Use of Grassed Buffer Strips to Remove Pesticides, Nitrate and Soluble Phosphorus Comlbs from Runoff Water	Va. Tech/Yagow	ITCF	France	winter wheat	grass buffer strip	Y	N	Y		experiment/control	Y	Y	Good. Yearly means presented	Experiments on grassed buffer strips have been conducted since 1993 by ITCF (Institut Technique des Céréales et des Fourrages) at three research farms (La Jaillière, Bignan and Plélo). Literature data and conclusions drawn from previous work with isoproturon and diflufenican were confirmed in a range of soil and cropping conditions: grassed buffer strips are effective in restricting pollutant transfer in runoff; those with widths of 6, 12 and 18 m reduced runoff volume by 43 to 99·9%, suspended solids by 87 to 100%, lindane losses by 72 to 100% and loss of atrazine and its metabolites by 44 to 100%. More than 99% of isoproturon and 97% of diflufenican residues in runoff were removed by buffer strips. Nitrate and soluble P in runoff were reduced by 47 to 100% and by 22 to 89%, respectively. At La Jaillière, a rainfall simulator was used in 1995 to verify that buffer strips are still effective in conditions of intense runoff. Investigation of the influence of sowing direction during the 1994-95 cropping period at Bignan showed that sowing perpendicular to the slope seemed to be beneficial in reducing pesticide content in runoff.
76	Penn et al., 2012	Trapping Phosphorus in Runoff with a Phosphorous removal structure			OK	residential/golf course	gypsum filter	Y	N	Y	54	inflow/outflow	Y	N	Not AG - candidate for urban BMP	Reduction of P (P) inputs to surface waters may decrease eutrophication. Some researchers have proposed fi ltering dissolved P in runoff with P-sorptive byproducts in structures placed in hydrologically active areas with high soil P concentrations. Th e objectives of this study were to construct and monitor a P removal structure in a suburban watershed and test the ability of empirically developed fl ow-through equations to predict structure performance. Steel slag was used as the P sorption material in the P removal structure. Water samples were collected before and after the structure using automatic samples and analyzed for total dissolved P. During the fi rst 5 mo of structure operation, 25% of all dissolved P was removed from rainfall and irrigation events. Phosphorus was removed more effi ciently during low fl ow rate irrigation events with a high retention time than during high fl ow rate rainfall events with a low retention time. Th e six largest fl ow events occurred during storm fl ow and accounted for 75% of the P entering the structure and 54% of the P removed by the structure. Flow-through equations developed for predicting structure performance produced reasonable estimates of structure "lifetime"(16.8 mo). However, the equations overpredicted cumulative P removal. Th is was likely due to diff erences in pH, total Ca and Fe, and alkalinity between the slag used in the structure and the slag used for model development. Th is suggests the need for an overall model that can predict structure performance based on individual material properties.
99	Pesant et al., 1987	Soil and nutrient losses in surface runoff from conventional and no-till corn systems			Canada	corn	conventional, no-till	Y	N	Y	37	experiment/control	Y	Y	Excellent.	A natural-rainfall erosion plot study was conducted during three consecutive growing seasons (May to September) on a tile-drained sandy loam with a 9% slope to evaluate differences in soil and nutrient losses (NO3-N, P, K) from conventional (C-T) and no-till (N-T) silage corn systems. For the N-T system, corn was seeded directly into an alfalfa-timothy sod that had been treated with atrazine at 4.5 kg/ha a few days prior to seeding to kill the sod. The conventional system involving continuous cultivation consisted of fall moldboard plowing, spring disking with a 2.2 kg/ha of atrazine applied to control weeds, and seeding. When compared with the C-T system, the N-T system reduced rainfall loss as runoff by 63.6% and soil losses by 92.4%. The 3-yr total soil losses amounted to 3.87 t/ha for N-T and 50.68 t/ha for C-T. The N-T system reduced K losses by 72.6% and P losses by 93.5% with respect to C-T. NO3-N losses were significantly lower for the C-T treatment as compared to the N-T treatment. Lower%age nutrient loss occurred in solution from C-T corn because of better incorporation of the fertilizer into the soil. Yield and% ear were not significantly different between the two systems.
133	Peterjohn et al., 1986	The effect of riparian forest on the volume and chemical composition of baseflow in an agricultural watershed	Va. Tech/Yagow	SERC	MD	corn, tobacco	riparian forest	Y	Y (watershed/ plot)	N	2-year	inflow/outflow	Y	Y	Good. Yearly means presented	For two years the nutrient, chloride, and hydronium ion concentrations in groundwater leaving agricultural fields and entering an adjacent riparian forest were compared to the chemical concentrations in stream water draining the riparian forest under baseflow conditions. Yearly mean nitrate-N concentrations decreased by approximately 4 mg/l whereas the chloride concentration increased by 3 mg/l due to evapotranspiration. The yearly mean pH increased by approximately one pH unit. The volumes of precipitation and baseflow were used in conjunction with the observed change in the groundwater chloride concentration to estimate an annual water budget for the riparian forest. The water budget, in turn, was used with the chemical compositions of precipitation, groundwater, and baseflow to calculate the change in the chemical load in groundwater moving through the riparian forest. From this study, a riparian forest in a coastal plain agricultural watershed: (a) acted as an important sink for nitrate-N; (b) had a significant effect on the volume of streamflow; and (c) significantly reduced the acidity of the groundwater and precipitation which enters it.
63	Petre, E., 2011	Side by Side Evaluation of Four Level Spreader-Vegetated Filter Strips and a Swale in Eastern North Carolina			NC	n/a, Full text unavailable	filter strip	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	N	Not clear if study focuses on cropland, full text unavailable	Level spreader-vegetated filter strips (LS-VFS) are versatile, low cost stormwater control measures with high community acceptance in urban settings. Their effectiveness has not been well studied, however, in eastern North Carolina. Four LS-VFSs and a swale in Wilson, North Carolina were evaluated to determine their pollutant removal efficiencies. Two VFSs of 8 m x 6 m and two VFSs of 20 m x 6 m were constructed. One VFS of each size was amended with ViroPhosTM, a specialized P sorptive aggregate provided by EnviRemed. Influent and effluent samples were collected over a ten-month period and analyzed for N, P, and total suspended solids (TSS) concentrations. The data was analyzed to determine the effects of VFS size and soil amendment in an urban, eastern North Carolina setting. Total N (TN) concentrations were significantly reduced in each of the amended treatments and the swale. TN was found to be irreducible when influent concentrations were less than 1 mg/l. TP concentrations significantly increased through the unamended VFSs, most likely due to the low influent concentrations and the high P-Index of the native soils. TSS concentrations were significantly reduced by all treatments when influent concentrations were greater than 10 mg/l. Size did not have a significant effect on pollutant concentration reduction, however, the ViroPhos amendment had a significant effect on TN, TP, and TSS reduction ($p<0.0001$). The reduction in TN and TSS and the smaller increase in TP in the amended VFSs may have been due to physical settling within the VFS, in addition to any effect of the ViroPhos amendment.
134	Phillips et al., 1980	Pollution potential and corn yields from selected rates and timing of liquid manure applications	Va. Tech/Yagow		Canada	corn	fertilizer management	Y	N	Y	6-year	experiment/control	Y	Y	Good. Yearly means presented	A6-year study was conducted to determine the effects of rate and time of liquid manure application, chemical fertilizer application, and no fertilizer, on the chemical composition of surface and subsurface water and on crop yield. Liquid manure was applied at three rates of 224, 560 and 897 kg/(ha-yr) of N in accordance with four application schedules (i.e. spring, fall, split rates in spring and fall, and winter). In all cases except winter application, manure was incorporated by plowing at time of application. During spring snow-melt, surface runoff concentra-tions of inorganic N, P, and K from winter-applied manure increased approximately in proportion to in-creased application rate. Also, they were much higher than concentrations from spring, fall, spring-fall, and chemical fertilizer treatments. In contrast to spring snowmelt surface runoff, tile drain effluent N03-N concentrations from the plots receiving manure at nearly 900 kg/(ha-yr) of N appeared to be little different from the plot chemically fertilized with 134 kg/(ha-yr) of N. However, at and above the 560 kg/(ha-yr) of N (140 kg/(ha-yr) of P) rates of manure the drain effluent P04-P concentrations tended to be higher than the concentration resulting from chemical fertilizer applications. Most of the N and P in surface runoff during June storms was associated with suspended sedi-ment that resulted from erosion. Neither the amounts of sediment nor their total N and total P contents were af-fected by manure or fertilizer applications. Although the concentrations of inorganic N and P04-P in the water portion of June storm runoff were small (<3%) compared to those in the sediment, plots with higher rate spring-applied manure tended to have higher concentra-tions of inorganic N, P04-P and K. No significant differences in silage corn yields were observed amongst any of the manure and the chemical fertilizer treatments. Based on trends in the water quality results, it is con-cluded that winter application of manure at any rate on areas that contribute runoff directly to bodies of surface water is not recommended. Non-winter applications of manure at and above rates of 560 kg/(ha-yr) of N may also lead to water quality impairment.
149	Poudel et al., 2001	Impacts of cropping systems on soil N storage and loss		many	Canada	corn, bean, tomato, safflower, winter wheat, oat, vetch	cropping systems	Y	N	N	9-year	experiment/control	Y	Y	Good. Yearly means presented	Organic and low-input cropping systems that use more C inputs are alternatives to conventional systems for sustaining long-term soil fertility. An understanding of the impacts of these cropping systems on N balance (N applied minus N removed in harvested plant material), storage and loss is necessary to improve long-term soil fertility and minimize the risk of environmental pollution. An evaluation of 4-year rotations of organic (N from legumes and composted manures), low-input (N from legumes and reduced amounts of synthetic fertilizers), and conventional (conv-4, N from synthetic fertilizers) and a conventional 2-year rotation (conv-2, N from synthetic fertilizers) on N balance, storage and loss was conducted from 1989 to 1998. Compared to the conv-2 system, the organic and conv-4 systems showed 119 and 8% greater cumulative N balances, respectively, over the duration of the study. However, N balance in the low-input system was 19% less than in conv-2 system. After 10 years of differential management, total N in the top 15 cm of soil was 1.46 g kg^{-1} in the organic, 1.26 g kg^{-1} in the low-input, 1.13 g kg^{-1} in the conv-4, and 1.1 g kg^{-1} in the conv-2 system. Compared to the conv-2 system, cumulative N losses for the organic, low-input and conv-4 systems were lower by 80, 92, and 10%, respectively. These findings suggest that organic and low-input cropping systems that add C to soil have the potential for storing N and making it available for future crop use, while minimizing the risk of environmental pollution.
58	Prassanna, H., 2006	Evaluating Alternative Agricultural Management Practices for a Minor Agricultural Watershed Using the ADAPT Model			MN	conservation tillage, fertilizer management	tillage, fertilizer	n/a, modeling study	n/a, modeling study	n/a, modeling study	1-year	modeling/predictive		N	If calibration data include BMPs, could be useful--need to review full text	In this study, a spatial-process based water quality model was calibrated (2001-2002) for flow, sediment, nitrate and P losses from the High Island Creek, a 3856 ha agricultural watershed located in south-central Minnesota. The calibrated model was used to evaluate alternative tillage and fertilizer management practices such as adoption of conservation tillage practices, rate, timing and method of N- and P-fertilizer applications, and method of manure application. Statistical comparison of calibration results with observed data indicated excellent agreement with r**2 of 0.95, 0.96, 0.87, and 0.97 for flow, sediment, nitrate and P losses, respectively. The model simulated a 37.5% reduction in annual sediment losses can be achieved by adopting conservation tillage on all row cropped land in the watershed. Reductions in annual nitrate losses can be achieved by switching the timing of application from fall to spring and by reducing the rate of N fertilizer application. The model predicted a 41% reduction in annual nitrate losses can be achieved if all farmers were to adopt injection as a method for animal manure application.

