Chapter 1
INTRODUCTION

Why Develop Guidelines for Natural Stream Channel Design?

Our understanding of what works best to restore a channel's natural equilibrium is still evolving, particularly across a state as diverse in geography and land use as Pennsylvania. The knowledge and skills required of professionals engaged in natural stream channel design constantly change as experiences are shared about how to work with, not against, a stream's natural form and function. It is the purpose of these guidelines to provide a common process for planning, designing, and evaluating natural stream channel restoration projects.

These guidelines will assist watershed organizations with the planning and implementation of stream restoration projects and professionals with stream restoration design, construction, and permitting. The guidelines are intended to open communication, facilitate the exchange of information, and build consistency across natural stream channel design projects. They will undoubtedly change over time to reflect both new-found successes and failures of design methods, as well as changes to permitting programs at both the state and federal levels. This document is not intended to provide a cookbook approach to natural stream channel design nor serve as a how-to manual.

The guidelines were developed by the Keystone Stream Team, an informal group comprised of government and environmental resource agencies, university researchers, sportsmen, citizen-based watershed groups, and private companies. As a result of the first Natural Stream Design Summit held in February 2000, a list of challenges was developed with regard to stream restoration permitting, data management, design and implementation, problem identification, success criteria, and education. The Keystone Stream Team categorized and prioritized this list of challenges. At the top of the list was the need to develop design guidelines for professionals engaged in natural stream channel restoration projects.

What is Natural Stream Channel Design?

A stream is a complex ecosystem and not simply a storm water conveyance. Its channel exhibits a dimension, pattern, and profile dependent on the characteristics of its watershed, as well as on the volume and timing of the water supplied to it. Proper stream function also includes the transport of water and sediment produced by the stream's watershed.

Natural stream channel design addresses the entire stream system including its biological and chemical attributes. It is based on fluvial geomorphology, or FGM, which is the study of a stream's interactions with the local climate, geology, topography, vegetation, and land use. The underlying concept of natural stream channel design is to stabilize impaired stream reaches by considering channel form and function in conjunction with "soft" engineering treatments, as opposed to traditional "hard" engineering that often ignores channel function. Reference reaches, empirical relationships, and analytical

models can be useful in deriving the appropriate channel dimension, pattern and profile. Project design must also address the stream's ability to transport water and sediment.

In addition to providing a stable condition, natural stream channel design promotes a biologically diverse system. Many of the structures employed "buy time" until riparian vegetation becomes established and matures. The establishment of a vegetated buffer that provides long-term protection is a keystone of natural channel design and will provide a number of aquatic and terrestrial benefits. These benefits include root-mass that stabilizes the bank, shade that lowers stream temperature, leaves that provide energy, food and shelter for wildlife, wildlife travel corridors, added roughness to the floodplain which reduces stream energy, and the uptake of nutrients from the soil.

Restoration of the proper channel dimension will insure that the stream is connected to the floodplain so that riparian vegetation and other components that roughen the channel will mitigate damage from flood-flows, in addition to maintaining stability. Structures used in natural stream channel design such as vanes, cross-vanes, and root-wads maintain pool habitat, which is often limited in degraded channels. In other words, they maintain the dimension, pattern and profile (or slope) of the stream. Restored streams also provide for sediment transport and the sorting of bed material that results in greater habitat diversity.

Successful natural stream channel designs achieve sediment transport, habitat enhancement, and bank and channel stabilization. The degree to which a project attains these goals depends on the project's specific objectives. Ultimately, a stream considered stable or "in equilibrium" will carry the sediment load supplied by the watershed without changing its dimension, pattern, or profile, and without aggrading or degrading.

What Makes a Successful Natural Stream Channel Design Project?

Professionals engaged in successful natural stream channel design often:

1) Assess the stability of a stream and its ecological functions.
2) Determine the appropriate level of intervention.
3) Accommodate a range of flows in the final design.
4) Derive stable channel geometry based on reference reach data, regional curve data, and/or analytical models.
5) Validate the final design using hydraulic and sediment transport models.
6) Select channel stabilization techniques that incorporate natural or native materials that provide for vertical and lateral stability.
7) Conduct monitoring to evaluate the success of a restoration project.

Successful stream corridor restoration depends on an understanding of how water and sediment are related to channel form and function, and on an understanding of the processes that are involved in channel evolution. This is particularly important in the context of Pennsylvania's diverse geology. What works in the lowlands of southcentral Pennsylvania may not work in the glacial till streams of north-eastern and north-central Pennsylvania or in streams impacted by coal mining. There can be no "one size fits all" design package for natural stream restoration. Data from the impaired stream reach and

data from reference reaches, regional curves, and analytical modeling are critical to designing a channel that will remain stable over a range of flows.

