Final Report to Ohio Lake Erie Commission

Project Title: A Decision Support System to Integrate Watershed and Transportation Planning in Northeast Ohio

LG File #: 02-15

Recipient: Cuyahoga River Community Planning Organization (CRCPO)

Project Amount: $100,000

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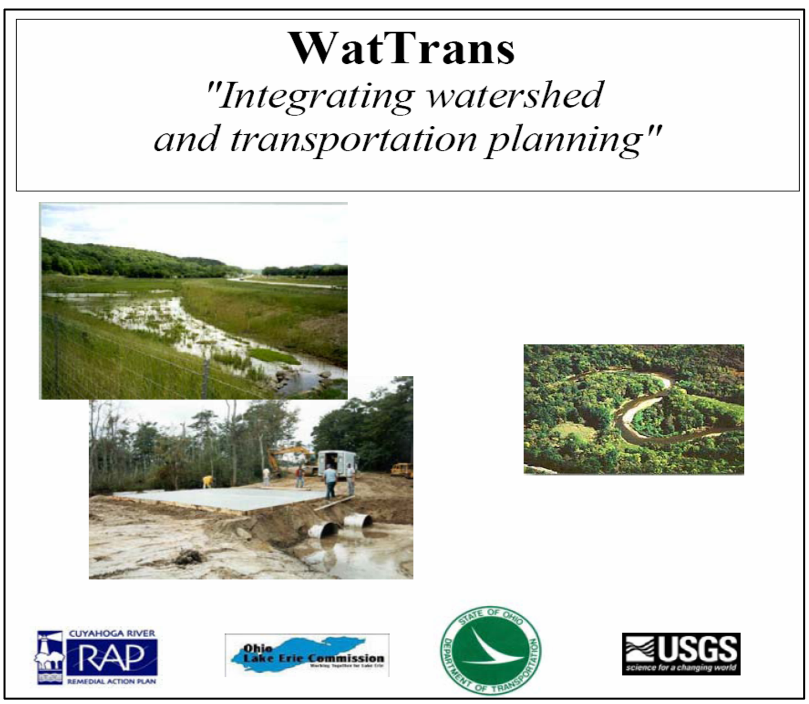

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Abstract

The project goal was to support the development of a decision support system (DSS) to help transportation planners and designers take watershed based environmental impacts into consideration in the planning, evaluation and analysis of transportation infrastructure projects. The project was intended as a *pilot project* targeting the transportation planning community. A DSS is a computer-based "smart map" or "spatial database" where GIS information about the map features can be viewed, analyzed, and manipulated. The DSS provides environmental information in a visual and tabular form about the study area and affected watersheds. Based on this information users can better avoid or minimize some of the negative effects of transportation development. The DSS was developed as an early planning tool with a suite of potential Best Management Practices (BMPs) to help raise awareness of the types of things that can be done to avoid or minimize the negative effects of the transportation project to the environment.

Organization

The Cuyahoga River Community Planning Organization (CRCPO) is the 501c3 financial parent for the Cuyahoga River Remedial Action Plan (RAP). CRCPO is also the lead community partner administering the Cuyahoga American Heritage River Initiative (AHRI). CRCPO implements RAP programs. *Our Core mission is to lead development of tributary-based watershed stewardship plans that support actions leading to the recovery of the Cuyahoga River AOC.*

Project Synopsis

The CRCPO/ RAP was a partner in two closely related grant projects: one from Ohio Lake Erie Commission through the Lake Erie Protection Fund and one from USEPA; both aimed at supporting the development of a computer based tool (using GIS data) to help transportation planners and designers take watershed based environmental impacts into consideration in the planning, evaluation and analysis of transportation infrastructure projects. The focus of the nearly 3-year project is the Lake Erie Watershed of the Cuyahoga and adjacent rivers. Application of the tool is intended for Local and Regional projects.

Project Partners
Cuyahoga River Community Planning Organization
US Environmental Protection Agency
US Geological Survey
Ohio Department of Transportation
Northeast Ohio Areawide Coordinating Agency

USGS provided the principle development of the computer base tool.

The Principle Role of CRCPO:

A) To develop and host a series of workshops to establish a shared level of understanding regarding the kinds of effects that transportation development can have on a watershed

B) Identify the kinds of GIS and Landsat information that may be available to help identify and understand these effects. The project includes consolidation of Data in to usable layers as part of a computer based tool. Data included the entire vicinity of the Cuyahoga Watershed.

C) Identify the kinds of measures or BMP's that might be appropriate to consider to help mitigate the negative effects.

D) Use the workshops to solicit input and feedback regarding the content and usability of the computer-based tool from the transportation design and development community.

Project Sequence and Goals

1. Assemble GIS and Landsat data in CDROM with a written inventory of content and source of data.
2. Prepare explanations regarding potential utility and applicability of data for groups review and comment.
3. Hold a series of workshops for transportation planning and design personnel to solicit feedback regarding the format, structure and data content of the proposed DSS tool.
4. Develop a series of explanation and procedure guides to direct the format and content of the DSS tool to be developed.

Applicability

The tool can be the model for a larger Lake Basin–based tool for the future: If GIS data management issues can be overcome, this tool and format can be a model Decision Support tool for the Lake Erie basin. We believe it will be very useful for the OLEC Balanced Growth Initiative Pilot Projects, such as the **Chippewa Creek Balanced Growth Project.**

The tool will be very useful resource for the CRCPO watershed planning projects: Beyond supporting the development of the DSS, the CRCPO and RAP plan to take full advantage of the tool's capabilities as we look to support a variety of watershed planning efforts with a variety Tributary-based watershed organizations in the Cuyahoga Watershed.

Background and Problem Identification

Urbanization pressures in northeastern Ohio threaten the health and functionality of the surrounding ecosystems and watersheds. A watershed-based approach to planning is an important means to ensure balanced growth. Through such an approach, the continued development of Northeast Ohio can be balanced with conservation of critical natural resources and the needs of the environment.

Currently, the Northeast Ohio Areawide Coordinating Agency's (NOACA) transportation planning division has no system-level watershed planning tools available. As part of its Transportation Plan, the *Framework for Action 2025*, NOACA is in the process of forming a task force to investigate the water-quality impacts of transportation investments. At the project level, NOACA has incorporated watershed considerations into its review process since the passage of the Transportation Equity Act for the 21st Century; however, efforts could be enhanced with improved Geographic Information System (GIS) capabilities.
The Ohio Department of Transportation (ODOT) includes environmental scoping in their new sixteen-step transportation development process. This process includes an analysis of the locally affected environmental, social, and cultural resources (ODOT, 2002).

