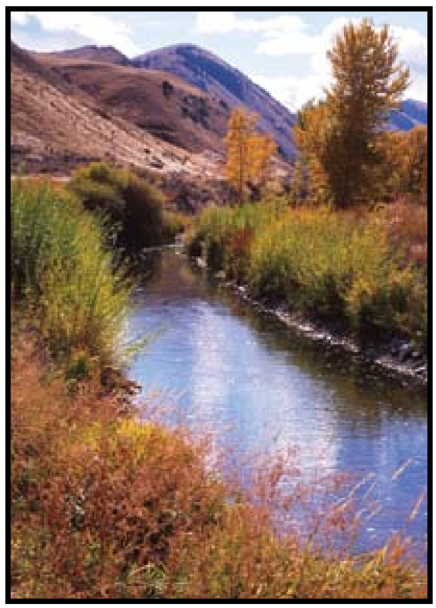
United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

**Part 654 Stream Restoration Design
National Engineering Handbook**

Chapter 2 Goals, Objectives, and Risk



Issued August 2007

Cover photo: Setting quantifiable, realistic, and achievable goals and objectives is a critical early step in planning successful stream restorations.

Advisory Note

Techniques and approaches contained in this handbook are not all-inclusive, nor universally applicable. Designing stream restorations requires appropriate training and experience, especially to identify conditions where various approaches, tools, and techniques are most applicable, as well as their limitations for design. Note also that product names are included only to show type and availability and do not constitute endorsement for their specific use.

Chapter 2 Goals, Objectives, and Risk

Contents

Tables

Figures

Chapter 2 Goals, Objectives, and Risk

654.0200 Purpose

The purpose of this chapter is to emphasize the need for the clear identification of the desired outcome or result of any action to restore or protect streams. Identification of the true nature and causes of stream problems is a critical step in the overall planning process and one which has been abbreviated or overlooked on many failed or poorly performing restorations.

The selection and evaluation of goals, as well as any design approach or treatment alternative must address risk or consequences of failure. This should be examined from both an ecological perspective, as well as a life and property standpoint. While risk is described at several points in this handbook, it is introduced in this chapter. Designing solutions is also an integral part of the overall planning process. The procedure for designing solutions is described in NEH654.04.

654.0201 Introduction

Conservationists are frequently faced with conditions along and in streams that are characterized as problems because certain functions are not being provided or simply because the overall character of the stream system has changed. It may be that the system is damaged and needs to be repaired or that a shift in perception of stream functions and values has occurred, spurring the need for some sort of action.

Understanding the true nature of stream problems is challenging because of the dynamic nature of streams, their seasonal changes, responses to disturbances, and their ability to recover. Recognizing the current condition of a stream, comparing it to historical conditions, and projecting its future conditions are, therefore, challenging; but, nonetheless, need to be documented and clearly understood to determine appropriate and achievable goals and objectives.

The goal of a stream restoration planning process is to formulate a plan that is feasible and effectively addresses the identified problems and goals of the restoration project without adversely affecting adjacent stream reaches or riparian areas.

The term stream restoration can be used to describe many different activities. Actions that support or lead to designed solutions are a critical part of the stream restoration process to assure that what is designed and implemented fits the goals and objectives of the job or project.

(a) Goals and objectives

The perceived success or failure of many stream restoration projects can be as much a function of the criteria selected as the design. Therefore, the importance of establishing achievable project objectives is critical. Once established, these objectives will delineate the data collection effort, methodologies for assessments, and finally the design itself. An interdisciplinary team is required since few people have all the skills necessary to conduct a successful stream restoration study and design. While the exact makeup of the team can vary, it should include engineering, geomorphological, and ecological expertise.

The team should also include the stakeholders. Stakeholders are the groups who may fund the project, affect the stream directly, or be affected by actions taken on the stream. A trained facilitator and interdisciplinary involvement may be needed to guide the development of goals and objectives and to assure that all stakeholders, problem identification issues, other opportunities, and constraints are fully recognized. Once agreement is reached on the alternatives to be pursued, the design process can proceed.

Generalities in objectives, such as *fixing the stream*, can lead to problems. Narrowing the objectives reduces ambiguity for the study team members. Objectives should be:

- specific
- realistic
- achievable
- measurable

Restoring streams to a given historical condition may be an objective. If this is the approach, care must be taken to ensure that physical or biological changes in the watershed have not prohibited a return to that historical condition. For example, the objective for an incised and widening stream in an urban watershed could be to restore it to support a sensitive fish species that was present before development. Changes in water quality and runoff patterns could make this an unattainable objective. Many restoration projects are actually environmental enhancement projects or rehabilitations, since it may not be feasible to return a system to an historical condition. Another of the principal reasons for this is that good, quantitative data on watershed and stream historical conditions is normally lacking. Restoration, therefore, becomes rehabilitation, since not all ecologically self-sustaining functions and values can be restored to the stream.

Clear objectives that are reachable, within the constraints and capabilities of the stream and its riparian area, will lead to better designs that perform as intended. Some objectives may, at first glance, appear to be realistic, but may need to be reformulated if preliminary design information indicates that either the costs will be too high, the intended results may not be achievable, or that boundary constraints may significantly alter or preclude the implementation of the final design.

Typical goals and objectives

Some typical goals for urban stream restoration and recovery are to:

- prevent streambank erosion on residential properties and protect infrastructure
- prevent flooding of residential properties caused by debris or sediment in the channel
- protect bridge abutments, bridges, and road crossings
- protect valuable agricultural land
- protect a municipal water supply (main source works and water quality)
- maintain or restore fish habitat
- maintain or restore water quality

Residential homeowners may be primarily interested in repairing eroded banks and removing debris or woody material blocking the channel to protect their yards, drainage pipes, septic systems, retaining walls, barns, and houses. A municipal water company may need to have a water main protected. Channel erosion may be causing headcutting of the channel, threatening bridge abutments or a road (fig. 2–1). Other stakeholders, including state and Federal agencies, may have primary interests in maintaining or improving aquatic habitat.

Further refinement of stakeholders' interests may produce more goals and better defined objectives such as:

- Maintain or rehabilitate environmental quality by designing and constructing stream restoration projects that:
  – look natural
  – function naturally with channels connected to flood plains
  – provide desirable stream and riparian habitat, including overhanging root cover and large woody material
  – reduce bank erosion
  – maintain water quality
  – are economical to design and build

- Protect infrastructure in channels and flood plains by designing and constructing stream restoration projects that:
  - do not increase flood profiles
  - do not migrate across flood plains
  - protect valuable riparian infrastructure
  - have a low risk of failure
  - do not send debris or woody material downstream to plug bridges and culverts
  - maintain water quality
  - are economical to design and build

In some cases, a compromise needs to be reached between goals for infrastructure protection and aquatic habitat. Sometimes these goals are incompatible, and sometimes they are mutually supportive. Some instances of incompatibilities are:

- An interest in having a project that can naturally evolve over time or rapidly change in response to large flow events, where the stability of riparian infrastructure requires a fixed and static bankline.
- Woody material can provide valuable habitat benefits, but can also increase flood profiles by plugging bridge openings.

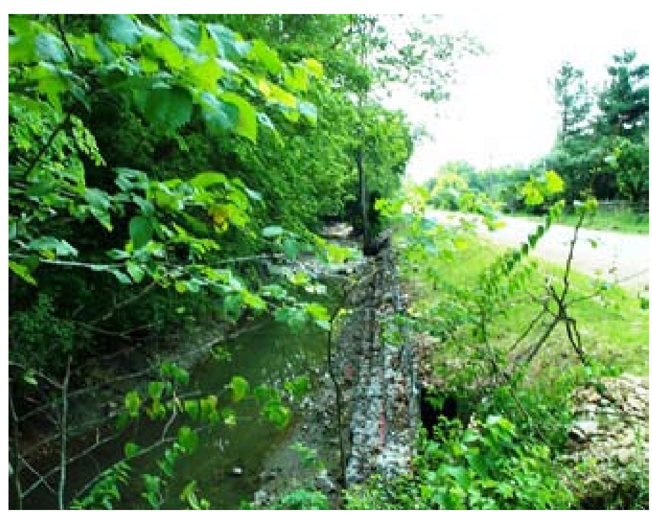
Some instances of mutually supportive goals are:

- Large woody material is valuable for aquatic habitat and on some streams can help achieve channel stability.
- Natural streams with channels connected to flood plains can reduce tractive forces in the channel by dispersing and attenuating high velocity flows, thereby increasing channel stability.