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107	Raczkowski et al., 2009	Comparison of conventional and no-tillage corn and soybean production on runoff and erosion in the southeastern US Piedmont		USDA	NC	corn, soybean	conventional, no-till	Y	N	Y	6-year	experiment/control	N	Y	Ok. Data as monthly averages	Because of expected climatic changes, it is important to understand how effective conservation tillage systems are at protecting against soil erosion. Of particular importance is to determine how these systems perform during high intensity rains that generate significant runoff. This study was conducted to evaluate the effectiveness of a no tillage application compared with a conventional tillage approach of row-cropped land under natural rainfall conditions for six continuous years. Runoff and soil loss were continuously monitored from May 1995 to April 2001 from erosion plots installed in conventional tillage (CT) and no tillage (NT) plots under a corn-soybean rotation in a Mecklenburg sandy clay loam and Enon clay loam (fine, mixed, thermic Ultic Hapludalfs) at a Piedmont location. Runoff was significantly less for NT than for CT in three of the six study years. The overall NT six-year average was 33% lower than that of CT. The tolerable soil loss level of 7.0 Mg/ha/yr was always exceeded in CT, while annual NT losses were consistently below. The six-year average soil loss was 74.7 Mg/ha and 2.6 Mg/ha for CT and NT, respectively. Excluding the soil loss generated during highly erosive storms, the soil loss rate in CT was slightly above the tolerable level at 8.4 Mg/ha. Collectively, the six-year data indicated that in CT highly erosive storm events were responsible for generating the greatest amount of soil loss. In contrast, NT was highly effective at protecting against soil loss during the same highly vulnerable times by restraining particle detachment and reducing runoff.
136	Randall et al., 1995	Impact of Long-term Tillage Systems for Continuous Corn on Nitrate Leaching to Tile	Va. Tech/Yagow	USDA-CSRS	MN	corn	tillage techniques	Y	N	N	11-year	experiment/control	Y	Y	Good. Yearly means presented	Information is lacking on the long-term impact of tillage systems on NO3 losses to surface and groundwater. An 11-yr (1982-1992) study was conducted to assess NO3 losses to subsurface, tile drainage for corn (Zea mays L.) grown with continuous conventional tillage (CT) and no tillage (NT) on a poorly drained Webster clay loam soil (fine-loamy, mixed, mesic Typic Haplaquoll) at Waseca, MN. Nitrogen was applied at an annual application rate of 200 kg/ha. Mean annual subsurface drain How during the 11-yr period was 35 mm higher for NT (315 mm) compared with CT (280 mm). Flow-weighted nitrate-N (NO3-N) concentrations increased dramatically in the wet years (1990 and 1991) following the dry period of 1987 to 1989. Flow-weighted NO3-N concentrations during the 11-yr period averaged 13.4 and 12.0 mg/L for CT and NT, respectively. Although subsurface drain flow was 12% higher with NT, NO3-N losses were about 5% higher with CT mainly due to higher NO3-N concentrations with CT in the last 2 yr. Corn grain yields and N removal were significantly higher in 6 out of 11 yr with CT compared with NT with no difference between tillage systems in the other 5 yr. Grain yields averaged 8.6 Mg ha-1 with CT and 7.3 Mg ha-1 with NT during the 11-yr period. Multiple regression equations showed that annual flow-weighted NO3-N concentration is best predicted from residual soil NO3 in the 0 to 1.2-m profile and spring rainfall while NO3-N flux can be predicted well from May and June rainfall. Results from this long-term study indicate that on this poorly drained soil, CT had a positive effect on corn grain yield and N removal compared with NT, but tillage systems had minimal impact on NO3 losses to subsurface drain flow. Higher drain flow with NT does not necessarily result in higher NO3-N fluxes lost via subsurface drainage.
137	Randall et al., 1997	Nitrate Losses through Subsurface Tile Drainage in Conservation Reserve Program, Alfalfa, and Row Crop Systems	Va. Tech/Yagow		MN	corn, soybean, alfalfa, grass	crop rotation	Y	N	Y	6-year	experiment/control	Y	Y	Good. Yearly means presented	Subsurface drainage of gravitational water from the soil profile through tiles is a common practice used to improve crop production on poorly drained soils. Previous research has often shown significant concentrations of nitrate-N (NO3-N) in drainage water from row-crop systems, but little drainage research has been conducted under perennial crops such as those used in the Conservation Reserve Program (CRP). Four cropping systems (continuous corn, a corn-soybean rotation, alfalfa, and CRP) were established in 1988 to determine above ground biomass yields, N uptake, residual soil N (RSN), soil water content, and nitrate losses to tile drainage water as influenced by cropping system. Hydrologic year rainfall during the 6 yr study ranged from 23% below normal to 66% above normal. In dry years, yields were limited, RSN accumulated at elevated levels in all crop systems but especially in the row-crop systems, soil water reserves and RSN were reduced to as deep as 2.7 m in the alfalfa and CRP systems, and tile drainage did not occur. Drainage occurred only in the corn and soybean systems in the year of normal rainfall. In years of excess precipitation, drainage from the row-crop systems exceeded that from the perennial crops by 1.1 to 5.3X. Flow-weighted average NO3-N concentrations in the water during the flow period of this study were continuous corn = 32, corn-soybean rotation = 24, alfalfa = 3, and CRP = 2 mg/L. Nitrate losses in the drainage water from the continuous corn and corn-soybean systems were about 37X and 35X higher, respectively, than from the alfalfa and CRP systems due primarily to greater season-long evapotranspiration resulting in less drainage and uptake and/or immobilization of N by the perennial crops.
135	Randall, 1990	Nitrate-N in the Soil Profile and Tile Drainage Water as Influenced by Tillage	Va. Tech/Yagow		MN	corn	tillage techniques	Y	N	N	1-year	experiment/control	Y	Y	good. Few data points	Conservation tillage systems facilitate the infiltration of greater amounts of precipitation into the soil profile by reducing surface runoff. Concern has developed among some scientists because higher infiltration and percolation rates are often linked to potentially higher leaching losses of agricultural chemicals. Soil samples were taken in 1 foot increments to a depth of 5 feet to ascertain the accumulation and distribution of nitrate-N (NO3-N) in the soil profile as influenced by tillage. Two long-term tillage studies on fine-textured, clay loam soils were sampled in July and November 1977 following 2 years of limited rainfall. Nitrate-N accumulation in the 0 to 3 foot profile in late July was reduced by 75% (no tillage) to 38% (chisel plow) compared with the conventional moldboard tillage system in this 8-year-old study. Accumulation in the 0 to 5 foot profile after harvest was 751, 546, 345, and 198 lb NO3-N/A for the moldboard plow, chisel-plow, disk-, and no-tillage systems, respectively. Another 3 year study showed accumulations of 625, 619, 468, and 391 lbs NO3-N/A after harvest with the moldboard plow, ridge-plant, chisel-plow, and no-tillage systems, respectively. These data indicate that tillage can have substantial effects on the accumulation of NO3 in soils and that additional research is needed to determine the mechanisms responsible for these differences.
181	Rasse et al., 2000	Rye Cover Crop and Nitrogen Fertilization Effects on Nitrate Leaching in Inbred Maize Fields			MI	Corn	cover crop, nutrient management	Y	N	N	3-year	experiment/control	N	Y	Good, data only presented in graphs	Nitrate leaching from maize (Zea mays L.) fields fertilized in excess of plant requirements continue to threaten water quality even though many agronomists have recommended reducing N fertilization rates to contain this environmental risk. Inbred maize has lower N uptake than conventional hybrid maize; therefore, inbred maize production exposes soils to even greater ground water pollution risks by nitrates. A 3-yr field experiment was conducted on sandy loam soils in southwestern Michigan to investigate the combined effects of N fertilization rates and rye (Secale cereale L.) cover crops on NO3 leaching in inbred maize fields. Inbred maize was fertilized at 0, 101, and 202 kg N/ha. Annual NO3 leaching losses were 7 kg N/ha higher in fields fertilized at 101 kg N/ha than in nonfertilized controls. Annual NO3 leaching losses to ground water between May 1995 and April 1998 from lysimeters fertilized at 202 kg N/ha averaged 88 kg NO3-N/ha. Rye interseeded with inbred maize fertilized at 202 kg N/ha sequestered from 46 to 56 kg/ha of excess fertilizer N. Rye scavenged little residual fertilizer N in plots fertilized at 101 kg N/ha. Well established rye cover crops in 1996 reduced NO3 leaching by as much as 65 kg N/hawhen the previous crop was fertilized with 202 kg N/ha. Therefore, rye cover crops sequestered substantial amounts of soil NO3 in heavily fertilized inbred maize fields.
156	Rausch et al., 1981	Sediment and Nutrient Trap Efficiency of a Small Flood-Detention Reservoir		USDA-ARS	MO	unclear from abstract	detention	Y	N	N	3-year	inflow/outflow	Y	Y	Good, yearly means presented	Significant amounts of sediment and nutrients are removed from storm runoff by small flood-detention reservoirs such as Callahan Reservoir in central Missouri, which stores 1 cm of runoff from its 1,460-ha drainage area. The purpose of this study was to compare the trap efficiencies of sediment and nutrients and determine which factors affect them. During a 3-year study, this reservoir trapped an average of 85% of the incoming sediment, 77% of the total sediment P (P), and 37% of the inorganic N (N). Sediment leaving the reservoir was clay and contained about 23% of the inflowing total sediment P. Sediment and P trap efficiencies (TE) for individual storms were related to concentrations of sediment and P (solution and sediment) in runoff, respectively
7	Rice, R.W., 2002	Phosphorus load reductions under best management practices for sugarcane cropping systems in the Everglades Agricultural Area	MPMINER		FL	sugarcane	fertilizer management	Y	Y	Y	4-year	watershed comparison	Y	Y		Stormwater run-off from the 290,000 ha Everglades Agricultural Area (EAA) is directed into South Florida's Everglades wetland ecosystem. Concerns regarding run-off water quality and environmental impact led to a 1992 regulatory program which requires P levels in basin run-off be reduced by at least 25% relative to historic trends. Farmers must collectively achieve this annual basin-level target by implementing best management practices (BMPs) to reduce P levels in farm drainage waters. At the time, proposed BMP strategies were largely untested, and to what extent they might reduce farm-level P discharge trends (also poorly documented) was unknown. Given these uncertainties, objectives of this study were to: (1) document long-term drainage P trends for EAA sugarcane systems and (2) quantify BMP effects on-farm drainage P loading. In late-1992, discharge pumps at five farm sites (cropped to sugarcane, sugarcane? Vegetables, and/or sugarcane? Rice) were instrumented to collect water samples for P analysis during all drainage events throughout baseline (BL; pre-BMP) and BMP operations. Highly variable rainfall distributions in the region strongly influence farm drainage requirements, thus, meaningful interpretations of water quality trends require hydrologic adjustment to P load data. Five rainfall-adjustment analyses were applied to the 6-year farm-level databases. Two analysis methods compared P load trends for the entire BL and BMP monitoring periods. In Method 1, unit area P load (UAL) to rainfall ratios (UAL:R) during BMP operations were 20.4?47.3% smaller across all five sites than those recorded during BL. In Method 2, slope coefficients describing cumulative UAL versus cumulative rainfall trends during BMPs were 14.9?25.0% smaller than BL slopes. The remaining three methods assessed data trends across five consecutive ??water years?? (WY). In Method 3, slope coefficients describing WY96?98 cumulative UAL versus rainfall distributions were 32.8% lower in magnitude relative to WY94. In Method 4, average UAL:R for the WY96?98 period were 31.0% smaller than for WY94. Basin-level P loads are calculated every WY by state water management regulators, using a hydrologic adjustment model calibrated to a historic load and rainfall database. During the first 3 years (WY96?98) of required BMP implementation, the basin recorded a 55% P load reduction. When this model was applied to the farm data (Method 5), farm P load reductions for WY96?98 averaged 59.7%. All five analytical methods confirm favorable P-reduction trends under recommended BMP strategies for EAA sugarcane-based cropping systems.

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138	Ritter et al., 1989	Influence of best management practices on water quality in the appoquinimink watershed	Va. Tech/Yagow	RCWP	DE	corn, soybean, small grains, potato, tomato, asparagus	permanent cover, waste control, strip cropping, terraces, diversions, grazing protection, waterways, crop cover, conservation tillage, stream protection, sediment/water control, fertilizer & pesticide management	Y	Y	N	7-year	before/after	Y	Y	Good. Yearly means presented	Surface and ground-water quality were monitored in the Appoquinimink Watershed as part of the Appoquinimink Rural Clean Water Project (RCW). Surface water was monitored for seven years and ground water was monitored for three years. As part of the RCWP plan, conservation tillage, fertilizer management and pesticide management were the most widely used best management practices. Best management practices decreased total P and total suspended solids concentrations in surface water. The unfiltered ortho P as%age of total P increased. Nitrogen concentration did not change over the seven year monitoring period. The BOD concentrations increased because of increased residues left on the surface from conservation tillage. Atrazine was detected in the shallow ground water at concentrations ranging from 1 to 45 mu g/L. Aldicarb was only detected in one monitoring well. Nitrate concentrations were above 10 mg/L in some areas of the watershed.
139	Ritter et al., 1998	Winter cover crops as a best management practice for reducing N leaching	Va. Tech/Yagow		DE	corn, rye	cover crop, tillage	Y	N	Y	3-year	experiment/control	Y	Y	Good. Yearly means presented	The role of rye as awintercovercrop to reduce nitrate leaching was investigated over a three-year period on a loamy sand soil. Acovercrop was planted after corn in the early fall and killed in late March or early April the following spring. No-tillage and conventional tillage systems were compared on large plots with irrigated corn. A replicated randomized block design experiment was conducted on small plots to evaluate arye covercrop under no-tillage and conventional tillage and with commercial fertilizer, poultry manure and composted poultry manure as N fertilizer sources. Nitrogen uptake by the covercrop along with nitrate concentrations in groundwater and the soil profile (0-150 cm) were measured on the large plots. Soil nitrate concentrations and N uptake by the covercrop were measured on the small plots. There was no significant difference in nitrate concentrations in the groundwater or soil profile with and withoutacovercrop in either no-tillage or conventional tillage. Annual amounts of nitrate-N leached to the water-table varied from 136.0 to 190.1 kg/ha in 1989 and from 82.4 to 116.2 kg/ha in 1991. Nitrate leaching rates were somewhat lower with acovercrop in 1989, but not in 1990. There was no statistically significant difference in corn grain yields between the covercrop and non-covercrop treatments. The planting date and adequate rainfall are very important in maximizing N uptake in the fall with a rye covercrop. On the Delmarva Peninsula, the covercrop should probably be planted by October 1 to maximize Nuptake rates in the fall. On loamy sand soils, rye wintercovercrops cannot be counted on asabestmanagementpractice for reducing nitrate leaching in the Mid-Atlantic states.
182	Robertson et al., 2009	In-Stream Bioreactor for Agricultural Nitrate Treatment			Canada	Corn, soybean	bioreactor	Y	Y	N	1.5-year	inflow/outflow	Y	Y	Good, first half of study presented in table	Nitrate from agricultural activity contributes to nutrient loading in surface water bodies such as the Mississippi River. This study demonstrates a novel in-stream bioreactor that uses carbonaceous solids (woodchips) to promote denitrification of agricultural drainage. The reactor (40 m3) was trenched into the bottom of an existing agricultural drainage ditch in southern Ontario (Avon site), and flow was induced through the reactor by construction of a gravel riffle in the streambed. Over the first 1.5 yr of operation, mean influent NO3-N of 4.8 mg/L was attenuated to 1.04 mg/L at a mean reactor flow rate of 24 L min−1 A series of flow-step tests, facilitated by an adjustable height outlet pipe, demonstrated that nitrate mass removal generally increased with increasing flow rate. When removal rates were not nitrate-limited, areal mass removal ranged from 11 mg N m^2 h−1 at 3°C to 220 mg N m^2h−1 at 14°C (n = 27), exceeding rates reported for some surface-flow constructed wetlands in this climatic region by a factor of about 40. Over the course of the field trial, reactor flow rates decreased as a result of silt accumulation on top of the gravel infiltration gallery. Design modifications are currently being implemented to mitigate the effects of siltation. In-stream reactors have the potential to be scaled larger and could be more manageable than attempting to address nitrate loading from individual tile drains. They could also work well in combination with other nitrate control techniques.
155	Romero et al., 1999	Restored wetlands as filters to remove N		CICYT-Spain	Spain	rice	wetland treatment	Y	N	N	3-year	inflow/outflow	N	Y	Good, monthly means presented	Four wetlands established in abandoned ricefields and dominated by Phragmites australis, Typha latifoliaand Scirpus lacustris were used to improve the quality of agricultural runoff in the Ebro Delta (NE Spain) in 1993, 1994 and 1995. The wetlands were continuously flooded with water from a ricefield irrigation network during the growing season and received water with between 5 and 200 mg N m^2/day in the form of dissolved inorganic N (DIN), between 0 and 67 mg N m^2/day in the form of dissolved organic N (DON) and between 1.2 and 225 µg m^2/day in the form of particulate N (PN). Surface N outflows contained between 0 and 12 mg N m^2/day of DIN, between 1 and 86 mg N m^2/day of DON and between 1 and 40 µg m^2/day of PN. The N retention efficiency was always positive 100% of the input, except for DON and PN at low inlet loadings. The emergent macrophytes accumulated between 20 and 100 mg N m^2/day, which accounted for between 66 and 100% of the inflowing DIN. The removal rate constants calculated according to first-order plug-flow kinetics, were between 0.003-0.09 m/day for total N, and 0.005-0.3 m/day for DIN. Plant uptake, detritus accumulation and decomposition, and N recycling in the sediment are the major processes which could explain N retention in the wetlands. Wetlands restored from ricefields act as highly efficient water polishing filters for agricultural runoff and, at the same time, can contribute to the habitat biodiversity of large areas where rice is cultivated extensively.
69	Rushton, B., 2003	Runoff Characteristics from Row Crop Farming in Florida			FL	row crops	wet detention	Y	N	N	4-year	inflow/outflow		Y	Appears promising	This monitoring project, collecting data from winter vegetable fields in Ruskin, Florida, documents water quality treatment by a wet-detention pond for a four-year period and represents both wet and dry years. The efficiency of the pond in reducing pollutant loads was usually over 60% and often over 80% for potentially toxic constituents. Organic N had the poorest load removal since many N transformations in the pond actually increased organic nutrients. Total P levels were measured at high yearly average concentrations of 1.0 to 2.1 mg/l at the inflow to the pond, which is greater than the 0.2 to 0.6 mg/l range measured in Florida. The El NiÁo storms in 1997-98 and more agricultural activity in 2000-01 increased concentrations of most pollutants. Concentrations were greatly reduced from the time runoff left the fields until it was discharged from the pond. Still some pollutants failed to meet state water quality standards. These included: copper, iron, and coliform bacteria. Even with a considerable reduction of chlorophyll and P by the system, pond water at the outflow was still in the eutrophic to hypereutrophic range. Some pesticides were detected including: chlordane, endosulfan, and DDT products, but of the ten pesticides and pesticide residues measured at the inflow of the pond only four were detected at the outflow. Sediment samples showed a large increase in ortho-P from 1997, when the pond was first constructed and the ditch cleaned out, compared to the following year. There were differences between sampling stations in the ditch with the highest concentrations measured at the most shallow stations that also had low flow, low dissolved oxygen and low oxidation-reduction potential.
64	Sadeghi, A., 2008	Watershed Model Evaluation of Agricultural Ditch Drainage Control Structures for Improved Water Quality			MD	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	tbd	Full text not available	Open ditch drainage water management (also referred to as controlled drainage) is an old management strategy in agriculture, but recently has gained widespread use because of its potential impacts on nitrate reduction through enhanced denitrification. This is particularly a useful management strategy for the Chesapeake Bay region in Maryland, where N loads from agriculture has been cited as major components of overall nitrate loads into the Bay. Excess nutrients (especially N & P) entering surface water have shown to increase algal production, causing eutrophication of coastal water ecosystems. Controlled drainage restricts outflow during periods of the year when equipment operations are not required in the field (i.e. winter and midsummer) and to allow natural drainage to occur during the rest of the year, maintaining the water table below the crop root zone. This practice not only restricts the water flows into the Bay, but also allows more denitrification to occur, reducing the level of N in the ultimate flowing waters into the Bay. A study is undertaken on the Choptank watershed in the Eastern Shore region of Maryland to assess the quantitative role of these control structures in reducing N loads into surface waters and their overall impact on watershed water quality.
157	Schepers et al., 1985	Water Quality from Erosion Control Structures in Nebraska			NE	unclear from abstract	sediment basins	Y	Y	N	4-year	inflow/outflow	Y	Y	Good, yearly means presented	Runoff collected from terrace and sediment-control basins having tile-outlet systems was compared with runoff water quality from Maple Creek in northeastern Nebraska. This study was part of a Model Implementation Project (MIP) initiated in 1978 to accelerate land treatment for erosion control and development of best management practices (BMPs). Soils in the area are very erosive (Nora-Crofton complex) when subjected to high-intensity rainfall in the spring and summer. Sediment concentrations in runoff from the terraces and sediment basins were initially high and comparable to stream concentrations until a pool of runoff water formed around the riser inlet of the tile discharge system. Formation of a pool allowed sediment to settle out away from the riser inlet, thus reducing sediment losses from the field. Sediment-borne N and P accounted for 85 to 98% of total N and P losses from the land. Because tile-outlet terraces and sediment basins effectively reduced sediment and nutrient concentrations in runoff, they proved to be an effective BMP for use by producers.
73	Schmidt 2012	Evaluation of a denitrification wall to reduce surface water N loads		Florida Dept of Envir Protection	Fl	unclear from abstract	denitrification wall	Y	N	Y - but not reported	2-year	control/experiment	Y	Y	Good	Denitrification walls have significantly reduced N concentrations in groundwater for at least 15 yr. This has spurred interest in developing methods to efficiently increase capture volume to reduce N loads in larger watersheds. The objective of this study was to maximize treatment volume by locating a wall where a large ground watershed was funneled toward seepage slope headwaters. Nitrogen concentration and load were measured before and after wall installation in paired treatment and control streams. Beginning 2 d after installation, N concentration in the treatment stream declined from 6.7 ± 1.2 to 3.9 ± 0.78 mg L and total N loading rate declined by 65% (391 kg yr) with no corresponding decline in the control watershed. This wall, which only comprised 10 to 11% of the edge of field area that contributed to the treatment watershed, treated approximately 60% of the stream discharge, which confirmed the targeted approach. The total load reduction measured in the stream 155 m downstream from the wall (340 kg yr) was higher than that found in another study that measured load reductions in groundwater wells immediately around the wall (228 kg yr). This indicated the possibility of an extended impact on denitrification from carbon exported beyond the wall. This extended impact was inauspiciously confirmed when oxygen levels at the stream headwaters temporarily declined for 50 d. This research indicates that targeting walls adjacent to streams can effectively reduce N loading in receiving waters, although with a potentially short-term impact on water quality.