Successful projects usually involve teams that include biologists, hydrologists, and engineers who understand natural stream functions. Successful teams make the effort to evaluate reference streams in planning and designing restoration projects, and they consider multiple alternatives before deciding on the best approach for a given stream project. Most importantly, successful stream restoration requires that we all learn from past mistakes and avoid repeating them.

Natural stream channel design must allow for the integration of "hard" engineering treatments on sites where adjacent land uses restrict efforts to work with a new or existing floodplain. Natural channel design places great emphasis on connecting a stream with its floodplain, but design options may be limited in developed areas where floodplain access is restricted. For more guidance on natural stream channel design options, *see* Chapter 3.

Scope of the Guidelines

These guidelines are intended for *stream restoration* work only. For purposes of this guide, *stream restoration* is defined as:

> "*the process of converting an unstable, altered, or degraded stream corridor, including adjacent riparian zone and flood-prone areas to a stable condition considering recent and future watershed conditions. This process also includes restoring: 1) a stable dimension, pattern, and profile, 2) biological and chemical integrity, and 3) the ability to transport water and sediment in a dynamic equilibrium.*"

Professional judgment is imperative in making the distinction between *stream restoration* projects and *stream enhancement* or *stream stabilization* projects. For purposes of this guide, *stream enhancement* is defined as:

> "*the process of implementing certain stream rehabilitation practices in order to improve water quality and/or ecological function.*"

Stream enhancement practices are typically conducted on the stream bank or in the floodplain but may also include the placement of instream habitat structures. They should only be attempted on a stream reach that is not experiencing severe aggradation or erosion. Care must be taken to ensure that the placement of instream structures will not affect the overall dimension, pattern, or profile of a stable stream.

For purposes of this guide, *stream stabilization* is defined as:

> *"the in-place stabilization of a severely eroding streambank and/or stream bed."*

Stream stabilization techniques that include "soft" methods or natural materials such as root wads, rock vanes, vegetated crib walls may be considered part of a restoration design. Stream stabilization techniques that consist primarily of "hard" engineering, such as concrete lined channels, rip rap, or gabions, while providing bank stabilization, will not be considered restoration or enhancement in most cases.

Some techniques provide both *stabilization* and *enhancement*. These include the placement of appropriate instream grade control structures and the establishment of appropriate stream bank vegetation. Alone, *stabilization* and *enhancement* techniques will not restore morphological or ecological stability to an unstable stream reach.

All situations should be evaluated on a case-by-case basis using the best professional judgment available. Meetings with the watershed community (*see* Chapter 3) will help answer the question of what type of project you have. Regardless of scale, it remains critical to consider a site's larger watershed conditions and to have field-verified data to support even smaller stream restoration projects. Permit conditions (*see* Chapter 5), provide further qualifications for projects that would fall under enhancement or stabilization categories.

Specifically, these guidelines provide direction on the following topics as they apply to natural stream channel design:

- Problem Identification
- Working with the Watershed Community
- Data Collection and Analysis
- Evaluation of Design Options
- Creating the Right Design
- Permitting Guidance
- Selecting a Qualified Consultant
- Construction Considerations
- Pre- and Post-Construction Monitoring

These guidelines are not an endorsement of one methodology or tool to the exclusion of others due to the fact that the design of natural channels is an evolving field. The Keystone Stream Team recognizes the need to address the strengths and limitations of all restoration methodologies and attempts to explain some of these observations in Chapter 4.

Where approval has been granted, the reader is referred to various tools and methodologies and credits the originators of these tools. Included in this document are sets of tables, charts, and other forms (*see* Appendix I) that the Keystone Stream Team believes are most helpful in data collection and analysis.

It is also important to note that the *Guidelines* suggest a sequence of steps to take you from project planning to project implementation. However, the exact sequence may vary depending on the person or group that has initiated the project and what type of information is already available. More important than the sequence is the attempt to cover the elements presented under each step so as not to overlook something altogether.

Finally, it is important to stress that this is an evolving document and the result of collective experience by a wide variety of professionals. Content is based on what members of the Keystone Stream Team have learned about natural stream channel design since it's inception in Pennsylvania. It is the team's intention that these guidelines will save practitioners time and money by avoiding mistakes in design and implementation.