Figure 2–1 Township road threatened by severe degradation of channel bed (Calhoun County, IL) (*Photos courtesy of Michael Hollow*)

(a) March 2003—Original concern about bank failure threatening road expanded to include rock riffle grade control structures to stabilize bed, reduce bank height, and improve aquatic habitat

(b) June 2003—2 months after treatment using rock riffle grade control structures to stabilize bed and gabion baskets to stabilize failing bank near road. Note water impounded in pool.



654.0202 NRCS Conservation Planning Process and stream restoration

A plan is a sequence of logical steps to reach a goal or objective. Most stream restoration projects consist of complex issues involving a number of people and ecological components. Using a multi-disciplinary planning team helps to identify and address many of the issues in a timely manner. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Conservation Planning Process (CPP) follows policy written in the National Engineering Manual (NEM), Part 510, Planning.

The NRCS CPP is referenced because of the need for NRCS field conservationists to recognize how stream work fits into the overall CPP.

Prescribing stream corridor restoration design elements requires progression through and iteration of NRCS CPP steps (fig. 2–2 (USDA NRCS National Planning Procedures Handbook (NPPH), 2003b)). As part of this process, alternative resource management systems (RMS) are developed for the conservation management unit (CMU) or, in this case, the stream reach or stream corridor, and an RMS is selected by the client and then implemented. The nine-step process is listed in detail in table 2–1, with relevance to stream restoration. Although sequential in steps, iterations and cycling back to a previous step commonly occur in the planning process. Plans may result in complex solutions involving a balance of watershed, riparian, and instream actions. The actions may be combinations of management, as well as designed and implemented practices and techniques. The planning process may be rapid for simple projects and may require extensive time for complex projects involving many people and resource issues.

Stream solutions start with landowners or stakeholders requesting assistance with a stream-related problem. The problem may be streambank erosion, which may be controlled and simultaneously protect or enhance ecological functions and values of the stream and riparian area. However, the problem may be a much more serious and widespread condition of multiple reach or systemwide instability, requiring detailed planning and coordination with many landowners and stakeholders. The area of streambank of concern to a landowner is also part of the stream system and its watershed. The focus of the planning team must be on the whole system to determine the cause of the problem, formulate alternatives, and evaluate the effects alternatives may have on the rest of the stream system.

Although these steps are listed in sequential order, the process may require an interactive or sometimes iterative approach. For example, the preliminary design for a planned alternative may not fit the site or may otherwise result in unacceptable construction requirements or unintended or poor overall performance. Recycling back through some steps of the planning process may be required to develop a more suitable alternative for which a new design can be developed.

The formulation and selection of an alternative solution should give consideration to the potential problems and human resource availability. Information must be identified that could affect installation such as construction access, safety concerns, material availability, pollution control requirements, and local ordinances. Some of the potential problems a planner may identify are:

- permitting requirements (surveying, clearing, earth-moving, dredging, cultural resources)
- ownership/land rights
- site access (season, timing, and physical limitations)
- material availability (earth materials, plant materials)
- construction scheduling (season, environmental windows flow conditions)
- local ordinances
- tolerance for risk and uncertainty
- utilities (underground, overhead)
- pollution control (instream, parking areas, sediment control, chemical control)
- safety concerns (working on slopes, in water, around heavy equipment, using hand tools)
- threatened or endangered species

Figure 2–2 NRCS CPP showing the dynamic interaction between the steps

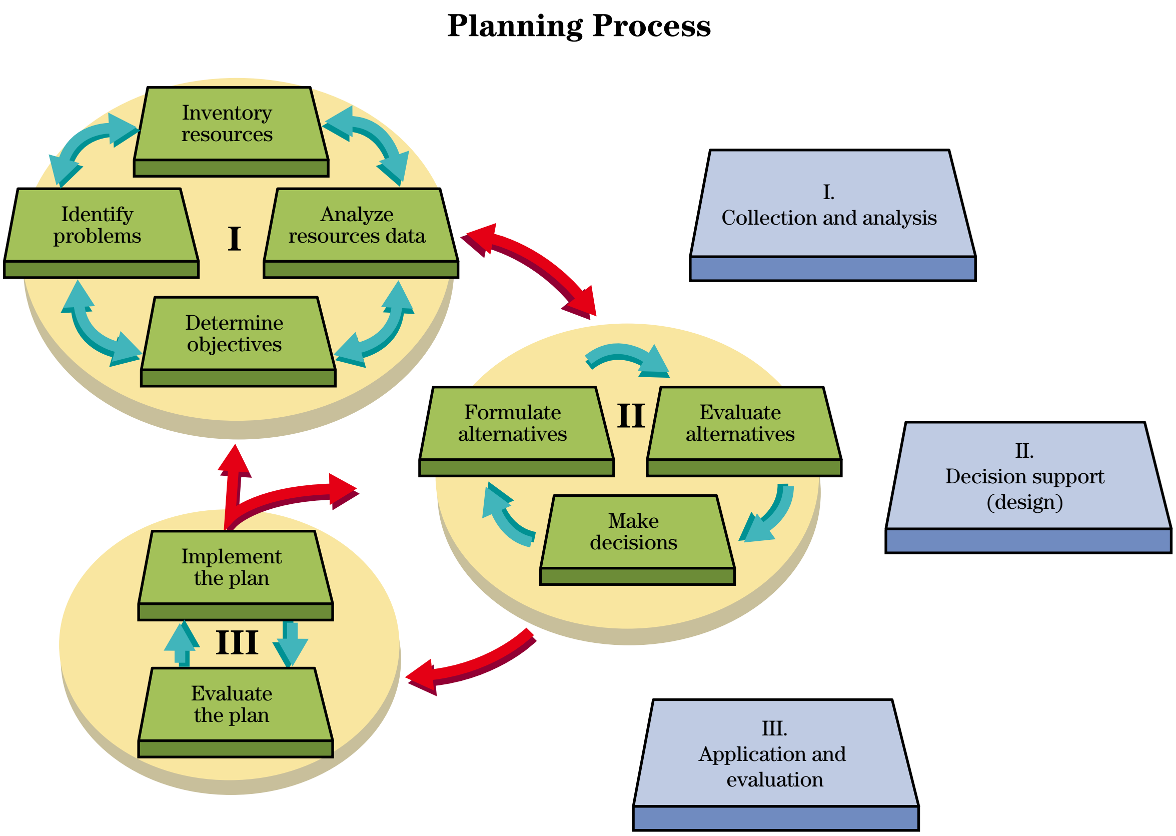


Table 2–1 Stream restoration planning process

Step no.*	Description	Generalized stream restoration planning step	NEH 654 chapter	Detailed stream restoration planning steps	Potential iteration of steps
Phase I—Collection and analysis (understanding the problems and opportunities)					
1	Identify problems and opportunities	Decide what stream characteristics need to be changed	1 2 4 17	Project identification: identify all • Stakeholders • Goals and objectives • Risks • Local vs. systemwide instabilities	Rigor of the assessment depends on the acceptable risk. As each element is addressed, use the information to confirm the initial assessments. It may be necessary to revisit the goals and objectives (may need to revisit step 2).
2	Determine objectives	Describe the desired physical, chemical, and biological changes in the stream			
3	Inventory resources	Study the stream to understand its primary physical processes, dominant impacts on water quality, and abundance and distribution of different biological populations	3 5 6 13 16 17	Assessment: assess the following at the watershed scale and at the site or reach scale: • Geomorphic condition (stream type) • Existing ecological conditions (riparian and instream) • Ecological and physical thresholds • Dominant physical and biological processes and constraints • Sediment budget and stability of existing conditions Acquire hydrologic data (watershed scale) Acquire hydraulic data (stream reach scale) Determine: • Why is the stream in its current condition • What is the ideal condition • What keeps it from naturally adjusting to the ideal condition	
4	Analyze resource data	Examine the collected information and decide what are the most important factors or processes that impact and influence the desired conditions in the stream			
Phase II—Decision support (understanding the solutions)					
5	Formulate alternatives	Determine which processes and factors can be changed, and decide if those changes are sustainable and self-reinforcing	4 5 6 7 8 9 10 11 12 13	Conduct the stability design Select practices or techniques for RMSs Select and design appropriate stabilization techniques • Cross section • Planform • Stabilization, soil bioengineering, integrated techniques • Profile, grade Conduct a sediment budget and stability assessment on the selected design, appropriate to design the practice, so it can be implemented	
6	Evaluate alternatives				
7	Make decisions				
Phase III—Application and evaluation (understanding the results)					
8	Implement the plan	Implement the selected changes to the stream system	15 16 17	Identify construction issues and impacts on design to fine-tune design and implementation Document maintenance and monitoring requirements: • Perform ongoing maintenance • Evaluate success and practice adaptive management	
9	Evaluate the plan	Modify the course of action as new information is collected and analyzed			

*NRCS Planning Procedures Handbook, Amendment No. 4, 180–VI–NPPH, March 2003

During the stream restoration planning process, information is gathered and decisions are made that will direct the design, determine the type of contract or agreement to use, and identify installation concerns. Decisions such as the extent of design needed are determined based on the complexity of the alternative selected, type of contract or agreement, availability of experienced staff to direct construction, and contractor experience.