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88	Schoonover et al.,2005	Agricultural sediment reduction by giant cane and forest riparian buffers	AGRICOLA	Many	IL	corn, soybean	vegetative buffer	Y	N	Y	19	inflow/outflow	N	Y	Means presented seasonally	The sediment filtering capabilities of giant cane (Arundinaria gigantea (Walt.) Chapm.) and forest riparian buffers were compared in a southern Illinois, USA non tile drained agricultural watershed. Giant cane, a bamboo species, serves as important wildlife habitat throughout its native range in the southeastern and lower midwestern United States. Overland flow samples were collected at the field edge and at 3.3 m, 6.6 m, and 10.0 m within the riparian buffers during 19 precipitation events over a 1-year period. On an annual basis, significant sediment reductions occurred by 3.3 m and 6.6 m in the cane and forest buffers, respectively. The giant cane buffer reduced incoming sediment mass by 94% within the first 3.3 m, while the forest buffer reduced sediment by 86% over 6.6 m. Within 10.0 m of the field edge, the cane and forest buffers reduced sediment mass by 100% and 76%, respectively. On a seasonal basis, the cane buffer outperformed the forest buffer. During each of the four seasons, the cane buffer reduced sediment masses within 3.3 m of the field edge, while the forest buffer showed initial reductions occurring at 6.6 m during the summer, fall, and winter. No detectable reductions occurred during the spring in the forested buffer. Reductions in sediment concentrations were less evident compared to mass basis, indicating that infiltration may be a more important sediment reduction mechanism than particle settling. Both the forest and giant cane buffers had relatively high measured soil infiltration rates. Study results indicate that giant cane is an appropriate species to include in riparian buffer restoration designs for sediment control.
141	Schreiber et al., 1998	Tillage effects on surface and groundwater quality in loessial upland soybean watersheds	Va. Tech/Yagow	USDA-ARS	MS	soybean	no-till, conventional till	Y	N	Y	4-year	experiment/control	Y	Y	Good. Yearly means presented	Evaluation of tillage practices on surface and subsurface water quality is essential for conserving and protecting the nation's soil and water resources. The objective of this research was to evaluate the water quality of perched groundwater (0.15 to 3.04 m) and surface runoff from a 2.13 ha no-till and a 2.10 ha conventional-till soybean watershed for plant nutrients during the 1990-1993 water years. Mean nitrate-N concentrations for all groundwater depths and sites of the no-till and conventional-till watersheds were 4.81 and 5.98 mg.L-1, respectively. Shallow groundwater NO3-N concentrations for some storms exceeded U.S. Drinking Water Standards. However, in a forested riparian zone, only 61 m down slope from the conventional-till watershed, the mean NO3-N concentration in groundwater was only 0.29 mg.L-1. Higher nutrient concentrations in surface runoff from the no-till watershed reflect the lack of sediment to sorb soluble PO4-P as well as the leaching of crop and weed residues. Despite greater runoff from the conventional-till watershed, soluble nutrient losses were generally similar from the no-till watershed due to the higher nutrient concentrations. Nutrient concentrations in surface runoff from both watersheds peaked a few days after a broadcast application of 0-20-20 and decreased during subsequent storms. Alterntive methods of fertilizer application are needed to reduce nutrient concentrations in surface runoff.
151	Seta et al., 1993	Reducing Soil Erosion and Agricultural Chemical Losses with Conservation Tillage		USFA-SCS	KY	corn	tillage	Y	N	Y	1	experiment/control	Y	N	Simulation study--no crops involved	As nonpoint source pollution of water becomes more evident, more concern is being focused on the effects of agricultural practices on water quality. This study evaluated the effects of conventional tillage (CT), chisel-plow tillage (CP), and no tillage (NT) on the quality of runoff water from a Maury silt loam soil (fine, mixed, mesic Typic Paleudalf) near Lexington, KY. The mean runoff rate, total runoff volume, mean sediment concentration, and total soil losses were significantly less for NT than for CP and CT. Concentration of NO-3, NH+3, and PO3−4 in the runoff water from NT were greater than from CP or CT. Concentration of atrazine [6-chloro-N-ethyl-N′-(I-methylethyl)-1,3, 5-triazine-2,4-diamine] in the runoff water tended to be higher from CP than from NT or CT. Total losses of NO-3, NH+4, PO3−4, and atrazine in runoff water were generally in the order CT > CP > NT. The sum of all chemicals lost was less than 3% of the total amount of each applied.
145	Sharpley et al., 1994	Wheat tillage and water quality in the Southern Plains	Va. Tech/Yagow	USDA-ARS	KS, OK, TX	grass, wheat	tillage	Y	N	N	14-year	experiment/control	Y	Y	Good. Yearly means presented	This study considers the impact of conventional-till (moldboard plow or sweeps) and no-till wheat (Triticum aestivum L.) management practices on surface and groundwater quality. Concentrations and amounts of sediment, N (N), and P (P) in surface runoff, and associated nutrient levels in ground waterwere determined for seven dryland watersheds at two locations for periods up to 14 years. In general, annual surface runoff was similar for both tillage practices, ranging from 6 to 15 cm. Compared with conventional till, no-till reduced sediment, N, and P loss an average of 95%, 75%, and 70%, respectively. Concurrently, elevated levels of dissolved P (maximum 3.1 mg/L) in surface runoff, and nitrate-N in ground water(maximum 26 mg/L) were observed. About 25% more available soil water was in the no-till soil profiles, but this did not translate into increased grain yield. Instead, no-till grain yields were reduced an average 33% (600 kg/ha) compared witj conventional till, which is attributed to a lower availability of surface applied fertilizer, and increasing cheat (Bromus tectorum L.) and associated weed problems. From an overall agronomic and environmental standpoint, our results indicate that the management of no-till systems should include careful fertilizer placement and timing.
142	Sharpley et al., 1996	Gully treatment and water quality in the Southern Plains	Va. Tech/Yagow		OK	bermudagrass	land shaping, pond	Y	N	N	13-year	experiment/control	Y	Y	Good. Yearly means presented	Erosion of agricultural land and transport of associated fertilizer chemicals N (N) and P (P) in runoff, can be detrimental to both soil productivity and water quality. In the Southern Plains, gully erosion is of concern due to periodically intense rainfall and a large acreage of erodible soils. As little information is available, we studied the loss of sediment, N, and P in runoff over 13 yr (1980-1992) from two adjacent extensively gullied native grass watersheds (3.8 and 5.7 ha of 5% slope and class 4 erosion) in the Little Washita River Basin, OK. In 1983, the gullies on one of the watersheds were treated by land shaping, Midland Bermudagrass [Cynodon dactylon (L.) Pers] establishment, and construction of a runoff detention pond. Prior to gully treatment, greater (p > 0.05) amounts of sediment, N, and P were lost from the subsequently treated than untreated watershed. Following gully treatment, 27,500 kg sediment, 7.1 kg N, and 4.1 kg P/ha yr−1 were lost from the gullied watershed, while only 4,900 kg sediment, 3.1 kg N, and 1.6 kg P/ha yr−1 were lost from the treated watershed. While gully treatment had no effect on nitrate-N and ammonium-N loss, dissolved P and bioavailable P losses were increased six-and threefold, respectively. This was attributed to the application of fertilizer N and P to the treated watershed only. The loss of N and P in runoff from gullied and treated watersheds was accurately predicted using kinetic and enrichment ratio approaches with soil properties reflecting the main zone of runoff and soil interaction. Subsoil (5-20 cm) properties accurately predicted N and P release and transport in runoff from the gullied watershed, whereas accurate predictions for the treated watershed were obtained with surface soil (0-5 cm) properties. The cost of gully treatment was $1,098/ha, with a reduced loss of 210 kg sediment, 5 g N, and 3 g P in the ensuing 10 years for every dollar spent on treatment.
101	Shipitalo et al., 1997	Herbicide losses in runoff from conservation-tilled watersheds in a corn-soybean rotation			OH	corn, soybean	chisel plough, no-till	Y	N	N	4-year	experiment/control	N	Y	Good. Yearly means presented	In areas with steeply sloping farmlands concern that soybean does not produce enough residue to control erosion under conservation tillage has favored production of corn in monoculture, although yields of both crops can be higher when grown in rotation. Previous research at our location has demonstrated that soil and nutrient losses in runoff from a corn\soybean rotation were tolerable when a rye cover crop following soybean harvest was used to provide additional residue cover. Herbicide losses in runoff under this cropping sequence, however, have not been evaluated. Therefore, runoff from two chisel and two no-till watersheds was monitored for 4 yr to determine the effect of the rotation on losses of four herbicides and to compare the behavior of atrazine and linuron, which control a similar spectrum of weeds. As a%age of applied chemical, average losses were small with atrazine (0.31%) > linuron (0.20%) > metribuzin (0.14%) > alachlor (0.05%). Atrazine concentrations, however, consistently exceeded the lifetime Health Advisory Level\Maximum Contaminant Level (HAL\MCL) of 3 ug/L in the first few runoff events after application and atrazine was detectable in the runoff during the soybean years, at times above the HAL\MCL. Linuron was rarely detected in runoff following corn harvest or during the soybean years. The 2 ug/L MCL for alachlor was only exceeded during the first few events after application, whereas metribuzin concentrations never exceeded the HAL of 200 ug/L.
83	Shipitalo et al., 2010	Impact of Grassed Waterways and Compost Filter Socks on the Quality of Surface Runoff from Corn Fields.	AGRICOLA	USDA-NRCS	OH	corn	tillage, grassed waterways, filter socks	Y	N	Y		control/experiment	Y	Y	Good	Surface runoff from cropland frequently has high concentrations of nutrients and herbicides, particularly in the first few events after application. Grassed waterways can control erosion while transmitting this runoff offsite, but are generally ineffective in removing dissolved agrochemicals. In this study, we routed runoff from one tilled (0.7 ha) and one no-till watershed (0.8 ha) planted to corn into parallel, 30-m long, grassed waterways. Two, 46-cm dia., filter socks filled with composted bark and wood chips were placed 7.5 m apart in the upper half of one waterway and in the lower half of the other waterway to determine if they increased removal of sediment and dissolved chemicals. Automated samplers were used to obtain samples above and below the treated segments of the waterways for two crop years. The filter socks had no significant effect (P = 0.05) on sediment concentrations for runoff from the no-till watershed, but contributed to an additional 49% reduction in average sediment concentration compared to unamended waterways used with the tilled watershed. The filter socks significantly increased the concentrations of Cl, NO3-N, PO4-P, SO4, Ca, K, Na, and Mg in runoff from at least one watershed, however, probably due to soluble forms of these ions in the compost. The estimated additional amounts contributed by the socks each year ranged from 0.04 to 1.25 kg, thus were likely to be inconsequential. The filter socks contributed to a significant additional reduction in glyphosate (5%) and alachlor (18%) concentrations for the tilled watersheds, but this was insufficient to reduce alachlor concentrations to acceptable levels.
65	Shukla, S., 2002	Field and Watershed Scale N Modeling to Analyze Lag Time and BMP Effects in a Mid-Atlantic Coastal Plain Watershed			VA	corn	tillage, fertilizer	Y	Y	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	Y	Full text unavailable--dissertation is on server	Long-term watershed and field N (N) balances were used in this study to quantify the surface (baseflow component only) and ground water lag times and effects of BMPs on N discharge from a Virginia Coastal Plain watershed. The baseflow lag time was equal to the ground water lag time plus the time required for the ground water to travel to the streams. Role of atmospheric N (atm-N) deposition was also investigated. Ten-year monitoring data collected in the watershed were used. Field (Field-N) and watershed (Watershed-N) scale N models were developed to simulate N balances and leaching. BMPs evaluated in this study included no-till corn and split N application (SNA). Atm-N deposition was a major source of N in the watershed, accounting for 23% of the total N input. Variations in atm-N deposition were larger than the fertilizer N. Comparison of Field-N results with observed ground water N revealed that the ground water lag time was 2-8 months. The unusually rapid transport of solute was facilitated by discontinuous clay lenses. Implementation of SNA reduced the post-BMP ground water NO3 concentration and detection frequency (> 9 mg/l) by as much as 12 and 44%, respectively. Watershed-N was able to accurately predict the effects of land use on watershed N balances (WNBAL) and baseflow and ground water N. Baseflow lag time was between 4 and 11 months. Post-BMP WNBAL was less than the WNBAL for the pre-BMP period. However, these reductions were mainly due to the 43% reductions in atm-N deposition and 31% increase in plant uptake due to better rainfall conditions. Reductions in WNBAL and N loading caused by BMPs were 5% and 10%, respectively.