A watershed-based approach to planning involves multiple elements, among which are a focus on water and natural processes, an understanding of the environmental consequences of urbanization, and the development of a mechanism through which decision-makers can consider planning alternatives intelligently. Foremost, this approach to planning recognizes the importance of water. The presence, quality, and quantity of water are the most critical components in preserving and maintaining habitats for local species, including humans. Watershed-based planning respects water's adherence to the laws of physics; water and water flow do not recognize political boundaries.

Local officials and transportation planners need to operate from a shared level of knowledge regarding environmental conditions and opportunities. An awareness of natural processes, such as the flow of water, will help planners design responsible plans. Natural solutions such as wetlands can be inexpensive to maintain, can minimize the detrimental effects of pesticides and fertilizers, and can mitigate some of the effects of increased imperviousness by retaining runoff. An awareness of the watershed-specific environmental factors is a vital step towards comprehensive watershed-based planning. Urbanization, especially through its effect on imperviousness, can drastically alter the future viability of streams:

- As imperviousness increases, the frequency of flooding and risk of property loss increases.
- Stream-channel geometry changes as a result of hydrologic alterations. This can negatively affect the riparian and stream-bottom habitat
- Urbanization can lead to an increase in water temperature, which affects habitat.
- Urbanization can lead to an increase in pollutants and nutrients entering streams.

A watershed-based approach to planning recognizes the possible effects of urbanization. Watershed planning objectives encourage techniques to mitigate increasing imperviousness, protect important natural areas, and improve the linkage of citizens to nature. Planning on a watershed level encourages collaborative regional approaches for managing storm water and flooding, because watersheds typically cross over various political boundaries.

An overall environmental assessment of a watershed would help decision makers understand the existing conditions and potential courses of action that may be available. Assembling GIS data in one format and location and developing a decision support system (DSS) to guide the decision makers would facilitate the environmental assessment and thus increase data availability and usability. The assessment could be a basis to identify and focus attention on issues in the watershed. Assembled data could be an important mechanism for educating local officials and transportation planners about environmental issues. For example, using GIS-based biological data, a decision support tool could be designed to prioritize and evaluate existing green space plans or identify the cumulative impacts of constructing a road.

Project Objectives

The overall goal of the project was to develop a decision support system computer tool that focuses on the diverse and sometimes competing transportation and environmental needs in northeastern Ohio. The DSS would facilitate the early integration of information about natural resources, cultural resources, and the environment early in the planning process. The study area includes the watersheds of the Cuyahoga, Chagrin, Black, and Rocky Rivers located primarily in Lake, Cuyahoga, Lorain, Summit, Medina, Geauga, and Portage Counties.

The project serves as a model for transferring the concept into other regions and watersheds of the Great Lakes. Specific objectives include the following:

1. Develop a GIS to integrate watershed data with transportation-relevant data. This GIS includes many layers of biological, physical, hydrologic and cultural data.

2. Develop a GIS-based DSS to allow users to select, view, and retrieve spatially referenced natural and cultural information about the user-defined area. The custom reports generated through this application will be based on the GIS data and will serve as a decision-support tool.

3. Test the DSS for applicability to NOACA's and other community transportation planning processes.

4. Evaluate the feasibility of applying the methods described herein on a larger basin- or statewide level.

Project Accomplishments

Increased Knowledge Among Partners: Expanded the level of knowledge among all participants during meetings and workshops. Both the environmental and transportation community became more knowledgeable about both each other's discipline and improvements needed in their own

Generated User Feedback**:** Workshops provided valuable feedback that helped shape the DSS tool. The workshops included presentations on the effects of transportation on watersheds and the DSS tool's features. Project partners provided an overview of sample applications and user feedback was sought regarding the tool's potential utility and limitations.

Efficient Project Development: Project team researched other DSS examples nationwide. This process helped generate ideas and expanded the usefulness of the final product. Identified critical natural areas

Assembled Best Management Practices**:** All of the most reliable and effective best management practices were assembled in this tool. The BMPs were organized into three primary categores: 1)BMPs for Water Quality; 2) BMPs for Hydrology and 3) BMPs for Habitat. The intended purpose of providing BMPs to the user was to inform the project manager of their options during later engineered and development phases.

Supports the Ohio Lake Erie Commissions Balanced Growth Initiative: The DSS project was designed with the ultimate needs of the Lake Erie Balanced Growth Initiative in mind. The tool will provide support for an upcoming Chippewa Creek Balanced Growth Initiative Project. This tool can help bridge the gap between the goals of the Balanced Growth Initiative and the local communities, by highlighting suitable for suitable for development and/or conservation.

Identified Critical Natural Areas: Critical Natural Areas represent portions of the landscape within this Decision Support System (DSS), that when disturbed, have the potential to adversely affect the ecosystem and human health functions of our surface water natural resources.
Critical natural areas are based on a combination of one or more of the following:

- **Floodplains**- are defined as being within the FEMA's 100-year floodplain
- **Steep slopes**- slopes greater than 15% or 8.5 degrees
- **Forest**- areas defined as forested by the National Landcover Dataset
- **Wetlands**- areas defined as wetlands by the National Landcover Dataset
- **Stream Buffer**- 100 meters on each side, from the center of a river
- **Wetland Buffer**- 100 meters surrounding the wetland

Assembled Relevant GIS Data onto an Interactive CD Program: The GIS data viewer comes loaded with about twenty vector and raster GIS datasets. The user can display these layers and get information about individual points, lines, or polygons (vector data).

The user can add their own data, provided it is already projected in Stateplane north, NAD83 feet. Data added in another (or no) projection will appear in the legend.

Generates Project Area Report (or what critical natural areas are within project footprint):
A report suitable for viewing or printing automatically pops up in a separate window. This report is also accessible by clicking the "*Show Project Area Report*" from the DSS section of the tool. Project Area Report tallies in acreage the amount of critical natural areas that are negatively impacted during project development. This tool is intended to be a planning, but this feature allows project managers to minimize their impacts during a later design and development stage.