An understanding of the different types of contracts and agreements is imperative during planning. Contract issues are described in more detail in NEH654.15. Once the planners know the available resources, they can select the type of contract or agreement. Project cost can determine the type of contracting procedure selected such as formal or informal (simplified) acquisition procedures. Funding may also dictate the selection of a particular type of contract. For example, labor may be provided by volunteer groups and the equipment acquired with an equipment rental contract, if funds are limited. A local sponsor may be able to do part or all of the work if they have the equipment, workforce, and experience.

During the planning process, installation must be considered when selecting alternative solutions. For example, complex solutions may require either experienced construction oversight to direct the work or a very detailed design package.

654.0203 Historic approaches for determining goals for stream restoration designs

Knowledge of the behavior of streams in relation to conditions in their watersheds before and during the historical period gives insights to effective watershed management. The design and restoration of streams is often guided by a desire to recover a lost condition. This historic basis requires asking to what standard or for what historical period we are designing. For example:

- What did a stream and its watershed look like at the time of European settlement?
- What did a stream and its watershed look like before the land use became what it is today?
- What did a stream and its watershed look like before the last big storm?
- What did the stream and its watershed look like before its condition became a concern?

The historical approach is not new. Some important earlier studies are by Gilbert (1914); Happ, Rittenhouse, and Dobson (1940); and Vita-Finzi (1969). A more recent, but classic, study using a large assortment of historical techniques for landscape reconstruction is that of Whitney (1995).

(a) Limitations of historical approaches

Goals for a stream restoration project are often determined by picking a point in the past from a photograph, writing, oral history, or from interpretation of landforms and attempt to put the stream back to that condition, or a desired point in time. However, things are not always as they seem. For example, a large Georgia swamp pronounced by authorities as primeval was shown to have been prime agricultural land in the 19th century that had been transformed to swamp by human action (Trimble 1970a). On the other hand, some Australian lakes and rivers commonly thought to have been radically transformed by human action were shown to have changed relatively little, and those changes may have had more natural than human causation (Finlayson and Brizga 1995).

Selecting a stream shape from a photograph and trying to replicate that shape ignores other factors that control the planform and other attributes of the stream and its corridor, including the riparian area. Photos of streams typically focus on crossings, easily accessible points, and cross sections. In many cases, usually little can be learned about the historical pattern and diversity of riparian vegetation from photographs at such locations.

Dynamic changes in timing, frequency and magnitude of flows, and sediment load and transport are also not revealed in photographs. The size, shape, and other physical characteristics of alluvial streams are a function of the types and quantities of sediment in the water and comprising the bed and banks, as well as the nature of the flow conditions. A photograph could easily show a transition phase between two relatively stable states, but may provide little understanding about the direction or magnitude of that change. Refer to NEH654 TS2 for an expanded description on the use of historic information for stream restoration design.

In a physical and possibly biological sense, streams are disturbance-driven systems. The current processes that can be observed in a stream channel were shaped by prior floods, sediment input and transport events, channel changes, vegetation changes, and species interactions. Although it is useful to think of a stream as having a most probable form, each of these extreme events resets or alters that form.

654.0204 Geomorphic approaches for determining goals for stream design

The geomorphic approach to stream restoration work encompasses a number of different activities including stabilizing unstable streambanks and channels, reconfiguring the planform of channelized or aggraded streams, restoring natural substrates and other habitat features, and even daylighting piped streams. Figure 2–3 illustrates a daylighting stream project showing a stream that formerly flowed through a pipe underuground and was restored to a more natural condition. This work can be undertaken on a single stream reach or comprehensively over an entire watershed. The geomorphic approach to stream restoration work provides a way to meet management objectives of:

- protecting streamside property or structures from erosion or reducing sedimentation rates in a downstream reservoir or navigable waterway
- improving ecological conditions for aquatic or riparian life

Work undertaken as compensatory mitigation is included in this latter management objective. Regardless of the management objective, stream geomorphic restoration design and construction techniques strive

Figure 2–3 Daylighting stream project

to produce a stable stream that is natural in appearance to the untrained eye, with minimal detrimental environmental impacts.

A structured planning process is needed for stream work that:

- examines the physical, biological, and chemical processes in and around a stream to determine their hierarchy and interaction
- describes in what historic range of variability those processes functioned
- determines which processes could be modified to bring about desired results
- describes desired results and how long it would take to achieve them
- monitors the results of a modification to a stream to determine the level of success
- adapts future actions according to monitoring and evaluation results

Many stream management and modification practices fail because of oversimplification, application of approaches that are not designed for dynamic fluctuations in site conditions, and a general lack of understanding about how streams function, physically, biologically, and chemically. A goal might be that the number of adult salmon returning to a stream will be increased tenfold in the next 20 years. Until the amount of habitat in the stream and its utilization are described, there may be no way of knowing if these fisheries goals can be achieved.

In addition, physical processes of sediment delivery and transport and streamflow fluctuations create physical habitat units. The amount of flooding and interactions between floodwaters, riparian vegetation, and the shallow alluvial aquifer and hyporheic corridor often play a major role in nutrient redistribution in a stream. This can impact primary food sources and productivity. Until these issues are understood in relative importance to one another, determining if the goal is realistic or sustainable may not be possible.

Ideally, environmental investigations should be conducted in the planning stage, prior to formulating a stream restoration plan. Work proposed to control erosion or sedimentation should be substantially different in scope from work proposed to benefit aquatic life. For the former, environmental planning investigations should be focused on collecting information necessary to develop the optimal design that will meet the erosion and sedimentation control objectives. Designs should keep conditions as natural as possible, and construction practices should be used that minimize adverse environmental impacts to stream life during construction. In contrast, when the management objective is to improve ecological conditions for aquatic life, it is important for restoration planners to determine that a stream is biologically impaired and that degraded geomorphic conditions are, indeed, a principal stressor to aquatic life.

(a) Geomorphic analog or reference reach

An analog section of stream, sometimes called a reference reach, can also be used in establishing goals. In this technique, a section of the project stream or a neighboring stream is identified that is thought to function in a desired manner. The reference reach is measured, vegetation is analyzed, and biologic conditions are characterized, and these become the goals for the reach of stream that is deemed to be not functioning properly.

In cases where there have not been substantial changes in sediment supply and hydrologic character, stream reaches up or downstream of the degraded reach could provide an appropriate template for restoration design. This situation is of greatest potential applicability when the cause of channel degradation is from direct channel disturbance or riparian vegetation changes.

More insight is gained by this reference reach approach than the desired point-in-time method, but the technique has some limitations. Directly transferring the properties of one stream to another makes the assumption that the recent disturbance regimes have been similar. Also implicit in this technique is that analog sections are in the same geologic materials and have similar size watersheds, chemical budgets, sediment budgets and sediment particle size distributions, and biologic food chains and predator-prey relationships. The lack of similarity between reference reaches and the restoration stream reach may induce more uncertainty into the process for setting objectives.

Geologic conditions may be controlling stream behavior in the reference reach. These larger scale geologic controls often create stable stream conditions. Unfortunately, this stability is not necessarily transferable to the restoration stream section that is under the influence of different geologic conditions. The limitations of this approach are addressed in more detail in NEH654.09.