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61	Shuman, J., 2005	Agricultural BMPs, Nutrient Load Reductions, and Watershed Restoration			PA/MD	dairy and swine	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	N	May not include BMP specific data--also appears to be focused on non-row crop ag, full text unavailable	The Octoraro Creek drains 208 square miles in Lancaster and Chester counties in Pennsylvania and Cecil County in Maryland, and enters the Susquehanna River at the head of the Chesapeake Bay. Land use is 75% agricultural, largely with Old Order Amish and English dairy farming and swine farming. Streamflow data over the last 9 years shows no change in nitrate concentrations in either branch of Octoraro Creek, with median nitrate concentrations in the 7.4 to 8.4 mg/L range. About 95% of the nitrates in Octoraro Creek are estimated to originate from nonpoint sources. Streamflow nitrates are highest during baseflow periods in winter, when biological uptake and denitrification rates are reduced. Nitrate concentrations in groundwater are also elevated, with the watershed being the epicenter in Pennsylvania for high groundwater nitrates. These high nitrate concentrations pose public health, herd health, and economic issues in the watershed. The absence of any change in nitrate concentrations in the Octoraro over the last 9 years has occurred despite the aggressive implementation of agricultural Best Management Practices (BMPs) in the watershed. Nutrient and sediment load reductions predicted when BMPs are implemented are theoretical reductions that, in some cases, may take years to be realized in a watershed. This is germane to the Chesapeake Bay watershed model, which assumes no time lag for full BMP effectiveness. The current use of Bay model predictions as data that document progress in reducing nutrient loads to the Bay is not an appropriate measure of restoration success. The definition and measures of success in restoration have direct implications for how we proceed with restoration science, policy, politics, and the reality of TMDL attainment.
143	Smith et al., 1991	Water Quality Impacts Associated with Wheat Culture in the Southern Plains	Va. Tech/Yagow	USDA-ARS	OK/TX	wheat	tillage techniques	Y	N	N	4-6 year	experiment/control	Y	Y	Good. Yearly means presented	Water quality information regarding wheat culture in the Southern Plains is sparse. The objective of this study is to determine the extent to which the area's surface and ground-water quality is influenced by different wheat cultural practices. Concentrations and amounts of sediment, N and P in surface runoff water were determined for conventional till (CT), reduced till (RT), and no till (NT) wheat (Triticum aestivum L.) watersheds in the High Plain, Reddish Prairie, and Rolling Red Plain land resource areas of Oklahoma and Texas. During the 4 to 6 yr study periods, RT and NT practices were superior to CT for reducing sediment and associated particulate nutrient discharge. Mean annual discharge ranged from 230 to 15 900 kg/ha for sediment, 1 to 27 kg/ha for total N, and 0.1 to 6 kg/ha for total P. Irrespective of tillage practice, annual soluble nutrient losses in surface runoff water tended to be small, often < 1 kg/ha N or P. Successful prediction of soluble P, particulate P, and particulate N losses was achieved using appropriate kinetic desorption and enrichment ratio procedures. Soluble N in runoff posed no particular water quality problem, but recommended P levels were exceeded, even from baseline, unfertilized grassland watersheds. With regard to groundwater quality, elevated levels of NO3- (e.g., 34 mg N/L maximum) were observed on one Reddish Prairie NT watershed.
71	Snyder, N., 1998	Impact of Riparian Forest Buffers on Agricultural Nonpoint Source Pollution	Va. Tech/Yagow	USDA-CSRS	VA	corn, soybean	riparian buffer	Y	N	N	1-year	inflow/outflow	Y	Y	seasonal data	A field monitoring study of a riparian forest buffer zone was conducted to determine the impact of the riparian ecosystem on reducing the concentration of agricultural nonpoint source pollutants. Groundwater samples were collected from 20 sampling locations between May 1993 and December 1994, and analyzed for NO3-N, PO4, and NH4-N. Statistical analyses such as Friedman's test, cluster analysis, cross correlation analysis and Duncan's test were performed for the nutrient data. The study showed that the ripanan buffer zone was effective in reducing nitrate concentrations originating from upland agricultural fields. Instream nitrate concentrations were 48% less than those measured in the agricultural field. Reductions in concentrations in sampling locations at the wetland edge ranged from 16 to 70%. The mean nitrate concentrations in forested hill slope were 45% less than concentrations in a well located in an upland agricultural field. Meanwhile, the concentrations of phosphate and ammonia did not follow any specific spatial trend and were generally higher during the summer season for most sampling locations.
103	Soileau et al., 1994	Sediment, N, and P runoff with conventional- and conservation-tillage cotton in a small watershed			AL	cotton	conventional, no-till	Y	N	Y	106	before/after	N	Y	Good. Event data presented graphically	Research on watershed runoff losses from cotton (Gossypium hirsutum L.) cropping systems in limestone soil regions is limited. Runoff of water, sediment, total N, NH4-N, NO3-N, and solution and particulate P were measured from a 3-8-ha (9.4-ac) watershed during three years of conventional tillage (CvT) cotton, followed by three years of conservation-tillage (CsT) cotton. The study was conducted from 1984 through 1989 in the Limestone Valley region of northern Alabama, on slopes of 1-6% and Decatur (Rhodic Paleudults) and Emory (Fluventic Um-bric Dystrochrepts) soils. Although CsT resulted in a higher proportion of annual rainfall as runoff than CvT, about twice as much sediment was discharged from the watershed with CvT than with CsT [average of 2,979 vs. 1,311 kg/ha yr−1, (2,660 vs. 1,170 lbs ac−1 yr−1) respectively]. A few intense storms during late winter through early spring, before full cotton canopy, contributed to most of the erosion losses in CvT. Annual mean concentrations of NO3-N in runoff were equally low for both tillage systems, ranging from 1.3 to 2.2 mg/L during the six years. Winter rye was very effective in diminishing NO3-N concentrations in runoff from January to spring fertilization. A temporary period of elevated NO3-N and P concentrations occurred in runoff sampled shortly after surface application of NP fertilizer in April, especially with CsT. In our study, most of the runoff P loss was associated with the solution rather than the particulate phase, and more P runoff occurred with CsT than with CvT In balance, however, CsT is more environmentally acceptable than CvT for cotton production, assuming prudent NP fertilizer management.
81	Spaan, et al.,2005	Vegetation barrier and tillage effects on runoff and sediment in an alley crop system on a Luvisol in Burkina Faso	AGRICOLA		Burkina Faso	grasses, woody species, succulents	alley cropping, tillage techniques	Y	N	Y	26	experiment/control	Y	Y	Good	The effects of vegetation barriers and tillage on runoff and soil loss were evaluated in analleycropsystem at a research station in central BurkinaFaso. On a 2% slope of a sandy loam various local species (grasses, woody species and a succulent) were planted as conservation barriers in order to examine their influence on sediment transport. After each erosive storm, runoff and sediment yield was determined. The dense effective barriers (Andropogon gayanus and dense natural vegetation) slow down flow velocity, build up backwater and promote sedimentation uphill. The through flow in the less effective barriers with woody species and succulents (Ziziphus mauritania and Agave sisalana) was slightly hampered and flow velocity was not reduced enough, resulting in a higher soil transport. Under degraded conditions soil loss diminished 50% with less effective and 70-90% with effective barriers. During the initial cropping phase (light tillage; sowing) erosion was reduced 40-60% with effective barriers and showed an increase of 45% with less effective barriers. In the full tillage (weeding) period erosion decreased by 80-90% for effective and 70% for less effective barriers, aided by the development of the barrier and the crop on the alley. Barriers of natural vegetation and A. gayanus are preferred for diminishing soil loss. Sediment yield could best be predicted by the erosivity index (AIm), second best by runoff amount (mm), closely followed by maximum peak intensity.
183	Strock et al., 2004	Cover Cropping to Reduce Nitrate Loss Through Subsurface Drainage in the Northern US Corn Belt			MN	Corn, soybean	Cover crop	Y	N	N	4-year	experiment/control	Y	Y	Good, yearly means presented	Despite the use of best management practices for N (N) application rate and timing, significant losses of nitrate N NO3-N in drainage discharge continue to occur from row crop cropping systems. Our objective was to determine whether a autumn-seeded winter rye (Secale cereale L.) cover crop following corn (Zea mays L.) would reduce NO3-N losses through subsurface tile drainage in a corn-soybean [Glycine max (L.) Merr.] cropping system in the northern Corn Belt (USA) in a moderately well-drained soil. Both phases of the corn-soybean rotation, with and without the winter rye cover crop following corn, were established in 1998 in a Normania clay loam (fine-loamy, mixed, mesic Aquic Haplustoll) soil at Lamberton, MN. Cover cropping did not affect subsequent soybean yield, but reduced drainage discharge, flow-weighted mean nitrate concentration (FWMNC), and NO3-N loss relative to winter fallow, although the magnitude of the effect varied considerably with annual precipitation. Three-year average drainage discharge was lower with a winter rye cover crop than without ($p = 0.06$). Over three years, subsurface tile-drainage discharge was reduced 11% and NO3-N loss was reduced 13% for a corn-soybean cropping system with a rye cover crop following corn than with no rye cover crop. We estimate that establishment of a winter rye cover crop after corn will be successful in one of four years in southwestern Minnesota. Cover cropping with rye has the potential to be an effective management tool for reducing NO3-N loss from subsurface drainage discharge despite challenges to establishment and spring growth in the north-central USA.
62	Subramani, J., 2012	Effects of Every Furrow vs. Every Other Furrow Surface Irrigation in Cotton			AZ	cotton	planting	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	3-year	experiment/control	n/a, Full text unavailable	N	BMP appears to be focused on water savings, full text unavailable	In 2001, the Arizona Department of Water Resources implemented an agricultural Best Management Practice (BMP) program. The program was designed to encourage the use of BMPs in irrigation with the goal of increasing the efficient use of water resources on the farm. Several BMPs were identified through meetings with stakeholders, researchers, and scientists. One of the BMPs identified was alternate furrow irrigation. This three-year study was designed to determine the impact of alternate furrow irrigation on surface irrigation water applications and cotton yield. There were two treatments, every furrow (EF) and every other furrow (EOF). Lint yields were 1794 and 1694 kg/ha in 2006; 1795 and 1902 kg/ha in 2007; and 1365 and 1237 kg/ha in 2008 for the EF and EOF treatments, respectively. Seasonal irrigation water applications were 187.7 and 162.3 cm in 2006; 151.4 and 137.2 cm in 2007; and 184.1 and 132.6 cm in 2008 for EF and EOF treatments, respectively. The results indicate that an average of 30.5 cm of water can be saved by the implementation of an alternate furrow irrigation scheme without significantly reducing lint yield.
146	Tan et al., 1995	Effect of controlled drainage and tillage on soil structure and tile drainage nitrate loss at the field scale	Va. Tech/Yagow		Canada	soybean	drain, tillage	Y	N	N	3-year	experiment/control	Y	Y	Good. Yearly means presented	Conservation tillage has become an attractive form of agricultural management practices for corn and soybean production on heavy textured soil in southern Ontario because of the potential for improving soil quality. A controlled drainage system combined with conservation tillage practices has also been reported to improve water quality. In Southwestem Ontario, field scale on farm demonstration sites were established in a paired watershed (no-tillage vs. conventional tillage) on clay loam soil to study the effect of tillage system on soil structure and water quality. The sites included controlled drainage and free drainage systems to monitor their effect on nitrate loss in the tile drainage water. Soil structure, organic matter content and water storage in the soil profile were improved with no-tillage (NT) compared to conventional tillage (CT). No-tillage also increased earthwonn populations. No-tillage was found to have higher tile drainage volume and nitrate loss which were attributed to an increase in soil macropores from earthworm activity. The controlled drainage system (CD) reduced nitrate loss in tile drainage water by 14% on CT site and 25.5% on NT site compared to the corresponding free drainage system (DR) from May, 1995 to April 30, 1997. No-tillage farming practices are definitely enhanced by using a controlled drainage system for preventing excessive nitrate leaching through tile drainage. Average soybean yields for CT site were about 12 to 14% greater than the NT site in 1995 and 1996. However, drainage systems had very little effect on soybean yields in 1995 and 1996 due to extremely dry growing seasons.