Provided Relevant Links to Additional Watershed and Transportation Planning Information:
The toolbar button "Links" lists different types of additional information:

1. Websites and additional information on Best Management Practices (BMPs).
2. Websites, including web sites on watersheds, wetlands, and other components of the natural environment.
3. GIS Metadata. Metadata for each layer provided is in html format. Metadata are data about data.
4. Project Rationale document: How this project came about, what were the goals and objectives.
5. Documents
    - i. The Link between Land Use & Water Resources (.pdf). Informational document.
    - ii. Streams and Watersheds (.pdf). Informational document.
    - iii. What Makes a Healthy Environment for Native Freshwater Mussels? (.pdf). Informational document
    - iv. What is the GAP Analysis Program? (.pdf). Informational document

Project Benefits

The project conceptualization was the outcome of a yearlong discussion with groups who have interest in watershed and transportation development issues. The following organizations participated in the meetings and help develop the concepts describe in this proposal: Federal Highways Administration-Olympia Fields IL, The Ohio Department of Transportation, Ohio Environmental Protection Agency, US Environmental Protection Agency, Akron Metropolitan Area Transportation Study, Cuyahoga County Planning Commission, Cleveland Metroparks, National Resource Conservation Service, National Parks Service, Summit and Cuyahoga County Soil and Water Conservation District, Cuyahoga American Heritage River, Northeast Ohio Four County Regional Planning and Development Board.

Benefits of Watershed-based Planning
Watershed-based planning is a logical approach for evaluating environmental stressors. The watershed, not the political boundary, is a structure in which many environmental effects are manifest. Increasingly, localities are required to consider water-quality impacts from roadway runoff. Watershed-based planning provides an opportunity for engaging various environmental interests in a collaborative approach to planning and problem solving.

Lake Erie Lake wide Management Plan
Of all the Great Lakes, Lake Erie has the most highly populated basin and is subject to the greatest stress from agriculture, urbanization, and industrialization. Lake Erie is particularly vulnerable to environmental changes in the surrounding landscape and pollutant loadings because of its shallow depths. The Lake Erie Lake-wide Management Plan (LaMP) 2000 identifies habitat loss and sediment loadings as two of the causes of beneficial use impairments for Lake Erie. Growth, balanced with environmental management, is necessary to help minimize the impacts of these stressors on the Lake Erie ecosystem.
The LaMP brings together a network of interested parties, with the guidance of federal, state, and provincial government agencies from Canada and the United States, to restore and protect the Lake Erie ecosystem. Protecting the Lake Erie ecosystem is a basic premise for the LaMP that will be supported by the use of the DSS. The DSS will provide information to planners to aid them in identifying environmental impacts to watersheds and, ultimately, Lake Erie from proposed projects and in determining potential options to minimize those impacts; this, in turn, will support the protection of the Lake Erie ecosystem.

Lake Erie Protection & Restoration Plan
This proposal addresses three strategic actions (two habitat and one biological) that are identified as priorities by the Ohio Lake Erie Commission. The DSS addresses the priority issue of Balanced Growth and Development.

The Lake Erie Protection & Restoration Plan cites the need for local access to information to aid in planning for economic development while balancing the needs and health of the environment. The DSS will greatly assist in these efforts and will provide an integral framework for use independently or with other techniques for watershed and transportation-project planning. The tool can aid in the protection of terrestrial and aquatic resources and can support meeting the requirements of the National Environmental Policy Act and the Transportation Equity Act for the 21st Century. The National Environmental Policy Act emphasizes a thorough understanding of the environment in the project-planning process, allowing resource managers and the public to make informed decisions. The DSS (1) makes use of environmental studies and transportation needs assessments, (2) facilitates early interagency coordination, and (3) facilitates identification of project alternatives.

Lessons Learned

Quality and Quantity a Regional GIS Data Varies**:** GIS data varies from county to county. The data varies by methodology, projections or sometimes data in neighboring counties does not exist. This obstacle highlighted the need for a regional entity to produce and manage GIS data for Northeast Ohio. Therefore the tool resorted to gross national data sets to provide a seamless layer. This data, for all intended purposes, is decades old and gross in scale. This produces some limitations of our final tool.

Static data vs. Web browser. The current version of the DSS tool is a static data set on a compact disc, meaning some of the provided data is obsolete. This form of data management limits the usefulness of the DSS Tool. Relying on a web browser was discussed at meeting at both partner and user-feedback meetings. A managed web browser would help provide continual update of information to base the DSS tool on. However, this approach requires housing the tool long-term with a capable entity. This approach always requires more resources and funding to support the tool.

A Simulated Project is not Precise: The footprint of a simulated roadway project does necessarily replicate the actual width or size of a real project. An end user may be shown that his/her project is impacting more critical natural area acreage than an actual engineered project may impact. While the DSS was never intended to be a design or engineer tool, a planning tool that provides accurate and reliable data is critical for end user endorsement.

User feed back is essential to develop a useful analytical tool: Project partners were surprised to learn of the low level of understanding regarding watershed and stream quality issues, which existed in the planning and transportation community. This required that more explanatory material be added to the tool to enable a user to achieve a proper level of benefit.

The User-feedback Workshops that were funded by EPA as a principle component of this project were extremely valuable in aiding the development of tool. The DSS-tool will be much more user-friendly, and therefore has the opportunity for wider use and acceptance.

DSS User-Feedback Workshops

First Workshop-

The first workshop of project partners and ODOT personnel was held 7 April 2003. Principle discussion items included GIS layers and sources. Determining the type planning questions that can be answered. RAP had developed and presented a narrative discussing the kinds of impacts that transportation infrastructure may have. These impacts were sorted by:

Effects resulting from Urbanization;
Effects from hydrologic alterations,
Effects from habitat alterations and

Potential changes to water quality

The RAP outline also presented a related list of recommended BMP's that might be addressed in the DSS. The group discussed potential GIS layers to graphically portray these elements. RAP reported that NOACA was not going to be able to provide much, if any GIS support, due to unavailability of technical staff. RAP noted GIS support was being developed with Kent State Department of Geography.

Second workshop-

The second workshop for Transportation and related planning personnel was held on 17 June 2003. The workshop was intended to solicit feed back on the initial content and approach to aiding the decision making process that the DSS was proposed to take. The agenda included power-point presentations and handouts. Input was sought by a structured feedback session and by the use of questionnaires. A wide variety of input was collected. Copies of the various PowerPoint presentations, summary notes and questionnaires are available.

A follow-up work session was held on 1 July 2003 to summarize the results of the workshop. RAP provided a tabulated questionnaire results and notes summarizing the content and direction of the model. There was significant discussion regarding data layers and mechanical sequence of steps that would direct the end-user through the tool.
A list of GIS layers has been developed. The CRCPO staff working with USGS conducted research to find the latest and most useful layers.

A follow-up session was held on 22 July 2003 to see a presentation from Dr. Jay Lee of Kent State University to see the Urban Growth Simulator he had developed for USEPA and to get guidance on developing a quality user–friendly tool. Following Dr. Lee's s presentation the project partners met and made significant progress in developing the structure and sequence of how and end-user would use the tool.