654.0205 Ecosystem approaches for determining goals for stream design

Prioritization of stream restoration work should first characterize the existing ecosystem condition, identify stressors, and then prioritize among these stressors. Stream restoration plans should be formulated to focus effort on correcting major stressors. To restore aquatic life, degraded stream conditions should be restored only if these conditions are a priority stressor for aquatic life and will not likely self-correct in a timely manner without intervention.

Several degraded conditions may be harmful to aquatic life. These include constructed fish blockages, upstream migrating headcuts, streams confined in underground pipes, streams confined by concrete, and recently maintained or channelized streams in earthen channels. These stream conditions should generally be considered priority candidates for stream restoration work, since remediation of the condition would likely benefit aquatic life.

The ecologic approach to stream restoration work may provide the greatest benefit to aquatic life in a short reach, but the results could benefit aquatic life over a much greater length of the stream system. When degraded conditions are widespread, the restoration work should be strategically targeted at local reaches that can eventually produce widespread improvement to benefit aquatic life, or work would need to be undertaken on a large scale. Table 2–2 shows likely impact scales for various stream problems.

Two opportunities where localized restoration work benefits aquatic life over a much greater length of stream are where a structure obstructs the upstream passage of aquatic life (fig. 2–4) and when a downstream change in base level causes a rapid upstream migrating headcut (fig. 2–5).

Fish blockages prevent upstream movement of fish and other aquatic organisms that are unable to pass through or over them. Following natural or human-caused events that result in depletion of aquatic species upstream of the blockage, populations occurring downstream may be unable to reoccupy upstream habitat when conditions improve. Also, following downstream migration, migratory aquatic species may be unable to return upstream of the blockage and cannot survive otherwise suitable habitat. However, it should be noted that fish blockages may be desirable if they are preventing the upstream movement of an unwanted invasive aquatic organism.

Diversion of water flow for irrigation, municipal and industrial water supplies, and recreation can have extreme consequences for aquatic habitat and riparian vegetation along the stream where water is diverted. The degree of impact from these diversions depends on state laws and regulations on instream flow conditions and water rights. In the past, some streams have been totally dewatered due to diversions, resulting in total loss of aquatic habitat. In the past 20 years, many irrigation diversions have installed fish screens with return flows that prevent fish from being diverted into ditches or irrigation fields.

Table 2–2 Situations in which ecologic restoration projects in a stream reach would have a high likelihood of benefiting aquatic life

Stream reach problem	Likely scale of impact
Constructed fish blockage in stream system naturally lacking fish blockages	Watershed
Rapidly upstream migrating headcut	Watershed
Piped stream	Stream reach
Concrete stream channel	Stream reach
Earthen stream channel recently channelized or maintained	Stream reach
Water diversions causing flows too low for fish passage or rearing	Stream reach

Figure 2–4 Fish blockage in stream

Figure 2–5 Upstream migrating headcut; smaller tributaries will also cut into fields, triggering gully erosion

Headcuts proceeding upstream can destabilize streams over a very large area, altering the relationship between the stream and its flood plain, drying out flood plain wetlands, and generating large volumes of sediment that can be harmful to aquatic life. Headcuts are also often fish blockages.

Two degraded geomorphic conditions that present restoration opportunities to improve conditions locally are piped streams and streams with concrete channels (fig. 2–6). When streams are piped or lined with concrete, habitat complexity is completely lost, and flow conditions are often severely altered. Water velocities are greatly increased during high-flow events, while the channels may run nearly dry at other times. Additionally, flow between the stream and ground water underlying the stream (the hyporheic habitat) is prevented, severely restricting the nutrient processing functions that the stream and its aquatic life would otherwise perform. Daylighting piped streams is the restoration of a stream's planform and normally involves substantial design efforts, especially in built-up areas. Removing concrete channel boundaries and restoring a stable planform may be the only way to restore functions to these streams. In either case, a first step is to begin to reconnect riparian areas and people to the streams. In the case of piped streams, the starting point is to gain awareness of what the stream once was and what it can be with daylighting. For concrete-lined channels, reconnecting can start with establishment of green areas and managed riparian areas along the channel.

Channelized streams with earthen channels (fig. 2–7) present unique challenges for restoration. The simplified substrate and depth conditions of the channelized stream constitute a loss in habitat quality for stream life.

Stream channelization is common in regions of the country where large areas of wetlands have been lost (fig. 2–8 (U.S. Fish and Wildlife Service (USFWS))). In these areas, opportunities to restore flood plain wetlands should be investigated as a way to contribute to stream ecosystem restoration. Generally, the self-restoration potential of lost wetlands in absence of intervention is low.

Although excessive sediment in streams is the principal stressor to aquatic life nationwide, restoration projects may not always benefit aquatic life. Excessive sediment, while not desirable, is not typically damaging to all stream aquatic life, as are some other stressors, such as highly degraded water quality and severe

Figure 2–6 Stream encased by concrete channel

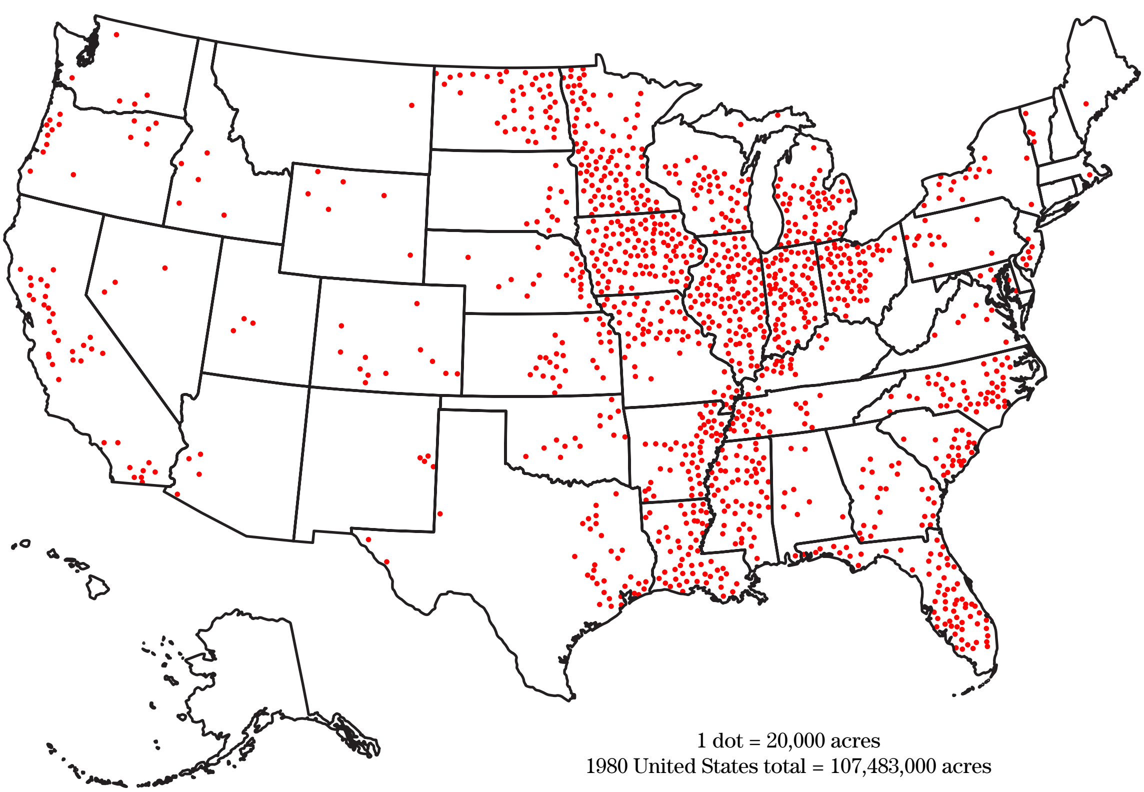
Figure 2–7 Channelized stream (lower left); former natural stream has been assimilated into the regional artificial drainage network

alterations in flows. The impacts of excess erosion and sedimentation impact primarily sediment-intolerant species such as:

- aquatic insect larvae in riffles
- fish that spawn on coarse substrates
- fish that eat insects of coarse substrate bottom habitat
- aquatic organisms that eat submerged aquatic plants

Excessive sediment damages some highly valued aquatic organisms such as many species of trout. Sediment-tolerant organisms, however, may thrive if no other stressors are present. Systemwide strategies may be needed to reduce watershed sediment production. The USDA Agriculture Research Service (ARS), NRCS, and U.S. Army Corps of Engineers (USACE) have undertaken projects to demonstrate such systemwide sedimentation/erosion control strategies in northern Mississippi (Demonstration Erosion Control project).