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104	Thoma et al., 2000	Tillage and nutrient source effects on water quality and corn grain yield from a flat landscape		MNDA	MN	corn	fall chisel, moldboard plow	Y	N	Y	24-30	experiment/control	N	Y	Good. Yearly means presented	Beneficial effects of leaving residue at the soil surface are well documented for steep lands, but not for flat lands that are drained with surface inlets and tile lines. This study quantified the effects of tillage and nutrient source on tile line and surface inlet water quality under continuous corn (Zea mays L.) from relatively flat lands (<3%). Tillage treatments were either fall chisel or moldboard plow. Nutrient sources were either fall injected liquid hog manure or spring incorporated urea. The experiment was on a Webster-Canisteo clay loam (Typic Endoaquolls) at Lamberton, MN. Surface inlet runoff was analyzed for flow, total solids, NO(3)-N, NH(4)-N, dissolved P, and total P. Tile line effluent was analyzed for flow, NO(3)-N, and NH(4)-N. In four years of rainstorm and snowmelt events there were few significant differences (p < 0.10) in water quality of surface inlet or tile drainage between treatments. Residue cover minimally reduced soil erosion during both snowmelt and rainfall runoff events. There was a slight reduction in mineral N losses via surface inlets from manure treatments. There was also a slight decrease (p = 0.025) in corn grain yield from chisel-plow plots (9.7 Mg ha(-1)) compared with moldboard-plow plots (10.1 Mg ha(-1)). Chisel plowing (approximately 30% residue cover) alone is not sufficient to reduce nonpoint source sediment pollution from these poorly drained flat lands to the extent (40% reduction) desired by regulatory agencies.
77	Tiessen et al., 2011	The Effects of Multiple Beneficial Management Practices on Hydrology and Nutrient Losses in a Small Watershed in the Canadian Prairies		WEBs	Canada	cereals, oilseeds, cattle	pond, riparian, grassed waterway, grazing, perennial, nutrient management	Y	Y	Y	65	control/experiment	Y	Y	Great - but individual BMPs not separated	Most beneficial management practices (BMPs) recommended for reducing nutrient losses from agricultural land have been established and tested in temperate and humid regions. Previous studies on the effects of these BMPs in cold-climate regions, especially at the small watershed scale, are rare. In this study, runoff and water quality were monitored from 1999 to 2008 at the outlets of two subwatersheds in the South Tobacco Creek watershed in Manitoba, Canada. Five BMPs—a holding pond below a beef cattle overwintering feedlot, riparian zone and grassed waterway management,grazing restriction, perennial forage conversion, and nutrient management—were implemented in one of these two subwatersheds beginning in 2005. We determined that >80% of the N and P in runoff at the outlets of the two subwatersheds were lost in dissolved forms, ≈ 50% during snowmelt events and ≈ 33% during rainfall events. When all snowmelt- and rainfall-induced runoff events were considered, the five BMPs collectively decreased total N (TN) and total P (TP) exports in runoff at the treatment subwatershed outlet by 41 and 38%, respectively. The corresponding reductions in fl ow-weighted mean concentrations (FWMCs) were 43% for TN and 32% for TP. In most cases, similar reductions in exports and FWMCs were measured for both dissolved and particulate forms of N and P, and during both rainfall and snowmelt-induced runoff events. Indirect assessment suggests that retention of nutrients in the holding pond could account for as much as 63 and 57%, respectively, of the BMP-induced reductions in TN and TP exports at the treatment subwatershed outlet. Th e nutrient management BMP was estimated to have reduced N and P inputs on land by 36 and 59%, respectively, in part due to the lower rates of nutrient application to fields converted from annual crop to perennial forage. Overall, even though the proportional contributions of individual BMPs were not directly measured in this study, the collective reduction of nutrient losses from the five BMPs was substantial.
78	Tiessen et al., 2011_2	The effectiveness of small-scale headwater storage dams and reservoirs on stream water quality and quantity in the Canadian Prairies		WEBs	Canada	cropland, rangeland	dams	Y	y	Y	9-year	inflow/outflow	Y	Y	Good	In response to flooding and soil erosion impacting the South Tobacco Creek watershed in south-central Manitoba, local landowners constructed a network of small dams and reservoirs in the headwaters. Between 1999 and 2007, two of the small dams/reservoirs (Steppler multipurpose dam and Madill dry dam) were intensively monitored for their effectiveness in reducing peak flows and downstream sediment and nutrient loading during spring snowmelt (typically mid-March to mid-April) and summer rainfall (typically May to November) periods. These small-scale headwater storage dams were effective in reducing peak flows from agricultural land. The two dams/reservoirs monitored also reduced annual concentrations of sediment and total N (TN) to downstream receiving waters. However, annual concentrations of total P (TP) were only significantly reduced at the Madill dry dam, and the average concentrations of N (N) and P (P) within outflow water samples still exceeded guidelines for freshwater in the Canadian Prairies. Both dams/reservoirs significantly reduced annual loads of sediment, TN, and TP (Steppler dam, average of 77%, 15%, and 12%, respectively; Madill dam, average of 66%, 20%, and 9%, respectively). This corresponded to an average annual retention of 25 Mg y-1 (28 tn yr-1) of sediment, 166 kg N y-1 (366 lb N yr-1) and 17 kg P y-1 (37 lb P yr-1) by the Steppler dam, while 6 Mg y-1 (7 tn yr-1) of sediment, 181 kg N y-1 (399 lb N yr-1) and 10 kg P y-1 (22 lb P yr-1) were retained by the Madill dam. Both reservoirs reduced annual loads of dissolved N and P to downstream water bodies (Steppler, average of 14% and 10%, respectively; Madill, average of 23% and 15%, respectively), and were generally effective in removing dissolved N and P during both snowmelt and rainfall-generated runoff. The% retention of dissolved nutrients was consistently higher during the summer than the spring. While the reservoirs removed particulates during snowmelt-generated runoff, they were often sources of suspended nutrients during rainfall-generated events. However, since dissolved nutrients were the dominant form of both N and P (>70% for both snowmelt and rainfall events), the two dams/reservoirs successfully reduced overall nutrient loads to downstream water bodies, annually and seasonally. In combination with improving flood and erosion control for the region, small headwater storage dams and reservoirs deserve consideration when developing watershed nutrient management plans, especially for undulating and hummocky regions on the Great Plains.
42	Tuppad, P., 2010	Assessing BMP effectiveness: multiprocedure analysis of observed water quality data			TX	corn, grain, sorghum	terraces, conservation tillage, grassed waterways, filter strips	Y	N	N	8-19 years	before/after	N	Y	Appears useful	Observed water quality data obtained from eight stream monitoring locations within Richland-Chambers Watershed in north central Texas were analyzed for trends using box-and whisker plots, exceedance probability plots, and linear and Mann-Kendall statistical methods. Total suspended solids decreased at seven out of eight stations, and at two of these stations, the decrease was significant. Mixed results were obtained for N across the stations. A nonsignificant and significant increase in nitrite plus nitrate N (nitrite + nitrate N) was noticed in two stations each, whereas at the other four stations showed nonsignificant decrease. The results of organic N (Org N) was similar to nitrite + nitrate N except that the two stations that showed significant increase in nitrite + nitrate N showed nonsignificant decrease in Org N. Mixed results were also noticed for orthoP (Ortho P) including nonsignificant decrease at two stations, significant decrease and increase at one P station each, and nonsignificant increase in four stations. In general, total P (TP) decreased at all stations, significantly at some, except one station where it increased significantly. Decreasing trends in sediment, Org N, Ortho P, and TP were likely related to implementation of best management practices (BMPs). Increasing trends in dissolved constituents including Ortho P and nitrite + nitrate N were likely due to increased surface residue as a result of some BMPs such as conservation tillage.
114	Turtola et al., 1995	Influence of improved subsurface drainage on P losses and N leaching from a heavy clay soil			Finland	barley, timothy, ryegrass	improved drains, and wood-chip backfill	Y	N	N	7-year	before/after	Y	Y	Excellent. Data presented annually	Without proper subsurface drainage of heavyclaysoil, water logging due to low hydraulic conductivity of the surface soil and especially the subsoil will lead to abundant surface runoff. The abundant runoff will induce soil erosion and P losses. To determine the influence of improvedsubsurfacedrainage(IMP) on soil erosion, P losses and N leaching, aheavyclaysoil with a 29 year old subdrainage system was fitted with new drains, with topsoil or wood chips used as backfill in the drain trenches. Before IMP, drainage water constituted only 10-40% of the total runoff (drainage+surface runoff) but after IMP 50-90%. Where topsoil was used as backfill, the estimated soil erosion and particulate P and dissolved orthophosphate P losses from ploughed soil during winter were lower after IMP than before (1168 vs. 1408 kg/ha, 0.58 vs. 0.69 kg/ha, 0.09 vs. 0.12 kg/ha, respectively). Where wood chips were used as backfill, soil erosion and particulate P losses were not reduced. Owing to the increased drainage discharge, N leaching during barley cultivation was much higher after IMP (14 vs. 7 kg/ha).
152	Ulen, 1997	Nutrient losses by surface run-off from soils with winter cover crops and spring-ploughed soils in the south of Sweden		National Board of Agriculture	Sweden	barley, oats, winter wheat	cover-crop	Y	N	N	5-year	experiment/control	N	Y	Good, yearly means presented	Winter cover crops are used as a method of reducing N (N) losses from arable land in several countries, but their effect on P (P) losses is poorly documented. Run-off and losses of nutrients and soil were measured from a clay loam with autumn-ploughed and spring-ploughed plots and from plots with winter wheat during three winter seasons (1993-1996) in Holland County in south western Sweden. The run-off water was collected in troughs dug into the soil at the end of collecting slopes placed in the experimental plots. As a result of the weather, there was only one winter in which surface run-off occurred to any great extent. On average, 75% of P was in particulate form (Ppart). Neither winter wheat (Triticum aestivum L.) nor catch crops of English ryegrass (Lolium perenne L.) reduced losses of P part when compared with losses from autumn-ploughedsoil; and losses from spring-ploughedsoil containing stubble and weeds were no lower than those from autumn-ploughedsoil. Losses of Ppart from all treatments were moderate considering its low bio-availability. Concentrations of phosphate-P (PO4-P) were low, with a mean 0.04 mg 1−1. Despite a significant increase in losses of PO4-P from spring-ploughed soil covered with stubble and catch crops or weeds compared with that in autumn-ploughed soil, the extra input from this P source was at most 2 g/ha yr−1. This mass loss was equal to 0.5 g kg−1 of the total mass of P in the vegetation. Thus, only very small extra P surface losses were found with winter cover crops compared with those with bare soils. N losses in run-off were low in all treatments.
184	van Vliet et al, 2002	Effect of fall-applied manure practices on runoff, sediment, and nutrient surface transport from silage corn in south coastal British Columbia			Canada	Corn	Manure application management	Y	N	N	2-year	experiment/control	Y	Y	Good, yearly means presented	Runoff from manured cropland during the wet fall and winter season, when 70% of the annual rainfall occurs, is a surface water quality concern in the Lower Fraser Valley of British Columbia. This study compares different fall-manure application strategies on runoff and contaminant transport from silage corn (Zea mays) land. The treatments were (i) a control, which did not receive manure in the fall; (ii) manure broadcast in the fall on corn stubble; and (iii) manure broadcast in the fall on corn stubble with an established relay crop. Runoff, solids, and nutrients loads from natural precipitation were measured on replicated experimental plots (0.0125 ha) from 1996 to 1998. Fall-applied manure on 3-5% sloping silage cornland without a relay crop resulted in a high risk to surface water quality, due to high suspended solid loads of between 7 and 14 Mg/ha/yr and high nutrient transport with mean annual total Kjeldahl N (TKN) P, and K loads of 98, 21, and 63 kg/ha, respectively. Compared with no relay crop, intercropping silage corn with a relay crop of Italian ryegrass (Lolium multiflorum) reduced the mean annual runoff and suspended solid load by 53 and 74%, respectively, TKN load by 56%, P load by 42%, K load by 31%, and Cu load by 57%. Even though total nutrient loads were lower with the relay crop treatment, all fall manure treatments including the relay crop resulted in nutrient loads above guidelines for the first three runoff events immediately following application.