The next planning session was held 22 August 2003. The USGS staff had presented a draft of the flow of the DSS tool. The RAP presented a refined Explanation and Procedure Guide outline that clarified the structure and flow of the proposed tool. There was considerable agreement regarding the content and structure of the tool. A copy of the RAP outline is available.

Based on the protocol agreements USGS staff preceded with detailed development of the DSS tool. The input from the workshops was vital in allowing the programmers to properly accommodate the needs of the target user community, so that the tool would be "User-friendly".

The extra attention required to make the tool user friendly pushed the project off the original schedule. An additional result was a need to hold a additional workshops with the end- user community to collect feedback on the tool's structure and design, which required an extension of the original grant timetable.

Third Workshop-
The third workshop was held in two sessions on 19 February and 24 March 2004. Attendance again included transportation planning personnel and Public Works officials from many communities throughout the Study area region. The tool in draft form was presented along with an overview regarding the prior input that had been received from the previous workshops and the resultant effect on the content of the DSS tool. The workshop participants reported excellent acceptance of the general application and conceptualization regarding the use of the tool as it was presented.

The workshop participants also discussed the pending Balanced Growth Initiative by Ohio Lake Erie Commission, which was underdevelopment by a blue-ribbon panel for OLEC. The participants agreed that this tool could a very useful tool to support Balanced Growth environmental planning.

The participants provided input that more emphasis should be added to the BMP guidance offered in the DSS tool.

The members of the development team reviewed the workshop input and final consensus was reached regarding tool development details.

CRCPO staff agreed to add more explanatory material to both the "Why this is Important" section and the "Recommended Approaches to BMP's" section.

Early in the development of the project, as a result of staff changes, NOACA reported it would be unable to provide GIS file support. CRCPO staff was able to overcome this gap and provided the necessary GIS files for the Tool's development that were requested by the USGS partners.

DSS Rollout

In December 2005, the RAP held a rollout workshop of the WatTrans v 1.4. The workshop included a presentation of the tool's features and provided an overview of some sample applications. All attendees received a self contained CD of the tool. User feedback was gathered regarding the tool's utility and limitations and these comments will help strengthen a possible Version 2 of WatTrans.

The DSS was also presented and distributed at the Cuyahoga River RAP's Coordinating Committee Meeting and Case Western Reserve University 2005 GIS Conference and showcased at the USGS booth of the 2006 national GIS for Transportation Symposium.

CD copies are made available by contacting CRCPO.

Project Questionnaires & Educational Pieces

A Decision Support System to Integrate Watershed Environmental Issues and Transportation Planning in Northeast Ohio

Growing recognition of the need to increase integration of transportation planning and watershed issues.

Impacts on watersheds from transportation infrastructure:

Ecosystem & Habitat Alterations
Habitat fragmentation / Loss of buffer / Increased thermal levels/ Lowers DO/

Hydraulic Flow Alterations
Increased local runoff flow volumes / Added erosion / Downstream sedimentation / Change in flow at bridges and culverts

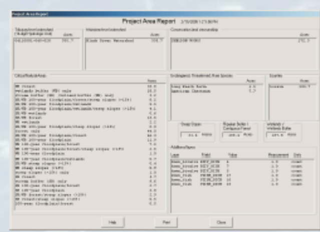
Water Quality Alterations
Nutrient additions from mowing /Salt additions/ Herbicides / Pesticides / Petrochemical additions from wash-off

Goals of the DSS Project:
Pilot project focused on Black, Rocky, Cuyahoga and Chagrin River watersheds

- Stakeholder input gathered via **feedback workshops** throughout the tool development process to make the tool **User-friendly**
- Provide data and info in an easy to use tool with **emphasis on non- GIS professional**
- At Macro-scale **identification of important environmental features in a watershed context** that could be impacted by development
- Treat the **water as a resource.** Protect aquatic species.

Tools Provides Spatial Presentation of Critical Watershed Features:
Streams/ Wetlands/ Buffers/ Contiguous Forests/ Floodplains / Steep Slopes - Critical Natural Areas defined as a combination of important interrelated features

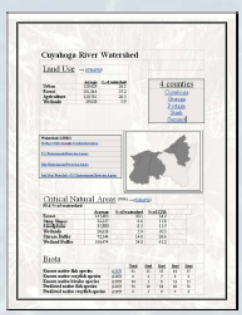
Tool allows user to simulate project by drawing locations and designating footprint size.



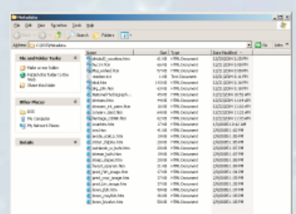
Tool tabulates and reports critical natural features impacted by the development project.

Tool Provides guidance for Best management practices that could mitigate impact:

A. Planning
B. Construction
C. Post-Construction



Tool provides a look at a watershed and its important features



Tool provides comprehensive help manual and explanations of GIS data

Project Partners:

Name: ______________________________

Representing ______________________________

Phone______________________ Email ______________________

Scoring: E=excellent; G=good; F=fair

Project & Road Selection

1. Is the selection and organization of **Project type** useful?

☐YES
☐NO

*Scoring

New Road ________
-Stream crossings ________
Road Maintenance ________
-Repair culvert/bridge ________
Road Capacity Improvements ________
-Road widening ________
-Adding through travel lanes ________
-Adding turn lane ________
-Bridge replacement ________
-Adding an interchange ________

Suggested Project Organization

2. Is the selection and organization of **Road Types** useful?

☐YES
☐NO

*Scoring

- One lane ________
- Two lane divided ________
- Two lane undivided ________
- Four lane divided ________
- Four lane undivided ________
- Other, unknown ________

Suggested Road Type Organization

Buffer Zones

3. Should the selection of **project type:** *New Road, Road Maintenance, Road Capacity Improvements* help determine the buffer size around the critical natural areas? If yes, what size?
☐YES
☐NO

____

____

Suggested Buffer Zones

Critical Natural Areas (CNA)

4. Is the current list of critical natural areas useful?
☐YES
☐NO

*Scoring

Steep slopes ______________
Floodplain ______________
Forested riparian areas ______________
Wetlands ______________
ETR Habitats ______________

Suggested CNA

5. Would it be useful to organize the critical natural areas into two categories of (1) Biological significance and (2) Hydrological significance?
☐YES
☐NO

____

____

Best Management Practices BMPs

6. Is the selection & organization the BMP's useful?
☐YES
☐NO

	Planning/Design	Construction	Post-Construction
Hydrology			
Ecosystem			
Water Quality			