Figure 2–8 Regions of the country where channelized streams would likely be associated with historic lost wetlands



654.0206 Rural stream restoration

The primary task in most rural situations is to protect an identified resource. Stream restoration in rural areas is often undertaken as a result of an individual landowner request at a specific site where there is no organized effort to restore a larger stream segment. While it may be legitimately questioned whether stream restoration can be accomplished on such a small scale, there are many opportunities to address local conditions and begin the process of education with a long-term goal of restoration on a larger scale. The problems or symptoms leading to the request can be analyzed and documented to determine the feasibility and probable effects of a local solution. The analysis will then conclude whether appropriate action can be taken to offset negative treatment effects and then assess the risk of action or inaction. The time and expense of large-scale studies and data collection may not be justified by a single request from an individual or a small group of individuals. However, in many cases, individual goals and objectives can be achieved by careful problem identification, root cause analysis, and appropriate application of restoration techniques. At the very least, a determination of no feasible action at the individual scale is far superior to an inappropriate attempt at a solution that may have negative impacts at the larger scale.

(a) Issues

Typical rural requests fall into two broad categories: protecting property or restoring and maintaining channel capacity. Both types of requests normally relate to one or more specific problems centered on the loss of tangible property due to bank erosion, excess bed-load deposits, excess woody material, or increased runoff exceeding channel capacity and, therefore, resulting in increased flooding or channel adjustments. The desired condition in these instances is simply to protect what is being damaged: crops, cropland, public roads, utilities, private roads, bridges, and levees. Unfortunately, the problem is seldom as isolated as the landowner's goal of protecting a resource.

The landowner objectives or goals must first be related to an immediate cause and a root cause before a treatment recommendation can be determined. Table 2–3 shows how the most common primary goals relate to problems, immediate causes, root causes, and solutions.

Where possible, it is preferable to address the root cause of the problem. Realistic goals must take into account the accurate assessment of the root cause of the problem. The first task is to broaden the landowner's concept of stream dynamics from merely patching a problem to understanding why the problem exists. Often asking about other current or past stream related problems will lead to a productive discussion about the landowner's longer term goals and objectives. And just as important, it will give the designer insight into the overall stream's behavior and state of equilibrium.

As an example, slope failure affecting an access road may be the problem, but there may also be a problem maintaining a stream crossing or keeping the large logjams out of the channel. Investigation may lead to the conclusion that the channel is degrading, causing the stream crossing to be undermined. The same incision process is then causing excessive slope failure as the bank height increases, resulting in channel widening and large mature trees being undercut and falling into the channel. The landowner may now understand that to patch the slope failure threatening the access road may be futile unless the incision problem is first addressed. The goal of protecting the access road has been broadened to address the cause of the problem. By halting the channel incision on this reach of stream, the landowner's access road can be protected. The stream then can be improved by moving it towards equilibrium, and the aquatic value and aesthetic qualities enhanced.

The task of addressing the immediate problem will remain the landowner's objective, but the method of attaining the goal must address the larger issue of channel instability by treating the root cause of the problem. A decision will then need to be made regarding the scope, risk, and cost analysis of all the proposed treatment alternatives. Before discussing alternatives, explore the secondary goals and objectives of the landowner. The requests are almost always generated by one of the primary objectives, but some landowners will also be interested in such secondary benefits such as aesthetics, aquatic habitat, wildlife habitat, or water quality.

Table 2–3 Common streambank problems, causes, and solutions

Primary goal	Problem	Immediate cause	Root cause	Solution
Protect property: cropland, forestland, residential land Infrastructure: roads, bridges, utilities, levees	Lateral migration	Excess energy/ increased velocity	Steepened gradient or increased flow	Reduce energy gradient by reducing slope with grade control or re-meandering stream. Increases in flow regime will require watershed treatment and/or temporary storage to reduce discharge
		Inadequate riparian vegetation	Clearing and/or removal of mature vegetation	Restore riparian vegetation and buffer area. Additional treatment (toe protection) may be needed during establishment period
		Channel obstruction	Woody material, landslide has reduced channel capacity at site forcing flow around obstruction	Remove obstruction to restore channel capacity
		Unstable channel planform	Normal lateral migration, channelization or modifications have created small radius bend(s)	Modify channel geometry to conform to natural channel geometry relationships of stable channels. Typically with radius of curvature/bankfull width ratio greater than 2.0
		Excessive bed-load deposition	Excessive erosion upstream generating more bed load than channel can transport. May be result of channel incision and widening upstream of problem. May be aggravated by channel widening, resulting in excessive width depth ratios. May also be depositional area created at delta above confluence with larger stream or reservoir	Find and treat sources generating excessive bed load. Channel may then need to have stable cross section and planform reestablished at problem reach. Attempts to modify channel to transport bed load through the problem reach are only successful in moving the problem downstream
	Slope failure	Critical bank height exceeded	Channel incision has created bank height that exceeds soil strength to resist failure	Stabilize bed to prevent additional incision, and raise bed elevation to restore bank heights that are less than critical height. An alternative after halting incision is to slope banks to an angle that is stable for the materials and heights
			Banks are over steepened by lateral erosion at the toe of the bank resulting in slope failure	Stop lateral erosion at the toe. Refer to causes of lateral migration to insure root cause is addressed
		Geotechnical problems	Banks have internal geotechnical problems resulting in bank failure only indirectly effected by streamflow (seeps, springs, weeps, differing soil materials)	Address the geotechnical problem before attempting any other solution. Consult with appropriate technical personnel for assistance

Table 2–3 Common streambank problems, causes, and solutions—Continued

Primary goal	Problem	Immediate cause	Root cause	Solution
Restore or maintain channel capacity	Bed-load accumulation	Excessive upstream sources	Large bank failures/escarpments or bed degradation contributing excessive bed load	Identify and make appropriate treatment to reduce bed-load contributions
		Reduced velocity in reach resulting in deposition of bed-load material	Change in slope or backwater effects from channel obstruction downstream reservoir or confluence with another stream	May be no effective practical solution without detailed project analysis and major project activity to reduce bed load
	Multiple or frequent logjams	Logjams restrict flow, resulting in loss of channel capacity and increased flooding or bank scour near obstruction	Introduction of woody material from logging, clearing ,or high mortality rate of mature trees upstream of problem, resulting in logjams at site	Locate source, and address problem by removing potential for excessive woody material in channel
			Excessive slope failure upstream causing large woody material from riparian zone to enter channel	Address problem of slope failure upstream of problem. Refer to causes of slope failure to ensure root cause is addressed
	Increased runoff/ flooding	Land use changes in watershed such as urbanization or intensified agricultural use	Change in flow regime resulting in increased peaks or extended durations initiating changes in channel morphology	Make watershed modifications to restore natural flow regime. Alternative is to allow channel morphology to adjust naturally, or make carefully planned adjustments to changes in flow regime

Fortunately, effective treatment to address the immediate problem will usually have positive impacts on these secondary goals if the root causes of the problems are addressed and the stream segment is brought back to a state of near equilibrium. However, by first identifying the secondary concerns, the level of improvement can be enhanced with appropriate design, construction, and operation and maintenance of treatment measures.

(b) Scale

After the root cause has been identified, the scale or scope of the solution must be determined. The question is, "Is this a local instability problem or a systemic problem?" If the problem is local, an individual landowner or cooperation between two or more landowners can implement the needed solutions. However, if it is a systemwide failure, rarely can the rural stream restoration project expand to the watershed level without a local organization to sponsor the project. Figures 2–9, 2–10, and 2–11 illustrate a systemwide stream stability problem, and figure 2–12 shows an example of a local stability problem treated with a grade control structure and stream barbs.

The question then becomes, "Is there a solution that can be implemented by the landowner?" If not, the only answers may either be to expand landowner involvement or abandon the project until the required area of treatment can be addressed.

Fortunately, many areas of the country have a grid of roads, culverts, and bridges that effectively confine many of the channel instability problems to segments between road crossings. Many times, even a systemwide failure may have some solutions or treatments available by working complete segments between these manmade stable points. The root cause again will indicate the extent or scale required to implement a satisfactory solution.