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43	van Vliet, L., 1995	Effects of planting direction of brussel sprouts and previous cultivation on water erosion on southwestern British Columbia, Canada			Canada	brussel sprouts	cross slope cultivation	Y	N	N	1-year	control/experiment	N	Y	limited scope, but useful data	Eight erosion plots were monitored under natural rainfall conditions from 1989 to 1991 to evaluate the effects of planting direction and slope steepness on soil loss and runoff from a brussels sprouts field in southwestern British Columbia Canada.
53	Vennix, S., 2002	Prioritizing Vegetative Buffer Strips within an Agricultural Watershed			MI	corn, soybean, wheat	vegetative buffer strips	Y	Y	N	n/a, model study	modeling/predictive		N	Data may be difficult to integrate	In this study, the Agricultural Nonpoint Source Pollution Model (AGNPS) was used to determine locations of vegetative buffer strip effectiveness on reducing sediment load within the East Bad Creek (EBC) watershed, a 690 ha agricultural watershed located mid Michigan. Modeling scenarios consisted of simulating the hydrology and sediment transport throughout the EBC watershed on a baseline scenario (no buffer) and with a 30-meter vegetative buffer strip placed around each stream segment (buffer strip scenario). The model's results showed a 17% decrease in sediment load at the watershed's outlet for a 10yr-24hr storm. As a result, the placement of buffer strips within the watershed was prioritized on three different scales. The reduction of sediment due to buffer strips was analyzed on a stream segment level, a field boundary level, and on a cell-by cell basis. The stream segment buffers and field buffers were ranked on their overall ability to reduce sediment load into the stream. The reduction in sediment yield from the stream segments and the fields varied from 3.49 to 58.54 tons and 0 to 19.31 tons respectively. The cell results were evaluated by highlighting 0.5 tons - 3.63 tons of sediment throughout the watershed, deeming those buffered cells efficient. The cell-by-cell evaluations highlighted specific critical areas of buffer efficiency on a 30-meter resolution where the stream segment and field evaluations identified specific stream segments and fields to target for buffer placement. The AGNPS model along with the Arcview Non-Point Source Model (AVNPSM) GIS interface demonstrates that agricultural watersheds can be quickly and efficiently evaluated to target locations of buffer placement. Therefore, helping watershed managers implement vegetative buffer strips in site-specific areas within the watershed to employ efficient implementation of conservation management programs.
57	Verma, S., 2010	Evaluation of Conservation Drainage Systems in Illinois Bioreactors			IL	n/a, Full text unavailable	bioretention	Y	N	Y	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	Y	Possibly useful, full text unavailable	Intensive cropping patterns coupled with the increased usage of fertilizers and pesticides in Midwestern United States have contributed to the formation of a hypoxic zone in the Gulf of Mexico. Bioreactors are in-situ bioremediation systems which can be used to treat agricultural contaminants in the water from subsurface (tile) drained systems. Over the past few years researchers at the University of Illinois, Urbana-Champaign have installed and monitored several bioreactor sites in Eastern and Central Illinois. The objective of this study is to evaluate the effectiveness of field scale bioreactors in removing nitrates from tile drain systems. The results are indicative that bioreactors are extremely effective in removing nitrates from tile discharge and can play a part in improving water quality from tile drained areas
147	Walker et al., 1993	Preliminary evaluation of effects of best management practices in the Black Earth Creek, Wisconsin, Priority Watershed	Va. Tech/Yagow	USGS	WI	unclear from abstract	conservation reserve, contour, tillage, rotation	Y	Y	N	4-year	before/after	N	Y	Good. Yearly data presented graphically.	Nonpoint-source contamination accounts for a substantial part of the water quality problems in many watersheds. The Wisconsin Nonpoint Source Water Pollution Abatement Program provides matching money for voluntary implementation of various best management practices (BMPs). The effectiveness of BMP s on a drainage-basin scale has not been adequately assessed in Wisconsin by use of data collected before and after BMP implementation. The U.S. Geological Survey, in cooperation with the Wisconsin Department of Natural Resources, monitored water quality in the Black Earth Creek watershed in southern Wisconsin from October 1984 through September 1986 (pre-BMP conditions). BMP implementation began during the summer of 1989 and is planned to continue through 1993. Data collection resumed in fall 1989 and is intended to provide information during the transitional period of BMP implementation (1990-93) and 2 years of post-BMP conditions (1994-95). Preliminary results presented for two subbasins in the Black Earth Creek watershed (Brewery and Garfoot Creeks) are based on data collected during pre-BMP conditions and the first 3 years of the transitional period. The analysis includes the use of regressions to control for natural variability in the data and, hence, enhance the ability to detect changes. Data collected to date (1992) indicate statistically significant differences in storm mass transport of suspended sediment and ammonia N at Brewery Creek. The central tendency of the regression residuals has decreased with the implementation of BMPs; hence, the improvement in water quality in the Brewery Creek watershed is likely a result of BMP implementation. Differences in storm mass transport at Garfoot Creek were not detected, primarily because of an insufficient number of storms in the transitional period. As practice implementation continues, the additional data will be used to determine the level of management which results in significant improvements in water quality in the two watersheds. Future research will address techniques for including snowmelt runoff and early spring storms.
109	Webster et al., 1996	Impact of vegetative filter strips on herbicide loss in runoff from soybean			MS	wheat, soybean	vegetative strips	Y	N	Y	24	experiment/control	Y	N	Good data. Use of rainfall simulator obscures results.	Metolachlor and metribuzin loss in runoff was determined in three soybean tillage systems with and without a 4 by 2 m tall fescue vegetative filter strip. Soil erosion plots were 4 by 22 m with 3% slope. Regression analysis was used to describe herbicide concentration in runoff, and to determine if vegetative filter strips reduced herbicide concentration. Analysis of covariance indicated no difference in concentration of metolachlor or metribuzin in runoff from the three tillage systems within any vegetative filter strip treatment. Metolachlor loss in 1991 was highest from the no-till monocrop without a vegetative filter strip, and it was 65 g/ha or approximately 2 % of the amount applied. In 1992 and 1993, the no-till doublecrop had a total loss of 120 and 147 g/ha, respectively, approximately 4% of the amount applied. Similar results were noted with metribuzin, but total loss was as high as 46 g/ha or 11% of the amount applied in 1993 from a no-till doublecrop system without a vegetative filter strip. When a vegetative filter strip was present, losses of metribuzin and metolachlor were reduced over 85% in 1993, and totaled 1.2 and 0.5%, respectively, of the amount applied. The vegetative filter strip reduced herbicide and suspended solids from runoff produced by a conventional-till production system to levels equal to or lower than a no-till doublecrop system.
110	Yan et al., 1998	Nutrient retention by multipond systems: mechanisms for the control of nonpoint source pollution		National Natural Sciences Foundation of China	China	rice	ponds	Y	N	Y	6	inflow/outflow	Y	Y	Excellent. Event data averaged between replicates	The processes of the multipond system in an experimental agricultural watershed located in southeastern China were studied during a 2-yr period (1994-1995), with the purpose of the research being the reduction of nonpoint nutrient pollution at its sources. The mechanisms studied included water storage capacity, sedimentation, denitrification, and removal of nutrients by the harvest of macrophytes from ponds and ditcher. The results showed that the retention of both water and nutrients depended on the water storage capacity of the ponds, the total pond volume, rainfall, surface runoff, and irrigation amounts. For the years of 1994 and 1995, the water retention rate was 85.5%, while the nutrient retention rate reached 98.1 and 97.8% for total N (TN) and total P (TP), respectively. Sediment deposit was another important mechanism. The average sedimentation rate was 30.0 mm yr-1 (from 1985-1995). For the whole multipond system (35 ha), the average retention amounts reached 9800 kg of N and 2800 kg of P by sediment accumulation per year. The results demonstrated that denitrification in ponds and ditches was an important mechanism for removing N from the watershed. The highest possible rate was more than 0.17 mg N g-1 soil during the summer season. The results suggested that the multipond system, which kept water in balance, benefited the water, nutrient, and sediment recycling in the terrestrial ecosystem, as well as helped to reduce agricultural nonpoint pollution at its sources. Therefore, the multipond system, with its low cost in construction and maintenance, is recommended as a good practice both for the control of nonpoint pollution at its sources and for sustainable agricultural development.
44	Yang, Q., 2010	Using the Soil and Water Assessment Tool to Estimate Achievable Water Quality Targets through Implementation of Beneficial Management Practices in an Agricultural Watershed			Canada	potato, barley, other	fertilization, tillage, crop rotation	Y	N	N	7-year	control/experiment	N	Y	Appears to have useful information	Runoff from crop production in agricultural watersheds can cause widespread soil loss and degradation of surface water quality. Beneficial management practices (BMPs) for soil conservation are often implemented as remedial measures because BMPs can reduce soil erosion and improve water quality. However, the efficacy of BMPs may be unknown because it can be affected by many factors, such as farming practices, land-use, soil type, topography, and climatic conditions. As such, it is difficult to estimate the impacts of BMPs on water quality through field experiments alone. In this research, the Soil and Water Assessment Tool was used to estimate achievable performance targets of water quality indicators (sediment and soluble P loadings) after implementation of combinations of selected BMPs in the Black Brook Watershed in northwestern New Brunswick, Canada. Four commonly used BMPs (flow diversion terraces [FDTs], fertilizer reductions, tillage methods, and crop rotations), were considered individually and in different combinations. At the watershed level, the best achievable sediment loading was 1.9 t/ha yr−1 (89% reduction compared with default scenario), with a BMP combination of crop rotation, FDT, and no-till. The best achievable soluble P loading was 0.5 kg/ha yr−1 (62% reduction), with a BMP combination of crop rotation and FDT and fertilizer reduction. Targets estimated through nonpoint source water quality modeling can be used to evaluate BMP implementation initiatives and provide milestones for the rehabilitation of streams and rivers in agricultural regions.
45	Yates, A., 2007	Effectiveness of best management practices in improving stream ecosystem quality			Canada	corn, grains, soybean, livestock	riparian vegetation, grassed waterway, erosion control	Y	N	N			N	Y	Uses statistical approach to isolate influence of individual BMP types under different scenarios.	Abstract Implementation of best management practices (BMPs), such as improved manure storage, buffer strips, and grassed waterways, through government funded conservation programs is a common approach for mitigation of the impacts agricultural activities have on the surrounding environment. In this study, we tested the ability of these practices to meet the environmental goal of improved stream quality at a ''micro-basin'' scale in the Upper Thames River Watershed, southern Ontario, Canada. Microbasins were first and second order basins, averaging 400 ha in area, representing gradients of land cover, geomorphology, and participation in conservation programs. At the outflow of each micro-basin the benthic macro-invertebrate community was sampled, water chemistry measurements completed, and habitat quality assessed. Results showed micro-basins with relatively high levels of BMP implementation consistently demonstrated improved stream ecosystem quality over the majority of micro-basins with low or no implementation. Streams in the Upper Thames River basin appeared to exhibit a threshold effect, where with several BMPs in the same basin an improvement in stream ecosystem quality is visible. In addition to the BMPs implemented through government funded conservation programs, the observed ecosystem improvements are probably due to increased environmental awareness and improved management by farmers.

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105	Yoo et al., 1988	Runoff, sediment, and nutrient losses from various tillage systems of cotton		TVA, USDA, others	AL	cotton	no-till, cover-crop, conventional	Y	N	Y	15	experiment/control	Y	Y	Excellent event data	Runoff, sediment and nutrient losses were studied from 3 tillage systems of cotton (Gossypium hirsutum L. 'McNair 235'): (1) no-till without a cover crop (NT); (2) reduced-till with a winter wheat (Triticum aestivum L. 'Coker 747') as a cover crop (RTC); (3) conventional-till (CT) in the Tennessee Valley of north Alabama during the 1985 growing season. Runoff samples were collected from natural rainfall events and analyzed for sediment and nutrient losses. Among the 3 tillage systems the RTC system was the most effective in reducing the surface runoff, sediment and nutrient losses while maintaining comparable crop yield. Runoff and sediment concentrations from the CT system were high during the "critical period" (from planting to the last cultivation of the CT system). During the "non-critical period" (between the last cultivation of the CT system to harvesting) sediment concentrations from all tillage systems were relatively low even with high-runoff events. Summer cultivations reduced both surface runoff and sediment concentrations from the CT system. This may signify that a combination of conservation tillage and summer cultivation has the potential for controlling weeds without enhancing soil erosion. Concentration of ammonium N (NH4-N) and soluble-P concentration in surface runoff were higher than the recommended standard level for public water supplies and the growth of algae, respectively. Concentration of nitrate N (NO3-N) in the surface runoff was well within the upper limit for drinking water.
148	Yoo et al., 1989	Runoff and soil loss by crop growth stage under three cotton tillage systems			AL	cotton	tillage	Y	N	N	3-year	experiment/control	Y	Y	Good, yearly means presented	Surface runoff and soil loss under natural rainfall were studied for cotton growth under three tillage systems on small plots in Alabama's Tennessee Valley. Conventional tillage resulted in the highest soil loss, followed by reduced tillage with no cover crop and reduced tillage with a winter wheat cover crop. When the growing season was divided into two periods based on the last cultivation of the conventional tillage, more than 85% of total soil losses occurred in the first period for all treatments. Runoff during the seedbed stage was the highest for conventional tillage; reduced tillage with no cover crop produced the highest runoff in all other crop growth stages. High-intensity rainfall caused more runoff from both reduced tillage treatments than from the conventional tillage treatment. The 3-year average yields of seed cotton were 2,223, 2,123, and 2,076 kg/ha (1,980, 1,890, and 1,850 lbs/acre) for reduced-tillage-with-cover, reduced-tillage-without-cover, and conventional tillage treatments, respectively. Effect of tillage systems on seed cotton yield also varied with years. Conservation tillage systems showed no benefits over the conventional tillage system in yields under drought conditions. The reduced-tillage-with-cover treatment resulted in a severe yield reduction in 1987 after 2 consecutive years of drought before planting and during the critical growth period.
158	Yoo et al., 1989	Effect of conservation tillage systems of cotton on surface runoff and its quality	Va. Tech/Yagow		AL	cotton	tillage	Y	N	N	3-year	experiment/control	N	Y	Good. Yearly means presented	Various tillagesystems for cotton were studied to determine their effects on the quantity and quality of surfacerunoff water under natural rainfall conditions in the Tennessee Valley region of northern Alabama. They included; reduced tillage without a cover crop (RT), reduced tillage with winter wheat as a cover crop (RTC), and conventional tillage (CT). Losses of sediment, plant nutrients, and pesticides were in the order of CT > RT > RTC in 1985. Runoff was the lowest from the RTC system, while the CT and RT systems had similar amounts of runoff. In 1986, runoff from the CT system was the lowest, followed by the RTC and RT systems, while sediment and pesticide losses were in the order of CT > RTC > RT. Mixed results were obtained for the losses of plant nutrients. The growth stage of cotton and the cultivation of the CT system influenced the patterns of runoff and sediment yield. More than 85% of the total sediment yield and 50 to 70% of the runoff approximately occurred during the first 2 months after planting. There were above average yields of seed cotton in 1985 from all systems, with the highest from the RT system. However in 1986, a drought during the critical stage of growth caused a reduction of yield from all systems, with the lowest yield from the RT system. Conservation-tillagesystems were not beneficial to the cotton yield, over the conventional-tillagesystem, under the drought condition.
98	Zeimen et al., 2006	Combining management practices to reduce sediment, nutrients, and herbicides in runoff		many	KS	soybean, sorghum	no-till, chisel-disk till	Y	N	N	4-year	experiment/control	N	Y	Good. Yearly means presented	Best management practices have been recommended for controlling nutrient, herbicide, or sediment losses with surface runoff. This study was designed to determine the best overall combination of tillage and application practices to reduce surface losses from cropland. Runoff was collected from two Kansas sites in sorghum-soybean rotation during the 2001 to 2004 crop years and analyzed for bioavailable P (P), soluble P, total P, ammonium, nitrate, total N (N), sediment, atrazine, and metolachlor concentrations. No-till treatments consistently experienced higher runoff water volumes than the chisel/disk tillage system used to warm and dry these clay soils in the spring. For this reason the no-till treatments also had higher nutrient and herbicide losses than chisel/disk tillage regardless of use of high or low application management techniques. The high included fertilizer and herbicide application practices intended to reduce losses with runoff while the standard application broadcast applied fertilizer and herbicide at planting. Few consistent differences were seen for pollutant loss between the high and standard application management. When average losses for all eight location-years were compared to chisel/disk low, soluble P losses were 3.0 and 2.1 times higher for no-till low and no-till high, respectively; metolachlor losses were 2.4 and 2.7 times higher for no-till low and no-till high, respectively; and atrazine losses were 4.8 and 6.1 times higher for no-till low and no-till high, respectively. The chisel/disk low did experience two times higher sediment losses compared with the no-till low or no-till high, when averaging over all eight location-years. However, tolerable soil loss was not exceeded. Chisel/disk low generally had small losses for all tested pollutants and may be the best management combination to simultaneously reduce nutrient, herbicide, and sediment losses with cropland runoff for sites like those used in this study.
55	Zhang, J., 2005	Estimated Phosphorus Load Reductions under Various Water Management Alternatives			FL	dairy, pasture, row crops, citrus	detention	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	n/a, Full text unavailable	tbd	Full text unavailable, appears to be focused on modeling without water quality monitoring	To determine the detention volume (in terms of an equivalent runoff depth detained) that can provide a P load reduction of approximately 20% at the basin level, the Watershed Assessment Model (WAM) developed by the Soil and Water Technology, Inc. was applied to the four drainage basins that contribute high P loads to Lake Okeechobee. The typical land uses that are suitable to detain water on site include abandoned/closed dairy pasture, citrus groves, dairy pasture, field crop, low and medium density residential areas, improved pasture, unimproved pasture, woodland pasture, and row crops. Scenario one included a water detention depth of 0.25 runoff for all land uses mentioned above, and an estimated 9% load reduction was obtained. Scenario two increased the water detention depth to 0.50 for all land uses except for residential, citrus, field crop, and row crop, resulting in an estimated 18% P load reduction. Therefore, detention depths that range from 0.25 to 0.5 of runoff could be implemented to achieve a basin level of 18% P load reduction.
159	Zhou et al., 1997	Management practices to conserve soil nitrate in maize production systems.	Va. Tech/Yagow		Canada	corn	subirrigation, intercropping	Y	N	N	1-year	experiment/control	N	Y	Good, seasonal means presented	Residual soil N following maize (Zea mays L.) harvest is susceptible to leaching over winter. There is no available information regarding the combination of intercropping system and water table control to conserve soil N in maize production systems. A 2-yr study was conducted to examine the effects of cropping systems (monocrop maize, and maize intercropped with annual Italian ryegrass [Lolium multiflorum Lam.]) and water table controls (free drainage, or subirrigation to establish water table depths at 70 and 80 cm below the soil surface) on conserving soil N, under climatic and soil conditions of southwestern Québec. The resulting six treatments were fertilized in the spring with 270 kg N/ha. The effects of adding fertilizer at 0, 180, and 270 kg N/ha on monocrop maize with free drainage were also investigated. Soil cores of 1 m in depth were collected in the spring and fall of 1993 and 1994. In 1993, intercropping decreased the amount of NO-3-N in the top 1 m of the soil profile by 47% (92.3 kg N/ha) relative to monocropped maize at harvest time. Water table depth had less effect on soil NO-3-N content than cropping system. Both increasing water table depth and monocrop maize enhanced downward movement of NO-3-N during the growing season and following spring. More NO-3-N was present in freely drained subsoil under maize given 270 kg N/ha than under maize given 180 kg N/ha.
50	Zhou, X., 2009	Cost Effectiveness of Conservation Practices in Controlling Water Erosion in Iowa			IA	corn, soybean, pasture, etc.	tillage, grassed waterways, filter strips, terrace systems	Y	Y	N				N	Modeling data for watersheds based on soil type and crop	Iowa has severe water-induced soil erosion and associated water quality concerns because of intense agricultural activities. The objective of this study was to determine the effectiveness and economic benefits of selected conservation practices in sediment reduction by water erosion in major soil areas of Iowa. One farm was selected to represent the typical soil and slope gradient in each of the eight Major Land Resource Areas (MLRAs) in Iowa. Three tillage systems [no-tillage (NT), strip-tillage (ST), and chisel plow tillage (CP)] and three conservation structures [grassed waterways (GS), grass filter strips (FS), and terrace systems (TS)] were investigated under a corn-soybean rotation using the Water Erosion Prediction Project (WEPP) model. Corn yields of some areas were statistically lower under NT than under CP while soybeans showed little response to tillage operations. Estimated annual sediment yield with the chisel plow system ranged between 0.7 and 56.9 T ha 1. The WEPP simulations showed that NT and ST systems were very effective in reducing soil erosion and sediment yield by approximately 90% in highly erodible lands compared to the CP system. The combination of conservation tillage with soil erosion control structures further mitigated soil loss and was more effective in areas with high water erosion potential than in the flat areas. The costs and benefits analysis indicated that the simulated conservation practices could increase the net benefit by up to $300 ha 1 compared to the CP system after the cost of eroded soil was taken into account. The findings suggest that NT and conservation structures have greater environmental and economic benefits in areas with high water erosion potential. The use of no-till in flat areas such as central Iowa may not be economically favorable because of the limited benefit in reducing soil water erosion. Overall, the study findings suggest that structural conservation practices coupled with tillage systems effectiveness were area-specific based on the soil and landscape in each area.