Suggested BMP Paradigm

7. Would the selection of a **road types** help in choosing appropriate BMP's?
☐YES
☐NO

*Scoring

- One lane ____________
- Two lane divided ____________
- Two lane undivided ____________
- Four lane divided ____________
- Four lane undivided ____________
- Other, unknown ____________

Suggested Means of BMP Selection

8. Is the selection of **project type** helpful in choosing appropriate BMP's?
☐YES
☐NO

*Scoring

New Road ____________
-Stream crossings ____________
Road Maintenance ____________
-Repair culvert/bridge ____________
Road Capacity Improvements ____________
-Road widening ____________
-Adding through travel lanes ____________
-Adding turn lane ____________
-Bridge replacement ____________
-Adding an interchange ____________

9. Are there any potential BMPs that you feel should be included?
☐YES
☐NO

Applicability

10. Do you see this tool's applicability in Balanced Growth Projects?
☐YES
☐NO

11. Could this tool play a part in community Phase II requirements?
☐YES
☐NO

12. Could this tool play a part in Transportation Corridor Studies and Land Development Proposals?
☐YES
☐NO

We need input on potential Min / Max range for selectable project related impact zone for various types of projects. (Note- Due to data constraints the minimum zone width would be no smaller than 30 meters and in 30-meter increments.)

Draft Revised Types of Projects	Draft Min- max range for width of project related impact zone
New:	
Roads	
Ultra-urban	_____-_____
Multi- lane (4 or more lanes) Limited Access Roads	
Open center strip	_____-_____
Solid divided	_____-_____
Other New Roads	
Primary	_____-_____
Arterial	_____-_____
Collector	_____-_____
Subdivision	_____-_____
Other Roads	_____-_____
Interchanges (size of circle of Impact?)	__________
Trials and Bike Paths	_____-_____
Commercial Land Developments (based on acres of site?)	_____-_____
Improvements:	
Roads	
Lane additions, Widening, Turn- lanes	
Interchange improvement	_____-_____
Bridges (based on length of span?)	___________
Other Stream Crossings (Culverts, etc.)	_____-_____

Please mark this draft up with your suggestions and return to Jim White

by 1 March 2004

Subject: The Effects of Highways & Roads on Our Watersheds

Background

Imperviousness is a water quality barometer. Roads, highways and parking lots are hard, impervious surfaces that alter drainage patterns in watersheds and restrict water from soaking into the ground, causing more water to run off the land, streams to fill up quicker and more vehicle and urban related pollutants to reach the waterways. W*atersheds* represent nature's most effective way of draining and filtering rain and snow melt off the land and into streams, rivers and lakes. Yet, the volume and quality of water that drains off a watershed is heavily affected by how we balance both the needs of economic growth with the health of the environment. There is a well-documented relationship between the percent impervious area of a watershed, and the water quality of the water body to which the watershed drains.

Our nation's network of highways and residential roads offer great benefits of quick and convenient travel, but it is also important to acknowledge the adverse unintended consequences. The Ohio Department of Transportation has recognized the effects of highways and roads and has developed a plan to fight pollutants generated by vehicles that accumulate on our highways and are washed off into nearby streams, wetlands and lakes.

The secondary impacts of the transportation infrastructure such as, subsequent commercial and residential development and the maintenance of roads tend to do more long-term harm to watersheds and receiving streams than the initial groundbreaking construction. There is therefore a need for transportation planners to apply a watershed-based approach that is capable of taking into account the uniqueness of each watershed and successfully minimize the negative effects that highways and roads may have on the quality of watersheds, streams, and all who depend upon the water, including humans.

When taking into account the above information, it may be useful to examine more fully the four major ways that transportation improvements can affect a watershed:

- **Urban Sprawl -** Long term effects from expanding impervious cover
- **Hydrologic & Hydraulic Flow Alterations-** Changes in volume and speed of run-off
- **Ecosystem Alteration-** Changes to stream and riparian habitats
- **Changes to Water Quality**- Biochemical pollutants and impacts from physical intrusions

Urban Sprawl's Effects on Watersheds

Unmanaged urban sprawl and the related increase in imperviousness are primary factors in the degradation of groundwater, streams, lakes and wetlands. Urban sprawl can be defined as the diffuse movement of population from urban core areas to less dense suburban and rural communities. The diffusion of population from urban centers effect watersheds by:

- Increasing impervious cover (highways, streets, driveways, parking lots and rooftops)
- Loss of water- draining land (meadows, wetlands, forests and farmlands).
- Impervious cover substantially affects the amount and speed of water entering streams, degrades the physical shape of stream bottoms and banks, impacts water chemistry and species that depend on the receiving bodies of water, and reduces groundwater infiltration.

Changes in Hydrology

As imperviousness increases, there is a corresponding change in the way water is transported and stored. Developed land and hardened surfaces increase the volume and velocity of storm water while decreasing the time it takes for storm water to reach streams. This same impervious ground cover also flattens the landscape, eliminating depressed areas of land where water may have once collected and eventually would have soaked into the soil or evaporated into the atmosphere**.** Loss of these areas leads to increased water flowing into storm drains, and receiving waters.

The increase of impervious surfaces is associated with all forms of transportation but most notably from highway and road system. An increase in impervious surfaces and a sprawling population degrades the hydrologic and hydraulic flow and the quality of water entering our waterways in the following manner:

- Increased Storm Flow Volumes & Flooding
- Increase in Erosion
- Water Flow Alterations from Bridges & Culverts
- Long-term reductions in the amount ground water
- Decrease Dry Weather Flow
- Increase in non-point source run-off and related pollutants

Increased Storm Flow Volumes & Flooding

An increase of impervious surfaces causes watersheds to lose their natural capability to absorb water into the ground. Storm flows are generated during rain events or snow melts, when precipitation is quickly expedited off streets and parking lots via storm sewers into receiving streams and rivers. Changes in stream flow resulting from an increased urbanized landscape include the following:

- Increases in peak discharges, relative to predevelopment levels
- Increased volume and velocity of storm run-off, relative to predevelopment levels
- Decreased lag time (the time it takes runoff to reach a stream)
- Increased frequency and severity of flooding

GIS Data Sources:

BMPs: (Reference BMP Table)

Planning & Design	P1, P2, P3, P4
During Construction	N/A
Operation & Maintenance	M5, M6
Structural Control	S1-11

**BMPs are aimed at reducing impervious surfaces and storm water flow*

Increase in Erosion

The force of water flowing through a stream is the most important factor in causing erosion. The rate of erosion increases exponentially as the force of water increases. Stream banks and bottoms become eroded as water volume and velocity swell and scour the channel, causing the stream to become wider and deeper. All of the eroded material is carried downstream and deposited disrupting biological habitats. In heavily urbanized areas that lack storm water detention, biological life can be wiped out, creating a stream which only functions as a drainage ditch. It is important to recognize that erosion is natural process in stream dynamics, but unmanaged urbanization and storm water run-off within watersheds have substantially increased stream erosion rates.