654.0207 Developing watersheds

Public officials are faced with ever-increasing liability pertaining to public safety, public infrastructure, property, and other forms of investment. As rural watersheds transform to urban, municipal governments must accommodate growth by annexing and zoning additional land parcels. Preparation for subsequent development of subdivisions and other construction may include an inventory of streams and other sensitive sites to assess the impact of additional runoff from impervious cover. Other planning measures include updating or revising the comprehensive plan, development codes, ordinances, and other protective measures. Rural communities and areas in the urban fringe undergoing transformation may not have technical or human resources to develop comprehensive plans, ordinances, or to carry out special studies. Others, however, play an active role in planning and guiding development.

In these newly urbanizing areas, as well as areas already urbanized, stream restoration can be viewed as a capital improvement because of the amount of public expenditure involved with working in and around streams. Measures are available to municipal and county governments to minimize future impacts on streams, as well as to protect improvements made along the stream. State legislation grants municipal home rule authority, enabling local jurisdictions to enact and codify ordinances. These legal instruments are used to further protect community assets, which include streams.

The U.S. Environmental Protection Service (EPA) Office of Water compiled a collection of municipal ordinances from various local governments throughout the country. These ordinances were collected as part of a larger partnership effort with organizations, such as the International City Municipal Association (*http://www.icma.org*), American Water Works Association, and others, as a template for those charged with making decisions concerning growth and environmental protection. These ordinances also address aquatic buffers, erosion and sediment control, open space development, stormwater control operations and maintenance, illicit discharges, and post construction controls.

Figure 2–9 Systemwide instability. Heavy bed load from upstream erosion exceeds this stream's capacity to carry bed load. The root cause is channelization and urbanization, resulting in loss of channel capacity as midchannel bars form. (Sugar Creek, McLean County, IL)

Figure 2–10 Systemwide instability. Very heavy bed-load deposits have filled original channel, forcing stream to move laterally into finer grained bank materials. This is an example of an alluvial or bed-load-driven stream. (Sexton Creek, Alexander County, IL)

Figure 2–11 Systemwide downcutting induced by channelization project downstream. Additional landowners must become involved to address the root cause of channel incision to stabilize the entire degrading reach. This is an example of a threshold or flow-driven stream. (Hurricane Creek, Jefferson County, IL)

Figure 2–12 Local instability problem above a township bridge. This channel became misaligned with the bridge opening due to lateral migration. The treatment includes stream barbs and a rock riffle grade control structure to protect against possible degradation as a result of shortening the channel during realignment. (Bay Creek, Pike County, IL)

654.0208 Urban stream restoration

The challenges of working to restore physical and biological functions and values in urban or developed streams and their watersheds focus on hydrologic characteristics that no longer fit a natural stream, as well as the obvious limitations provided by physical and legal boundary constraints. To accurately understand the objectives and risks of stream restoration in a developed watershed both the social complexity, as well as the biophysical complexity of the landscape, must be understood (fig. 2–13). Stakeholder goals and objectives must also be clearly defined and the community's interests prioritized. Implementing any successful project also requires that risks be understood mutually by the community, as well as the planners and designers.

Understanding the temporal and spatial scales of stream processes, channel evolution process, and linkages between flow and sediment movement and channel dynamics is essential in any stream restoration project. Understanding these interrelationships will be incomplete, however, without a dynamic watershed context. Recognizing that many developed watersheds are, in fact, actively developing is essential to implementing a successful stream restoration project.

Figure 2–13 Developed area (urban or suburban)

How streams and their watersheds change over time must be clearly understood. It is important to recognize, at the time of observation, where the channel exits in the space-time continuum of its dynamic equilibrium with the water and sediment of its watershed. Failure to do so can result in the implementation of a stream restoration project which is neither in harmony with the land management objectives of the community nor meets the biophysical needs of the resource.

(a) Issues

The issues and interests of landowners within developed watersheds often are similar to those in rural watersheds. These issues and interests often include loss of property, fish and wildlife habitat, recreational opportunities, risk of flooding, and aesthetics. However, this difference in residence time, so to speak, significantly affects all steps in planning a stream restoration project in an urban area.

The human community affects ecological processes and is also affected by the implementation of a stream restoration project. Fully engaging the community in the planning process to identify issues and interests encourages people to look beyond their own backyards and to identify ways to integrate the complex facets of a given project.

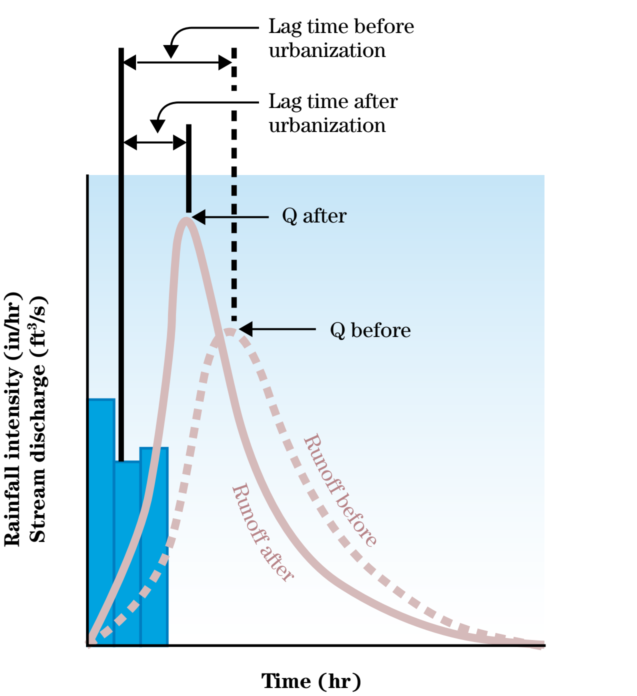
The scale of the project, degree to which the stakeholders wish to participate, and in some cases, the resource issues being evaluated will determine the amount of public participation. An issues and interests meeting has two principal objectives:

- All stakeholders can identify the issues and interests that they feel are important, both as related to the specific project resources and to the area as a whole. These include the natural resources of the area, as well as the social and economic resources of the local community. This allows all members of the community who choose to participate to have a voice in the resource conservation decisionmaking process. By doing so, it creates a way for stakeholders to communicate, explore different perspectives, and see the project in a larger context than might otherwise be possible.
- Stakeholders attending the meeting(s) can participate equally in a collaborative process

to identify the project objectives and focus. The goal is to design and implement a technically sound stream restoration plan that meets the needs of the ecosystem and is in harmony with the resource management objectives of the community and the respective local, state, and Federal agencies. This meeting establishes common threads and common ground for stakeholders and creates a way for their dialogue to be translated into action by implementing an achievable plan to conserve, protect, manage, or rehabilitate the stream corridor resources.

It is of paramount importance to recognize how changes in land use affect watershed hydrology and sediment regime. Urban development produces more impervious surface area, subsurface drains, land grading, and stormwater conveyance systems. The effects of increased imperviousness and the subsequent disconnect of the water infiltration and water storage capacity of the watershed soils and ground water result in a distinct shift of the streamflow hydrograph to the left, as shown in figure 2–14 (Federal Interagency Stream Restoration Working Group (FISRWG) 1998). Both the rising limb and recessional limb of the hydrograph have an increase in slope with a higher peak discharge and a decreased lag time between the onset of a particular storm event and peak streamflows. How this changed and changing hydrology affects the morphology and stability of urban streams and channels must be understood, recognizing that regional curves of typical stream dimensions for various drainage area sizes may not be usable at all.

Figure 2–14 Comparison of hydrographs before and after urbanization



Increased flows in urban watersheds often result in channel incision. In addition, the clear-water discharge associated with present day storm drainage systems results not only in increased streamflows, but also results in streamflows with a higher capacity to transport sediment. The process of incision often results in the simplification of the streambed topography. The pools shorten in length, become shallower, and pool slope is steepened. Riffles become more extensive and steeper.

The process of incision and resulting change in stream morphology operate in a negative feedback loop, perpetuating instability and loss of habitat within the stream. Consider the equation for stream power:

$$\phi = \gamma Q S \qquad \text{(eq. 2–1)}$$

where:

ϕ = stream power (ft-lb/s-ft)
γ = specific weight of water (lb/ft^3)
Q = discharge (ft^3/s)
S = slope (ft/ft)

As shown in figure 2–15, development within a watershed results in an increase in stream Q during a storm event. An increase in Q results in a direct increase in stream power. The increase in stream discharge and, thus, in stream power translates to an increased ability to transport sediment. The channel must adjust (incise) to accommodate the increased flows now generated by its watershed.