Review Number	Reference (author, year)	Report Title	Other Database Source (if applicable)	Sponsoring Program	Location (s)	Crop(s)	Practices Implemented/ Evaluated	Quantitative Practice Data? (y/n)	Quantitative Watershed Data? (y/n)	Quantitative Event-Based Data (y/n)?	# of Events/ Study Duration	Study Technique (upstream/ downstream, control-reference, before/after, influent/effluent)	Data Tabulated or Electronically Available? (y/n)	Consider for More Detailed Review? (y/n)	Comments	Abstract (*using cut & paste*)
51	Zhou, X., 2009	Cost-effectiveness and cost-benefit analysis of conservation management practices for sediment reduction in an Iowa agricultural watershed			IA	corn, soybean	tillage, grassed waterways, filter strips, terrace systems	Y	Y		4-year		Y	Y	This study included surface runoff measurements	Soil erosion from agricultural lands can be reduced by adoption of conservation management practices. The objectives of this study were to investigate the effectiveness and cost-benefit of conservation management practices on sediment reduction under a corn-soybean rotation. The experimental site was 6.4 ha (15.8 ac) and located within the Four Mile Creek watershed in eastern Iowa. Management practices consisted of tillage with a moldboard plow with a row cropped system of corn and soybeans. Annual sediment yield from this site was estimated using the Water Erosion Prediction Project (WEPP) model for three tillage systems (chisel plow, disk tillage, and no-tillage) as well as three conservation structures (grassed waterways, filter strips, and terraces). The WEPP model was validated using five-year (1976 to 1980) field-measured sediment yield and surface runoff data. Without supplemental conservation measures, predicted sediment yield was 22.5, 17.7, and 3.3 t/ha/yr (10.0, 7.9, and 1.5 tn/ac/yr) from chisel plow, disk tillage, and no-tillage, respectively. Supplemental conservation measures had the most impact on sediment yield reduction when used in conjunction with chisel plow management and the smallest impact with the no-tillage system. The value of lost soil resulting from soil erosion ranged between $10.9 and $137.3/ha/yr ($4.4 and $55.6/ac/yr) for the simulated scenarios in the study when a soil value of $6.1/t ($5.5/tn) was considered. When factoring in the value of soil, no-tillage was the most efficient practice with the highest net benefit of $94.5/ha/yr ($38.2/ac/yr). This study indicated that the economic value of soil that is lost should be considered in the cost-benefit assessment of conservation practices in order to reflect the true value of the conservation practices in the long term.
106	Zhu et al., 1989	Runoff, soil, and dissolved nutrient losses from no-till soybean with winter cover crops		USDA-ARS	MO	soybean, chickweed, bluegrass, brome	no-till, cover-crop	Y	N	Y	4-year	experiment/control	N	Y	Good. Yearly means presented	Soils are more vulnerable to erosion following cropping to soybean (Glycine max [L.] Merr.) than corn (Zea mays L.). This has been attributed to lower dry matter production, less residue cover, and soil-loosening action by soybean roots. To augment soil cover, common chickweed (Stellaria media L.), Canada bluegrass (Poa compressa L.), and downy brome (Bromus tectorum L.) were grown as winter cover crops with no-till soybean on natural rainfall erosion plots located on a poorly drained Mexico claypan soil (Udollic Ochraqualf). No-till soybean without a cover crop served as the check. Winter cover crops significantly increased soil cover by 30 to 50% during the critical erosion period of late spring to early summer. Compared to the check, mean annual soil losses from the chickweed, downy brome, and Canada bluegrass were decreased by 87, 95, and 96%, and runoff was reduced 44, 53, and 45%, respectively. Dissolved NH+4 concentration in runoff from cover crops was 1.61 to 3.72 times more, and dissolved PO3-4 was 1.61 to 2.86 times more than that of the check. However, runoff from the check plots had 96 to 117% greater concentration of dissolved NO-3 than cover crop plots. Mean annual dissolved nutrient losses were decreased 7 to 77% by using winter cover crops. Thus, winter cover crops were very effective in reducing soil erosion and dissolved nutrient losses from no-till soybean.

Attachment 2. NRCS Conservation Practices Standards

Conservation Practice Name (Units) (Code) (Date Issued)	PDF	Word	Info. Sheet	CPPE	Job Sheet	National Statement of Work Template	Network Effects Diagram	NRCS CODE #
Access Control (Ac.) (472) (9/10)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	472
Access Road (Ft.) (560) (7/10)	PDF	DOC	PDF	DOC		DOC	PDF	560
Agrichemical Handling Facility (No.) (309) (2/08)	PDF	DOC	PDF	DOC		DOC	PDF	309
Air Filtration and Scrubbing (No.) (371) (4/10)	PDF	DOC				DOC		371
Alley Cropping (Ac.) (311) (5/11)	PDF	DOC		DOC	DOC	DOC	PDF	311
Amendments for Treatment of Agricultural Waste (AU) (591) (4/05)	PDF	DOC		DOC			PDF	591
Anaerobic Digester (No.)(366) (9/09)	PDF	DOC	PDF	DOC		DOC	PDF	366
Animal Mortality Facility(No.) (316) (9/10)	PDF	DOC		DOC		DOC	PDF	316
Animal Trails and Walkways (Ft.) (575) (4/10)	PDF	DOC	PDF	DOC		DOC	PDF	575
Anionic Polyacrylamide (PAM) Application (Ac.)(450) (5/11)	PDF	DOC		DOC		DOC		450
Aquaculture Ponds (Ac.)(397) (1/10)	PDF	DOC	PDF	DOC		DOC		397
Aquatic Organism Passage (Mi.) (396) (4/11)	PDF	DOC				DOC	PDF DOC	396
Bedding (Ac.) (310) (7/10)	PDF	DOC	PDF	DOC		DOC	PDF	310
Bivalve Aquaculture Gear and Biofouling Control (Ac.) (400) (4/11)	PDF	DOC				DOC		400
Brush Management (Ac.)(314) (9/09)	PDF	DOC	PDF	DOC		DOC	PDF	314
Channel Bed Stabilization(Ft.) (584) (9/10)	PDF	DOC	PDF	DOC		DOC		584
Clearing and Snagging(Ft.) (326) (7/10)	PDF	DOC	PDF	DOC		DOC		326
Combustion System Improvement (No.) (372) (4/10)	PDF	DOC				DOC		372
Composting Facility (No.)(317) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	317
Conservation Cover (Ac.)(327) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	327
Conservation Crop Rotation (Ac.) (328) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	328
Constructed Wetland (Ac.)(656) (7/10)	PDF	DOC		DOC		DOC	PDF	656
Contour Buffer Strips (Ac.)(332) (4/10)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	332
Contour Farming (Ac.)(330) (6/07)	PDF	DOC	PDF	DOC		DOC	PDF	330
Contour Orchard and Other Perennial Crops(Ac.) (331) (1/10)	PDF	DOC	PDF	DOC		DOC	PDF	331
Cover Crop (Ac.) (340) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	340
Critical Area Planting (Ac.)(342) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	342
Cross Wind Ridges (Ac.)(588) (9/08)	PDF	DOC	PDF	DOC	DOC	DOC		588
Cross Wind Trap Strips(Ac.) (589C) (4/11)	PDF	DOC	PDF	DOC	DOC	DOC		589C
Dam (No. and Ac-Ft) (402) (5/11)	PDF	DOC	PDF	DOC		DOC		402
Dam, Diversion (No.) (348) (5/11)	PDF	DOC	PDF	DOC		DOC		348
Deep Tillage (Ac.) (324) (11/08)	PDF	DOC		DOC	DOC	DOC	PDF	324
Dike (Ft.) (356) (11/02)	PDF	DOC	PDF	DOC		DOC	PDF	356
Diversion (Ft.) (362) (4/10)	PDF	DOC	PDF	DOC		DOC	PDF	362
Drainage Water Management (Ac.) (554) (9/08)	PDF	DOC		DOC		DOC	PDF	554
Dry Hydrant (No.) (432) (9/11)	PDF	DOC		DOC		DOC		432
Dust Control from Animal Activity on Open Lot Surfaces (Ac.) (375) (9/10)	PDF	DOC				DOC		375
Dust Control on Unpaved Roads and Surfaces (Sq. Ft.) (373) (4/10)	PDF	DOC				DOC		373
Early Successional Habitat Development/Management(Ac.) (647) (9/10)	PDF	DOC		DOC		DOC	PDF	647
Farmstead Energy Improvement (No.) (374) (5/11)	PDF	DOC				DOC		374
Feed Management (No. of Systems and AUs Affected) (592) (9/11)	PDF	DOC		DOC		DOC		592
Fence (Ft.) (382) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	382
Field Border (Ac.) (386) (9/10)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	386
Filter Strip (Ac.) (393) (9/10)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	393
Firebreak (Ft.) (394) (9/10)	PDF	DOC		DOC		DOC	PDF	394
Fish Raceway or Tank (Ft. and Ft^3) (398) (9/09)	PDF	DOC	PDF	DOC		DOC		398
Fishpond Management(Ac.) (399) (9/11)	PDF	DOC	PDF	DOC		DOC		399
Forage and Biomass Planting (Ac.) (512) (1/10)	PDF	DOC	PDF	DOC		DOC		512
Forage Harvest Management (Ac.) (511) (4/10)	PDF	DOC	PDF	DOC		DOC	PDF	511
Forest Stand Improvement(Ac.) (666) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	666
Forest Trails and Landings(Ac.) (655) (9/11)	PDF	DOC	PDF	DOC		DOC	PDF	655
Fuel Break (Ac.) (383) (4/05)	PDF	DOC		DOC		DOC	PDF	383
Grade Stabilization Structure (No.) (410) (10/85)	PDF	DOC	PDF	DOC		DOC	PDF	410
Grassed Waterway (Ac.)(412) (4/10)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	412
Grazing Land Mechanical Treatment (Ac.) (548) (9/10)	PDF	DOC		DOC		DOC		548
Heavy Use Area Protection(Ac.) (561) (1/10)	PDF	DOC	PDF	DOC		DOC	PDF	561
Hedgerow Planting (Ft.)(422) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	422
Herbaceous Weed Control (315) (Ac.) (4/10)	PDF	DOC				DOC	PDF	315
Herbaceous Wind Barriers(Ft.) (603) (1/10)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	603
Hillside Ditch (Ft.) (423) (5/08)	PDF	DOC	PDF	DOC		DOC		423
Integrated Pest Management (Ac.) (595) (1/10)	PDF	DOC	PDF	DOC		DOC		595
Irrigation Canal or Lateral(Ft.) (320) (9/10)	PDF	DOC	PDF	DOC		DOC		320
Irrigation Ditch Lining (Ft.)(428) (5/11)	PDF	DOC	PDF	DOC		DOC		428
Irrigation Field Ditch (Ft.)(388) (4/11)	PDF	DOC	PDF	DOC		DOC		388
Irrigation Land Leveling(Ac.) (464) (9/10)	PDF	DOC	PDF	DOC		DOC		464
Irrigation Pipeline (Ft.)(430) (5/11)	PDF	DOC	PDF	DOC		DOC	DOC	430