GIS Data Sources:

BMPs: (Reference BMP Table)

Planning & Design	**P1, P2, P3, P4**
During Construction	**C1-5**
Operation & Maintenance	**M4, M6**
Structural Control	**S1-11**

**BMPs focus on storm water reduction, detention, and infiltration*

Water Flow Alteration from Bridges & Culverts

Culverts and bridges allow for traffic to conveniently travel over waterways, but they can simultaneously disrupt a stream's flow. Bridges that are designed with narrow, hardened embankments eliminate flood plains and decrease channel widths causing a concentration of water and an increased rate of stream flow. Unlike bridges, culverts are barrel shaped and have a bottom that is embedded in the stream channel. Culverts that are designed with small diameters and installed at a different slope than a stream's natural slope, can change flow velocity, flow depth and outfall heights. Alterations in a stream's flow affects the ability of species to swim upstream, plants to take root, and adds increased erosion on stream banks and downstream sedimentation.

GIS Data Sources:

BMPs: (Reference BMP Table)

Planning & Design	P1, P2, P3
During Construction	N/A
Operation & Maintenance	M6
Structural Control	N/A

**BMPs are aimed at reducing the number of developments around or across sensitive streams*

Decrease in Groundwater Quantity & Quality

Impervious cover restricts the amount of water soaking into the water table by creating more overland flow. Streams and aquatic life depend on groundwater a source of base flow. Yet, groundwater quantity and quality will decrease significantly over the years as impervious surfaces and polluted runoff increase from unmanaged urbanization. Reduced and polluted infiltration affects both the quantity and quality of drinking water resources, including wells and receiving aquifers, streams, wetlands and lakes.

GIS Data Sources:

BMPs: (Reference BMP Table)

Planning & Design	P1, P2, P4
During Construction	N/A
Operation & Maintenance	M5, M7
Structural Control	S1, S5, S6, S8, S11

**BMPs are designed to promote more groundwater infiltration*

Decreased Dry Weather Flow

Water tables beneath streams help establish a base flow of water. A rise or drop in the amount of water in the ground is dictated by the amount of water infiltrating into the soil. Impervious cover increases surface runoff, there is a corresponding decline in the levels of groundwater. Resulting in a further reduction of dry summer water levels in urban streams and rivers.

A decrease in dry weather flow has tremendous implications on habitat quality, specifically, migrant fish and bottom-dwelling (benthic) species. Moreover, dry weather flow in permanent flowing streams may become intermittent and intermittent streams may disappear altogether.

GIS Data Sources:

BMPs: (Reference BMP Table)

Planning & Design	P1, P2, P4
During Construction	N/A
Operation & Maintenance	M5, M7
Structural Control	S1, S5, S6, S8, S11

**BMPs are designed to promote more groundwater infilitration*

Non-point Source Run-off

Much of the pollutants reaching our streams and river occur from urban run-off. Today, non-point source run-off is the primary source of surface and groundwater pollution in the United States, especially in the Lake Erie Basin. When rain or snowmelt flows over land that has been altered by human actions (such as highways, lawns, parking lots), it washes off any accumulated pollutants. Non-point source pollution is hard to monitor and trace due to its generation from many different actions, by many different people, over wide expanses of land. Surface run-off from urbanized areas contains a mixture of pollutants including:

Effects	**Pollutants**	**Sources**
Decreases dissolved oxygen, disrupts spawning,	Thermal Pollution	Impervious cover (heated pavement) & Loss of shade
Harmful to aquatic life; Public health risk	Pathogens, Bacteria	Pet waste; Faulty septic systems; Combined sewer overflows (CSOs)
Toxic to biological life; bioaccumulates in food web and restricts sport fish consumption	Metals	Wear and tear of Vehicle brake pads & tires; Urban run-off
Produces algal blooms and decreases dissolved oxygen	Organics & Nutrients	Fertilizer; grass clippings; leaves; faulty septic system; pet waste
harmful to fish & bottom dwelling insects; decreases light absorption & photosynthesis	Sediment	Unmanaged construction; Erosion from increased flow

GIS Data Sources:

BMPs: (Reference BMP Table)

Planning & Design	P1-4
During Construction	C1-4
Operation & Maintenance	M1-6
Structural Control	S1-12

**BMPs are designed to reduce run-off and pollutants and promotes broad-based changes in individual knowledge and behavior and direct involvement by local governments.*

Ecosystem Alteration

Road and highway additions and improvements and new housing developments infringe and degrade habitat conditions needed for a diverse population of plant and animal species. Critical habitats such as, streams, floodplains and riparian zones are modified to provide benefits to human society, but often have adverse effects on the ecosystem. As the urban landscape extends to undeveloped areas, there is a corresponding effect on the environment in the following ways:

- Habitat Fragmentation
- Loss of Vegetated Buffer
- Increased Sedimentation
- Loss of Endangered Plants & Animals

Habitat Fragmentation

Breaks or interruptions in habitats, caused by the building of roads and highways, which cross streams, disrupt the interlocking network of ecosystems. Bisecting streams and creating remnant patches of riparian corridors, affects a habitat's carrying capacity. Carrying capacity is a habitat's ability to perform and support a diverse number of species. Isolated habitats quickly become biologically impoverished and dominated by a select few invasive plant and animal species. Establishing habitat linkages where roads cross streams helps to improve habitat continuity and provides more opportunity of species diversity, movement and interactions.

GIS Data Sources:

BMPs: (Reference BMP Table)

Planning & Design	P1, P2, P3
During Construction	N/A
Operation & Maintenance	M6
Structural Control	S3, S11

**BMPs are designed to conserve and create linkages among sensitive habitats.*

Endangered Plants & Animals

Endangered species are defined as those in imminent danger of extinction in all or a significant portion of their ranges. More often than not, the central problem behind endangered species is habitat fragmentation and destruction. Urbanization, a leading factor in habitat destruction, has caused the reduction in many plant and animal species. They are at an increased risk of further harm and potential extinction resulting from expanding urban developments.

The cumulative impacts of land development extend far beyond the boundaries of development. This creates imbalances in natural ecosystems and further endangers sensitive species and generates new endangered species.