Incision tends to decrease bed topography, thereby increasing channel slope. An increase in channel slope results in a direct increase in stream power. Again, the increase in stream power translates to an increased capacity to transport sediment, which is expressed as incision. Figure 2–15 illustrates the relationship between changes within a developed or a developing watershed, relative to incision and loss of habitat, with respect to the variables of the stream power equation.

An often overlooked and misunderstood risk associated with stream restoration in urbanizing or developed watersheds is the acceptance of the project by the community. It is important for the resource professional, both the planner and designer, to recognize that the community is not only one of the resources affected by the project but also one of the resources which affects the project. A stream restoration project, which is technically sound from a biophysical perspective, but not in harmony with the resource management objectives of the community, may also be considered a failure.

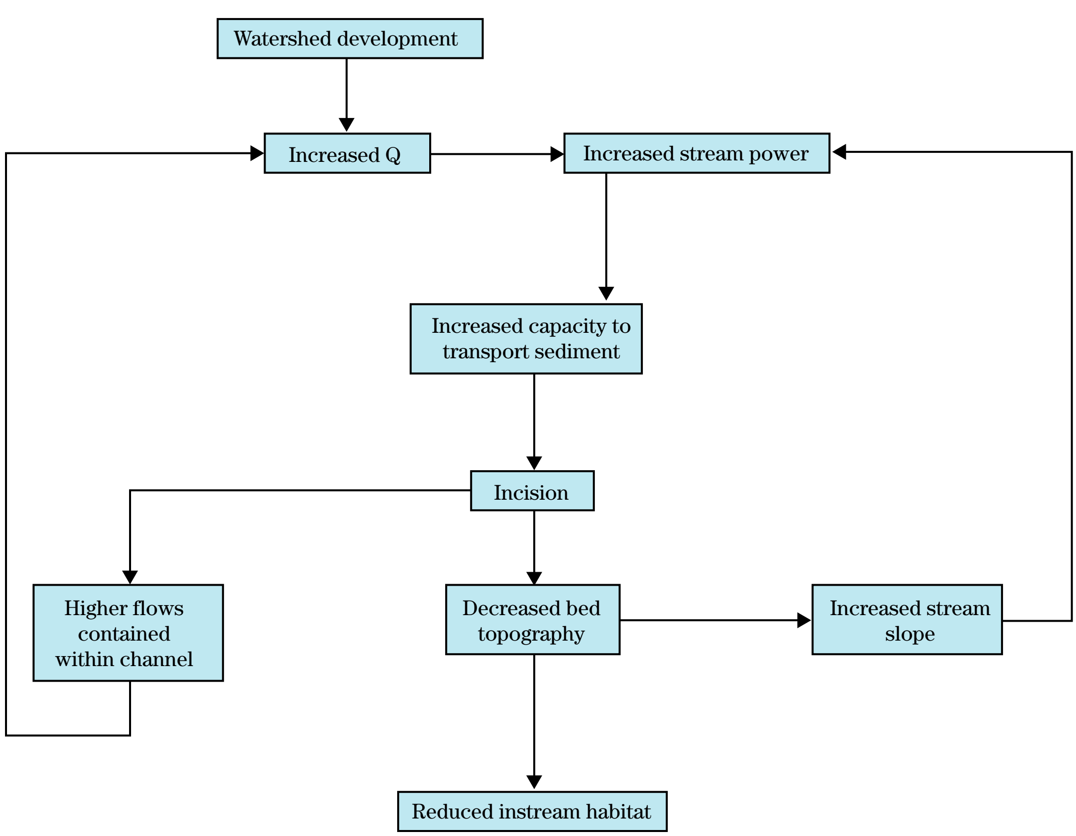
Case study 8 of this handbook, Copper Mine Brook, provides some limited risk analysis for an urban stream restoration project involving concerns about infrastructure, as well as biological and physical stream processes.

(b) Scale

In a rural watershed, the entire stream reach (say, 12 meander wavelengths) may be located on the property of a single landowner who has resided on the property for the past 25 years. The description of the issues and interests of the landowner, relative to the temporal and spatial scales of the channel instability, is comprehensible for the landowner. The landowner has witnessed the evolution of the channel and has a stake in its entire reach.

Conversely, in a developed watershed, that same reach of stream may be home to 30 different property owners who have an average residence time of approximately 5 years. The discussion of issues and interests

Figure 2–15 Potential effects of urban development in a watershed



expands accordingly, and the description of the spatial and temporal scales of the channel process may not be as relevant to these landowners. The perspective of each landowner rarely extends beyond the adjoining properties if it extends beyond their individual property. In addition, their perspective of the channel and its associated processes, on average, do not extend beyond 5 years. They own only a portion of the channel and have been witness to its evolution for only a short period of time.

654.0209 Constraints

Constraints limit the possible actions. Determining project constraints is just as important as establishing objectives. There is a feedback loop between constraints and project goals and objectives. Constraints can be natural anthropogenic. Examples of natural constraints include:

- mountains that limit channel planform
- bedrock outcrops that limit or control channel grade
- water quantity that limits the aquatic species that can use a channel

Examples of anthropogenic constraints include:

- flood plain development or land use that limits channel planform
- tolerance for risk of project failure
- endangered species or regulatory concerns that helps defines acceptable treatment practices

Anthropogenic constraints are particularly common in urban flood plains and include rights-of-way, highways and bridges, utility crossings, buildings, archeological and historical sites, and cemeteries.

Another common concern is contaminated sediment in the streambed or banks. To ensure that these polluted sediments stay in place, it may be necessary to stabilize the banks, preventing the natural channel migration process.

Technical and nontechnical issues affect the feasibility of any stream restoration project. Technical constraints are generally reasons why a particular treatment recommendation cannot function or meet the landowner objective. Nontechnical constraints are generally reasons why the treatment recommendation will not be implemented.

(a) Technical constraints

Data availability—In most rural situations, the existing data are sparse and general in nature. Typically, information is limited to existing aerial photography, topographic maps, soils maps, and local knowledge. The information from these sources is invaluable, especially historical photography that can be used to determine changes in planform, land use changes, lateral migration, and some bed features such as point bars and central bars.

Additional data collection at these rural sites is usually limited, as the scale of the project will not justify large data collection expenses. If more data are needed than can be collected locally, the technical constraint may then be the lack of sufficient data to make a recommendation or to design a treatment. This constraint must be balanced with the experience and judgment of the designer, as it is unlikely that any project will have all the data the designer would like to have available.

Number of landowners—Another technical constraint enters when the scale of the project requirements exceeds the level of interest. In other words, effective treatment requires work on several properties and there is not the interest or the resources available to implement a solution. The technical decision will then quickly be reduced to answering questions about long- and short-term feasibility and risks. Questions to be asked include:

- Is there a treatment that can be effectively applied within the scope of the project area?
- Would the proposed solution have negative impacts on stream stability on a larger scale?
- Will the effect of upstream or downstream instability threaten the implementation or planned life of the treatment?

If these questions cannot be answered satisfactorily, the treatment is not technically sound and should not be implemented.

Experienced designer(s)—The lack of sufficient data and the lack of justification to devote resources to data collection make experience and professional judgment extremely critical in these rural settings. It becomes essential that the designer investigating these sites has the knowledge, time, and experience to gather basic field information and make sound observations of stream characteristics and behavior both at the site, as well as upstream and downstream, for a considerable distance, before making any treatment recommendation. The investigation must be thorough enough to make sound judgments about the stage of channel evolution in the project reach, sediment transport efficiency, bed-load transport capability, bank materials, presence of geotechnical concerns, planform geometry, geomorphic bankfull dimensions, and incision. Local data are not widespread in the form of reference reach data or localized regional curve information to determine the normal or expected size, shape, and slope of a stable channel in the local physiohydrological region. Therefore, until and unless these resources are developed locally, the designer will need to rely on professional judgment to apply appropriate technical information from other regions and base recommendations on experience gained from similar applications.