Attachment 2. NRCS Conservation Practices Standards

Conservation Practice Name (Units) (Code) (Date Issued)	PDF	Word	Info. Sheet	CPPE	Job Sheet	National Statement of Work Template	Network Effects Diagram	NRCS CODE #
Irrigation Reservoir (Ac-Ft) (436) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	436
Irrigation System, Microirrigation (Ac.) (441) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	441
Irrigation System, Sprinkler (Ac.) (442) (5/11)	PDF	DOC	PDF	DOC			PDF	442
Irrigation System, Surface and Subsurface (Ac.) (443) (5/11)	PDF	DOC	PDF	DOC		DOC		443
Irrigation System, Tailwater Recovery (No.)(447) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	447
Irrigation Water Management (Ac.) (449) (5/11)	PDF	DOC	PDF	DOC		DOC	DOC	449
Karst Sinkhole Treatment (No.) (527) (9/10)	PDF	DOC		DOC		DOC	PDF	527
Land Clearing (Ac.) (460) (9/11)	PDF	DOC	PDF	DOC		DOC	PDF	460
Land Reclamation, Abandoned Mined Land(Ac.) (544) (8/06)	PDF	DOC	PDF	DOC		DOC	DOC	544
Land Reclamation, Currently Mined Land (Ac.)(544) (8/06)	PDF	DOC	PDF	DOC		DOC	DOC	544
Land Reclamation, Landslide Treatment (No. and Ac) (453) (2/05)	PDF	DOC		DOC		DOC	DOC	453
Land Reclamation, Toxic Discharge Control (No.)(455) (4/05)	PDF	DOC	PDF	DOC		DOC	DOC	455
Land Smoothing (Ac.)(466) (7/02)	PDF	DOC	PDF	DOC		DOC	PDF	466
Lined Waterway or Outlet(Ft.) (468) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	468
Livestock Pipeline (Ft.) (516) (9/11)	PDF	DOC	PDF	DOC		DOC	PDF	516
Mine Shaft and Adit Closing (No.) (457) (2/05)	PDF	DOC	PDF	DOC		DOC	DOC	457
Mole Drain (Ft.) (482) (3/03)	PDF	DOC		DOC		DOC	DOC	482
Monitoring Well (No.) (353) (9/10)	PDF	DOC		DOC		DOC		353
Mulching (Ac.) (484) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	484
Multi-Story Cropping (Ac.) (379) (7/10)	PDF	DOC		DOC		DOC	PDF	379
Nutrient Management (Ac.)(590) (1/12)	PDF	DOC	PDF	DOC	PDF	DOC	PDF	590
Obstruction Removal (Ac.)(500) (1/10)	PDF	DOC	PDF	DOC		DOC		500
Open Channel (Ft.) (582) (10/87)	PDF	DOC	PDF	DOC		DOC	PDF	582
Pond (No.) (378) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	378
Pond Sealing or Lining, Bentonite Treatment (No.)(521C) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	521C
Pond Sealing or Lining, Compacted Clay Treatment (No.) (521D) (9/10)	PDF	DOC		DOC		DOC	PDF	521D
Pond Sealing or Lining, Flexible Membrane (No.)(521A) (9/11)	PDF	DOC	PDF	DOC		DOC	PDF	521A
Pond Sealing or Lining, Soil Dispersant Treatment(No.) (521B) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	521B
Precision Land Forming(Ac.) (462) (7/02)	PDF	DOC	PDF	DOC		DOC		462
Prescribed Burning (Ac.)(338) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	338
Prescribed Grazing (Ac.)(528) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	528
Pumping Plant (No.) (533) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	533
Range Planting (Ac.) (550) (4/10)	PDF	DOC	PDF	DOC		DOC	DOC	550
Recreation Area Improvement (Ac.) (562) (10/77)	PDF	DOC	PDF	DOC		DOC	PDF	562
Recreation Land Grading and Shaping (Ac.) (566) (4/02)	PDF	DOC	PDF	DOC		DOC	PDF	566
Residue and Tillage Management, Mulch Till(Ac.) (345) (5/11)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	345
Residue and Tillage Management, No-Till/Strip Till/Direct Seed (Ac.) (329) (5/11)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	329
Residue and Tillage Management, Ridge Till(Ac.) (346) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	346
Residue Management, Seasonal (Ac.) (344) (5/11)	PDF	DOC	PDF	DOC		DOC	DOC	344
Restoration and Management of Rare and Declining Habitats (Ac.)(643) (9/10)	PDF	DOC		DOC		DOC	PDF	643
Riparian Forest Buffer (Ac.)(391) (7/10)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	391
Riparian Herbaceous Cover (Ac.) (390) (9/10)	PDF	DOC		DOC		DOC	PDF	390
Road/Trail/Landing Closure and Treatment (Ft.) (654) (11/08)	PDF	DOC		DOC		DOC	PDF	654
Rock Barrier (Ft.) (555) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	555
Roof Runoff Structure (No.)(558) (9/09)	PDF	DOC	PDF	DOC		DOC	PDF	558
Roofs and Covers (No.)(367) (9/10)	PDF	DOC		DOC		DOC	PDF	367
Row Arrangement (Ac.)(557) (11/02)	PDF	DOC	PDF	DOC		DOC	PDF	557
Salinity and Sodic Soil Management (Ac.) (610) (9/10)	PDF	DOC		DOC		DOC	DOC	610
Sediment Basin (No.) (350) (1/10)	PDF	DOC	PDF	DOC		DOC	PDF	350
Shallow Water Development and Management (Ac.) (646)(9/10)	PDF	DOC		DOC		DOC	PDF	646
Silvopasture Establishment (Ac.) (381) (5/11)	PDF	DOC		DOC		DOC	PDF	381
Solid/Liquid Waste Separation Facility (No.) (632) (4/05)	PDF	DOC		DOC			PDF	632
Spoil Spreading (Ac.) (572) (1/10)	PDF	DOC	PDF	DOC		DOC	PDF	572
Spring Development (No.)(574) (5/06)	PDF	DOC	PDF	DOC		DOC	PDF	574
Stormwater Runoff Control (No. and Ac.) (570) (9/10)	PDF	DOC	PDF	DOC		DOC		570
Streambank and Shoreline Protection (Ft.) (580) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	580
Stream Crossing (No.) (578) (9/11)	PDF	DOC		DOC		DOC	PDF	578
Stream Habitat Improvement and Management (Ac.)(395) (9/10)	PDF	DOC		DOC		DOC	PDF	395
Stripcropping (Ac.) (585) (9/08)	PDF	DOC	PDF	DOC		DOC	PDF	585
Structure for Water Control (No.) (587) (4/10)	PDF	DOC	PDF	DOC		DOC	PDF	587
Subsurface Drain (Ft.)(606) (9/11)	PDF	DOC	PDF	DOC		DOC	PDF	606

Attachment 2. NRCS Conservation Practices Standards

Conservation Practice Name (Units) (Code) (Date Issued)	PDF	Word	Info. Sheet	CPPE	Job Sheet	National Statement of Work Template	Network Effects Diagram	NRCS CODE #
Surface Drain, Field Ditch(Ft.) (607) (9/09)	PDF	DOC	PDF	DOC		DOC	PDF	607
Surface Drain, Main or Lateral (Ft.) (608) (9/09)	PDF	DOC	PDF	DOC		DOC	PDF	608
Surface Roughening (Ac.)(609) (9/09)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	609
Trails and Walkways (Ft.)(568) (1/10)	PDF	DOC	PDF	DOC		DOC	PDF	568
Terrace (Ft.) (600) (4/10)	PDF	DOC	PDF	DOC		DOC	PDF	600
Tree/Shrub Establishment(Ac.) (612) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	612
Tree/Shrub Pruning (Ac.)(660) (1/06)	PDF	DOC	PDF	DOC		DOC	PDF	660
Tree/Shrub Site Preparation (Ac.) (490) (1/06)	PDF	DOC	PDF	DOC		DOC	PDF	490
Underground Outlet (Ft.)(620) (9/10)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	620
Upland Wildlife Habitat Management (Ac.) (645) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	645
Vegetated Treatment Area(Ac.) (635) (5/08)	PDF	DOC		DOC		DOC	PDF	635
Vegetative Barrier (Ft.)(601) (1/10)	PDF	DOC		DOC	DOC	DOC	PDF	601
Vertical Drain (No.) (630) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	630
Waste Facility Closure (No.) (360) (4/11)	PDF	DOC		DOC		DOC		360
Waste Recycling (Ac.) (633) (5/11)	PDF	DOC	PDF	DOC		DOC	PDF	633
Waste Storage Facility(No.) (313) (10/03)	PDF	DOC	PDF	DOC		DOC	PDF	313
Waste Transfer (No.) (634) (11/08)	PDF	DOC	PDF	DOC	DOC	DOC		634
Waste Treatment (No.) (629) (4/05)	PDF	DOC		DOC		DOC	PDF	629
Waste Treatment Lagoon(No.) (359) (10/03)	PDF	DOC	PDF	DOC		DOC	PDF	359
Water and Sediment Control Basin (No.) (638) (9/08)	PDF	DOC	PDF	DOC	DOC	DOC	PDF	638
Water Harvesting Catchment (No.) (636) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	636
Water Well (No.) (642) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	642
Water Well Decommissioning (No.)(351) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	351
Watering Facility (No.)(614) (9/10)	PDF	DOC		DOC		DOC	PDF	614
Waterspreading (Ac.)(640) (7/02)	PDF	DOC	PDF	DOC		DOC	PDF	640
Well Water Testing (No.)(355) (9/10)	PDF	DOC		DOC		DOC		355
Wetland Creation (Ac.)(658) (9/10)	PDF	DOC		DOC		DOC	PDF	658
Wetland Enhancement(Ac.) (659) (9/10)	PDF	DOC		DOC		DOC	PDF	659
Wetland Restoration (Ac.)(657) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	657
Wetland Wildlife Habitat Management (Ac.) (644) (9/10)	PDF	DOC	PDF	DOC		DOC	PDF	644
Windbreak/Shelterbelt Establishment (Ft.) (380) (5/11)	PDF	DOC	PDF	DOC	DOC	DOC	380 and 650(PDF, 85KB)	380
Windbreak/Shelterbelt Renovation (Ft.) (650) (7/10)	PDF	DOC	PDF	DOC		DOC	380 and 650(DOC, 96KB)	650
Woody Residue Treatment (Ac.) (384) (5/11)	PDF	DOC		DOC		DOC	PDF	384

Attachment 3. Virginia Tech Agricultural BMP Database (2002)
(Provided by Dr. Gene Yagow, Biological and Agricultural Engineering Department)

Order	Table	Field	Description
1	Articles	ArticleID	Unique number automatically assigned to each article
2	Articles	LastName	Last name of the primary author
3	Articles	FirstName	First name or initials of the primary author
4	Articles	AuthorList	List of authors in citation format
5	Articles	PY	Year of publication
6	Articles	Title	Article title
7	Articles	Source	Journal name, volume and pages; publisher and document number; proceedings; or other source description
8	Articles	Abstract	Published abstract or article overview
9	Articles	Keywords	Descriptive identifiers
10	Articles	Reviewer	Person extracting data from articles
11	Articles	ReviewDate	Date of review
12	Articles	DBASEcheck	Person checking review and data entries
13	Articles	CheckDate	Date of checking
14	Study Sites	LocationID	Unique number automatically assigned to each study site/article combination
15	Study Sites	City	City nearest to study site
16	Study Sites	State	State where study site is located
17	Study Sites	Region	Name of special region, if applicable
18	Study Sites	Nutrient EcoRegion	Manually interpreted EPA Level III Ecoregion Codes used for the National Nutrient Strategy
19	Study Sites	BeginDate	Beginning date of the study (mm/yy)
20	Study Sites	EndDate	Ending date of the study (mm/yy)
21	Study Sites	Soil Series	List of predominant soil series and/or Great Groups
22	Study Sites	Study Design	Experimental design of the study
23	Study Sites	Water Source	Source of water inputs to the study area
24	Study Sites	Acreage	Drainage area of the study site (acres)
25	Study Sites	Notes	Miscellaneous information about the study
26	BMPs	BMP ID	Unique number automatically assigned to each BMP/study site combination
27	BMPs	Treatment Site	Plot, watershed, station or treatment code used at the study site
28	BMPs	Description	Short description of the treatment, including land use, if appropriate
29	BMPs	ExpUnitType	Is the data for this entry used as a control? Or as a BMP treatment to be evaluated?
30	BMPs	Comparison	If this entry is for a treatment, the BMP ID of its comparison control
31	BMPs	BMP Type	USDA-NRCS or other BMP category designation
32	BMPs	BMP Acreage	Extent of the installed BMP
33	BMPs	Acres Benefited	Acreage whose pollutant contribution is impacted by the BMP
34	BMPs	CapCostUnits	Units of the cost rate
35	BMPs	CapCostRate	Cost per area, length, or other measure
36	BMPs	Capital Cost	Cost of installing or implementing the BMP
37	BMPs	AnnCostUnits	Units of the annual operating cost
38	BMPs	AnnCostRate	Annual operating cost rate
39	BMPs	Annual Cash Cost	Annual operation and maintenance cost of the BMP
40	BMPs	Practice Life	Design life of the BMP
41	BMPs	YieldUnits	Units of the reported yield
42	BMPs	YieldLow	Low end of yield range
43	BMPs	YieldAve	Average yield
44	BMPs	YieldHi	High end of yield range
45	BMPs	NetRetUnits	Units of net return
46	BMPs	NetRetLow	Low end of net returns range

Attachment 3. Virginia Tech Agricultural BMP Database (2002)
(Provided by Dr. Gene Yagow, Biological and Agricultural Engineering Department)

Order	Table	Field	Description
47	BMPs	NetRetAve	Average net return
48	BMPs	NetRetHi	High end of net returns range
49	BMPs	Risk Impact	Relative impact of BMP on perceived risk
50	BMPs	Risk Impact Explanation	Logical basis for the relative risk
51	BMPs	CEunits	Units of cost-effectiveness
52	BMPs	CE-N	Cost-effectiveness per measure of nitrogen
53	BMPs	CE-P	Cost-effectiveness per measure of phosphorus
54	Measurements	PollutantID	Unique number automatically assigned to each pollutant/BMP combination
55	Measurements	PollutantType	Name of the specific nutrient or other pollutant
56	Measurements	Flow Regime	Location of water sample - surface, subsurface, combined
57	Measurements	Data Category	Measurement category - concentration, depth, load, volume, UAL, UAV, etc.
58	Measurements	Value Transform	Transformation used to summarize data, e.g. mean, total, median, geometric mean, etc.
59	Measurements	Value Period	Time period over which data transformation is reported
60	Measurements	Unit	Units in which the data measurement is reported
61	Measurements	ValueLow	Low end of measurement range
62	Measurements	ValueAve	Average measurement
63	Measurements	ValueHigh	High end of measurement range
64	Measurements	RedLow	Low end of reported reduction range
65	Measurements	RedAve	Average reported reduction
66	Measurements	RedHigh	High end of reported reduction range
67	Measurements	RedSignificance	Significance of the reduction (Y/N)
68	Measurements	RedStats	Statistical test for significance
69	Measurements	MeaAv	Average treatment measurement
70	Measurements	RedAv	Average reported treatment reduction
71	Primary Author	LastName	Last name of author
72	Primary Author	FirstName	First name or initials of author
73	Primary Author	UniversityOrEmployer	Name of university of other employer
74	Primary Author	DeptOrUnit	Name of department, branch or other employment division, if applicable
75	Primary Author	Address	Street address
76	Primary Author	City	
77	Primary Author	State	
78	Primary Author	PostalCode	Mail Zip code
79	Primary Author	EmailAddress	
80	Primary Author	WebSite	