GIS Application:

BMPs: (Reference BMP Table)

Planning & Design	P1, P3
During Construction	N/A
Operation & Maintenance	M1, M6
Structural Control	N/A

**BMPs are designed to conserve and create linkages among sensitive habitats.*

Loss of Aquatic Buffer

When forests and streamside vegetation (riparian zones) are removed or fragmented their ability to function is either lost or impaired. Lost or degraded riparian zones would not be able to provide the following crucial benefits to the environment:

- ✓ Provides critical shade- a shaded stream controls water temperature, and oxygen levels. The quantity of dissolved oxygen in the water body is a leading factor in providing a high quality aquatic environment.
- ✓ Offers habitat to wildlife- habitats provide food, protection and nesting grounds for animals
- ✓ Stabilizes stream banks- deep network of roots from trees and plants stabilize the soil and prevents erosion and absorbs nutrient laden run-off.
- ✓ Reduces surface run-off- plants help slow the velocity of over land flow, which allows for pollutants to settle out and absorb into the soil**.**

GIS Data Sources:

BMPs: (Reference BMP Table)

Planning & Design	P1, P2, P3
During Construction	N/A
Operation & Maintenance	M6
Structural Control	S3,

**BMPs are designed to preserve riparian corridors.*

Increased Sedimentation

Sediment, a seemingly benign substance, is capable of severely damaging aquatic ecosystems. Sediment is capable of suffocating fish by clogging their gills, smothering and thereby destroying stream bottom habitat, reducing the amount of available oxygen in water, inhibiting light penetration for photosynthesis, and it easily binds to and transports harmful contaminants into streams, rivers and lakes.

Harmful amounts of suspended sediment can come from a variety of places, but the largest source is under managed construction sites. The exposure of soil from improper grading practices and the lack of sediment retention often gives rise to massive loads of suspended sediment in receiving streams. When exposed soil is washed off a site, it scours the landscape and stream banks causing further erosion and sedimentation. Other sources of sedimentation come from massive storm water discharges scouring stream channels, atmospheric fallout, automobile wastes, and debris from the wear and tear of streets.

GIS Data Sources:

BMPs: (Reference BMP Table)

Planning & Design	P1-4
During Construction	C1-5
Operation & Maintenance	M3-6
Structural Control	S1-12

**BMPs are designed to preserve vegetation and sediment retention on construction sites.*

Biochemical Changes to Water Quality

Road construction, maintenance and vehicle traffic contribute pollutants (i.e. nutrients, chemicals, oil, metal) that significantly alter the biochemical properties of receiving water bodies. Existing practices of maintaining highways and adjacent manicured greenways contribute large sources of these pollutants. Pollution that enters streams, rivers and lakes does not simply disappear. Pollutants can become either dissolved, suspended, or deposited, creating problems for photosynthetic organisms as well as plants, animals and reduces the current and future viability of our water resources. Types of bio-chemical pollutants entering streams are as following:

- Nutrient Pollution
- Salts
- Heavy metals
- Herbicides & Pesticides
- Petrochemicals

Increased Levels of Nutrient Pollution

Toxic levels of nutrients can come from a variety of areas, but a significant source comes from the maintenance of greenspace adjacent to highways and roads. The current practices of cutting and fertilizing these large tracts of manicured grass contributes significant amounts of organic debris, which add nutrients (phosphorus & nitrogen) as it decomposes. High loads of nutrients can enter a stream via storm drainage or simply by wind. Too much of a nutrient can negatively impact water quality by feeding algal blooms which will reduce the amount of needed oxygen for plants and animals. Increased algal growth can also dramatically alter the ecosystem by shading out other photosynthetic organisms and eventually inhibiting their growth, thereby disrupting the food web of the stream. Nutrients are a common source of pollution to streams in urbanized areas.

GIS Application:

BMPs: (Reference BMP Table)

Planning & Design	P1-4
During Construction	N/A
Operation & Maintenance	M1, M3, M5, M6,
Structural Control	S1,S3, S4, S5, S7, S8, S9, S10, S11, S12

**BMPs are designed to reduce or eliminate the use of fertilizers and maintain natural right a ways.*

Saline Pollution is a Major Aquatic Stressor

In northeast Ohio, road salt can be a major pollutant to urban streams. Rapid, efficient movement of people, goods and services depend upon on a well-maintained road, even in the event of a snowstorm. In order to provide such a service, transportation departments have become increasingly dependent on road salt. The use of de-icing chemicals on highways and roads and are easily washed into streams from precipitation. Concerns have increased about the effects of sodium chloride (road salt) on aquatic life and the quality of our water. Spring shower runoff carries high salinity that is harmful to both roadside vegetation and receiving streams. Roots and leaves of sensitive trees & shrubs are affected by accumulate chloride resulting in reduced growth and drought like symptoms. Small streams and creeks adjacent to large, heavily traveled roads are sensitive to salinity levels that have proven to be stressful on fish, aquatic plants, wetland habitats, and are toxic to (benthic) bottom-dwelling insects. The impacts of salt in aquatic environments are reduced when there is an increase in both stream water volume and distance from roadways.

GIS Application:

BMPs: (Reference BMP Table)

Planning & Design	P1-4
During Construction	N/A
Operation & Maintenance	M6
Structural Control	N/A

**BMPs are designed to reduce high salinity levels of run-off from entering water ways.*

Heavy Metal Pollution are Toxic & Long Lasting

Heavy metals refer to metallic elements that have a high density and are poisonous at low concentrations. Metallic particles from vehicle brake pads are large sources of metallic pollutants in surface water. Heavy metals, such as lead, cadmium and nickel, have extremely long life spans that effect water quality and poses health hazards to plants, animals and humans. For example, biological organism's reproductive rates and life spans are adversely affected as heavy metals bioaccumulate to unsafe levels in animal tissue and the food chain.

GIS Application:

BMPs: (Reference BMP Table)

Planning & Design	P1-4
During Construction	N/A
Operation & Maintenance	M1, M3, M5, M6
Structural Control	S1, S5, S7, S11, S12

**BMPs are designed to reduce heavy metals from entering waterways.*

Herbicides & Pesticides Stay Active in Streams

Synthetic herbicides and pesticides are used along highway green spaces to ward off noxious weed infestation and brush encroachment. These toxic chemicals can be washed off into streams creating long lasting effects on all species within the environment, including humans. For example, many aquatic plants die from the chemicals active state in the water. Moreover, many of these synthetic compounds are not soluble in water but are actively absorbed in the food chain. The concentration of these chemicals increases towards the top of the food chain, ultimately becoming toxic to fish, birds and humans.