Availability of materials, equipment, and labor—For any solution to be implemented, it must be feasible to construct with materials and equipment readily available. Many stream restoration projects are in areas where access is difficult. These types of questions should be asked before finalizing a recommendation:

- Is there access for the necessary equipment to get to the site?
- Is there room for the equipment to operate safely at the site?
- Is the right kind of equipment available locally?
- Will construction be done from the land or bank side or the streamside?
- What kind of environmental damage is likely?
- Will there be damage to roads, lawns, or fences that must be considered?
- Is there access to get materials to the site?
- Are required materials readily available?
- Will access be available for repair or maintenance?
- Are skilled and experienced contractors available?
- Is the labor pool locally restricted during the time of installation?
- Are volunteers available, and can they perform the work?

(b) Nontechnical constraints

Costs—Economic constraints are often the most obvious constraints. In rural areas, the cost may easily exceed the value of the resource to be protected. In many circumstances, protecting rural land may not have a favorable cost/benefit analysis unless other factors, such as improvement to water quality, aesthetics, and habitat enhancements, make the project viable. Landowners may not value these secondary benefits enough to make the project economically attractive. Therefore, a large portion of rural projects often include protection of roads, bridges, utilities, and access points. For this reason, some areas or projects may qualify for financial assistance from Federal, state, or local funding sources to provide landowners an incentive to apply stream restoration practices that would not be economically feasible if the landowner were to bear all costs.

Regulations—Regulatory constraints may also impact the project design and feasibility. All projects are subject to review by regulatory authorities under Section 404 of the Clean Water Act (33 U.S.C. 1344), Section 10 of the Rivers and Harbors Act (33 U.S.C. 403), State Section 401 Water Quality Certification, and Section 106 of the National Historic Preservation Act. Most areas also have state and local regulations that must be met. Become familiar with all the regulatory guidelines in your project area before completing final designs to be submitted to permitting agencies. NEH 654.17 provides additional information and consideration regarding permitting requirements.

Aesthetics—Aesthetic or societal constraints may also affect planning in rural settings, although usually to a lesser degree than in an urban project. By addressing the root cause of the identified problem, the stream segment can be stabilized, and the damage caused by previous erosion or construction activities will be restored through natural regeneration. In settings and locations where natural regeneration is permissible, substantial cost savings can make a project economically viable. In areas with adequate seed supply and fertile soils, sites can naturally revegetate during the first growing season. Figure 2–16 shows a project site on Kickapoo Creek in Illinois, where the banks were revegetated naturally. Some locations will require the restoration of all disturbed or eroded areas with vegetation due to aesthetic, societal, or regulatory requirements.

654.0210 Risk, consequences, and uncertainty

Evaluating risk, consequences, and uncertainty help designers and stakeholders make decisions on what design choices to make. Such measures of probability are described in many texts and handbooks (Fripp, Fripp, and Fripp 2003). Risk is the probability of some event happening. Uncertainty describes the level of error in estimates of risk and consequences. Examples of these are:

- *Risk*—There is a 50 percent chance a 2-year storm will occur each year.
- *Consequences*—If the 2-year storm occurs, the following series of consequences could happen:
  - The streambank could erode 5 feet.
  - Part of a state highway will slide into the river.
  - Motorists could be killed and highway repairs would be expensive.
- *Uncertainty*—Tools to predict the discharge and velocities from various frequency storms are commonly used. Given a certain frequency storm, present tools to evaluate the certainty of the bank eroding with resultant damages are not that accurate or precise.

The analysis of both short- and long-term benefits must consider the risk factor of the proposed treatment alternative. The concept of risk is mentioned here because of its relevance in defining realistic goals for stream restoration.

In rural settings, the risk factor is normally somewhat lower than in an urban setting. If the stream restoration project fails, the consequences are often much greater in a heavily developed area than in an undeveloped area. At the same time, a rural setting can have a high risk factor when infrastructure, such as roads, bridges and buildings, is involved. Generally, the more risk involved in a potential failure, the more caution should be taken in the recommendation and design. This risk assessment should always be considered and discussed with the landowner so that all parties are aware of the level of risk taken. In a low-risk location where only moderate damage may occur, many

Figure 2–16 Project site where banks were vegetated naturally (Kickapoo Creek, IL)

(a) December 2000—lateral bank affecting adjacent cropland

(b) April, 2001—5 months after installation of stream barbs. No shaping or seeding of banks was included in project. Eroding banks will be allowed to vegetate naturally.

(c) September 2001—10 months after installation of stream barbs. Eroding banks have sloughed to stable angle and revegetated.

landowners are willing to accept possible damage that would need some repair, rather than accept substantial cost increases to lower the potential damage. As the riparian corridor matures, a well-designed stream restoration project becomes more stable over time. The greatest risk of damage normally occurs in the period immediately after installation.

More often than not, as a result of increased infrastructure, as well as compromised ecosystem health, the risks of action or inaction tend to be higher in a developed watershed than in a rural watershed. The risks associated with any one particular project vary based on the scope and scale of the subject stream reach and watershed. Although the risks associated with stream restoration are often interrelated, they can be related to the objectives for the social and biological communities.

Different approaches to achieving a given objective may involve varying degrees of risk to public safety, natural resources, property, or infrastructure. They may also offer varying certainties for success. These risks and the probability for success must be weighed against other project considerations when selecting and prioritizing projects. Table 2–4 shows an interpreted range of qualified risks for selected instream treatment techniques.

In any stream project, the "do nothing" alternative should be evaluated. This is also referred to as the "future without action" alternative. However, even this apparently simple approach should not be considered casually. Allowing an unstable condition to continue can have significant detrimental consequences from both a physical, as well as an ecological perspective.

Table 2–4 Potential range of qualified risks for selected instream treatment techniques*

Technique	**Risk to habitat**	**Risk of channel change**	**Risk to infrastructure, property, or public safety**	**Uncertainty of technique**	**Probability of success**
Boulder clusters	Low	Low to moderate	Low	High	Moderate
Channel modification	High	High	Low to high	High	Low to high
Drop structures	Low to moderate	Moderate	Low to high	Low	Moderate to high
Fish passage restoration	Low to high	Low	Low to moderate	Low	High
Instream sediment detention basins	Moderate to high	Low to moderate	Moderate to high	High	Low to high
Large wood and logjams	Low	Moderate	Moderate to high	Moderate to high	Moderate
Side channel/off-channel habitat restoration	Low	Low to moderate	Low	Low	High

* Derived from Stream Habitat Restoration Guidelines, September 2004; Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and Washington Department of Ecology: *http://wdfw.wa.gov/hab/ahg/shrg/*

654.0211 Conclusion

The accurate identification and prioritization of the issues and interests of the land user or community is crucial in planning and designing a stream restoration project. Objectives or goals that are preconceived or defined unilaterally for a restoration project often result in failed projects or projects that do not perform properly or meet expectations. Detailed designs, based on poorly formulated goals and objectives, will not normally meet expectations of the restoration. Time and resources should only be expended on detailed designs if the objectives are specific, realistic, achievable, and measurable.

Objectives of a restoration should be as specific as possible, with the resulting conditions clearly described in terms that stakeholders understand. Improving the environment would be a poorly stated objective, without any other description of what will be different with the project in place.

Objectives should be realistic and achievable. Early optimism during project planning should be tempered by what can actually be done. For example, restoration of a cold-water fishery in a stream that has been severely altered by urbanization and watershed changes may not be achievable, even though it is a noble goal. The temperature regime of the stream, both before and after restoration, should be thoroughly understood. Another example might be the desire to restore a stream to an historical condition, but the current watershed conditions differ significantly. It may not be possible to restore all of those historical functions and values to the system, but a few could actually be restored.

Objectives should be measurable. Subjective goals, such as improve water quality, may seem to be good, but should be further refined to state exactly what changes in water quality parameters are the desired outcomes of the restoration. Monitoring of the before and after conditions will reveal exactly how much change has been achieved or to what degree the desired functions and values have been restored to the stream.

The selection of goals and objectives must take into consideration the risk associated with the current, as well as the proposed project condition. This risk must be evaluated from both an ecologic, as well as a life and property prospective. In addition to the risk of the project, the uncertainty associated with the design approach and the probability of success should be taken into account. The evaluation of risk and uncertainty may force a revision of the goals and objectives.

The restoration design should include a balanced approach between structural and management elements. For example, stabilizing streambanks should include not only bank stabilization practices, but also riparian practices to manage cattle crossing (fencing), access to water (designed stream crossing), and grazing management. The final plan and design for the restoration should consider ways to meet the goals and objectives of the stakeholder(s), as well as to benefit or improve water quality, fish habitat, and riparian habitat.