GIS Application:

BMPs: (Reference BMP Table)

Planning & Design	P1-4
During Construction	N/A
Operation & Maintenance	M1, M5, M6
Structural Control	N/A

*BMPs are designed to reduce or eliminate the use of herbicides & pesticides in highway management.

Petrochemical Pollution

Petroleum hydrocarbons, such as oil, gasoline and tar, comprise a large percentage of storm water pollution. The source of most petrochemical pollution found in urban runoff comes from vehicle engines dripping onto highways, roads and parking lots.

Many hydrocarbon compounds contain polynuclear aromatic hydrocarbons (PAH), which are known to be toxic to aquatic life at relatively low concentrations. Hydrocarbons also have a high affinity for sediment. They easily attach to particles and can persist on channel bottoms for long periods of time and result in adverse effects on (benthic) bottom-dwelling insects. As the rate imperviousness increases, there is a corresponding increase in petrochemical pollution impairing both water quality and biological activity.

GIS Application:

BMPs: (Reference BMP Table)

Planning & Design	P1-P4
During Construction	C1-C5
Operation & Maintenance	M3, M6
Structural Control	S1,S3, S4, S5, S7, S11, S12

*BMPs are designed to reduce the flow of petrochemical pollutants from entering our waterways.

Highway & Road Best Management Practices (BMPs) For Improved Water Resource Integrity:

● **Effective**
⦿ **Moderate**
○ **Ineffective**

Symbol	*Best Management Practices (BMPs)*	*Chemical Integrity*	*Physical Integrity*	**Biological Integrity**	**Description**
	Planning & Design				
(P1)	Restrict Development in sensitive areas	●	●	●	Preserves habitat & water quality
(P2)	Reduce Impervious surfaces	●	●	●	Reduces run-off & related pollutants
(P3)	Preserve existing vegetation (minimize clearing & grading)	⦿	●	⦿	Slows run-off, pollutant uptake, stabilizes soils
(P4)	Eliminate the use of curbs	●	●	●	Reduces pollutant run-off, flashy flows & promotes infiltration
	Operation & Maintenance				
(M1)	Reduce or eliminate the use of herbicides, pesticides, & fertilizer	●	○	●	Reduces run-off pollutant concentrations
(M2)	Street sweeping/or more frequently	⦿	⦿	⦿	Removes some sediment & pollutants
(M3)	Manage & stabilize exposed soils (grass, sod, mulch)	○	●	⦿	Prevents erosion & sedimentation
(M4)	Wildflower Cover (along roadways)	⦿	●	⦿	Slows run-off & pollutant absorption; Aesthetically pleasing
(M5)	Debris & Litter Pick up	○	●	⦿	Reduces solids from entering water ways
(M6)	Outreach & Education Programs	●	●	●	Reduction of pollutants of all kinds
	Construction Site- Structural Impact Control (Temporary)				
(C1)	Straw Bale	○	●	●	Sediment control
(C2)	Brush Barrier	○	⦿	⦿	Sediment & Storm Water control
(C3)	Silt Fence	○	⦿	⦿	Sediment control
(C4)	Sediment Basin	○	●	⦿	Sediment & storm water control
(C5)	Storm Drain Inlet Protection	○	●	⦿	Filters sediment-laden water

● **Effective**
⦿ **Moderate**
○ **Ineffective**

Symbol	*Best Management Practices (BMPs)*	*Chemical Integrity*	*Physical Integrity*	**Biological Integrity**	**Description**
	Planning & Design				
(P1)	Restrict Development in sensitive areas	●	●	●	Preserves habitat & water quality
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(P3)	Preserve existing vegetation (minimize clearing & grading)	⦿	●	⦿	Slows run-off, pollutant uptake, stabilizes soils
(P4)	Eliminate the use of curbs	●	●	●	Reduces pollutant run-off, flashy flows & promotes infiltration
	Operation & Maintenance				
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(M2)	Street sweeping/or more frequently	⦿	⦿	⦿	Removes some sediment & pollutants
(M3)	Manage & stabilize exposed soils (grass, sod, mulch)	○	●	⦿	Prevents erosion & sedimentation
(M4)	Wildflower Cover (along roadways)	⦿	●	⦿	Slows run-off & pollutant absorption; Aesthetically pleasing
(M5)	Debris & Litter Pick up	○	●	⦿	Reduces solids from entering water ways
(M6)	Outreach & Education Programs	●	●	●	Reduction of pollutants of all kinds
	Construction Site- Structural Impact Control (Temporary)				
(C1)	Straw Bale	○	●	●	Sediment control
(C2)	Brush Barrier	○	⦿	⦿	Sediment & Storm Water control
(C3)	Silt Fence	○	⦿	⦿	Sediment control
(C4)	Sediment Basin	○	●	⦿	Sediment & storm water control
(C5)	Storm Drain Inlet Protection	○	●	⦿	Filters sediment-laden water

Symbols	BMPs (continued)	***Chemical*** **Integrity**	***Physical*** **Integrity**	***Biological*** **Integrity**	**Description**
	Structural Control (Permanent)				
(S1)	Grassed Swales	⦿	⦿	⦿	Slows overland flow, infiltrates water & pollutants
(S2)	Check Dams	○	●	●	Velocity Control
(S3)	Forested Buffers Strips	●	●	●	Run-off & pollutant control; Provides stream bank stabilization & habitat for wildlife
(S4)	Grass Filter Strips	⦿	●	⦿	Diffuses run-off, reduces pollutants & nutrients in small overland flow
(S5)	Bio-Retention	⦿	●	⦿	Controls & treats first flush of runoff
(S6)	Terracing	○	●	⦿	Reduces erosion & enhances infiltration along steep slopes
(S7)	Wet Ponds	●	●	●	Controls sediment, nutrients & heavy metals
(S8)	Dry Ponds	⦿	●	⦿	Controls Storm Water
(S9)	Infiltration Trenches	⦿	●	⦿	Collects Storm Water & removes sediment
(S10)	Conveyance Channel (Grass or Rock lined)	⦿	●	⦿	Controls Storm Water & Reduces erosion
(S11)	Constructed Wetlands	●	●	●	Controls Storm Water & removes pollutants. Habitat enhancement
(S12)	Sand/ Organic (Peat) Filter	⦿	⦿	⦿	Strains & traps run-off pollutants

Definitions

- Best Management Practice (BMP): Techniques used to lessen the environmental impacts of land use.
- Chemical Integrity: maintaining low levels of chemical pollutants to preserve the beneficial uses of water for wildlife and humans.
- Physical Integrity: maintains streambeds, banks and associated floodplain, which allows streams to function, improve & maintain themselves.
- Biological Integrity: promotes diverse & hardy aquatic life populations.