This document is one chapter from the EPA "Handbook for Developing Watershed Plans to Restore and Protect Our Waters," published in March 2008. The reference number is EPA 841-B-08-002. You can find the entire document **http://www.epa.gov/owow/nps/watershed_handbook**.

Handbook for Developing Watershed Plans to Restore and Protect Our Waters

Chapter 4. Define Scope of Watershed Planning Effort

March 2008

4. Define Scope of Watershed Planning Effort

Chapter Highlights

- Identifying issues of concern
- Using conceptual models
- Setting preliminary goals
- Developing quantitative indicators

Read this chapter if...

- You want to engage stakeholders in identifying issues of concern
- You want to take stakeholders out into the watershed
- You want to develop a conceptual model that links sources of pollution to impairments
- You're unsure of the extent of the watershed boundaries for your project
- You want to develop preliminary goals for the watershed plan
- You want to select indicators that will be used to assess current environmental conditions in the watershed

4.1 Why Define the Scope of Your Watershed Planning Effort?

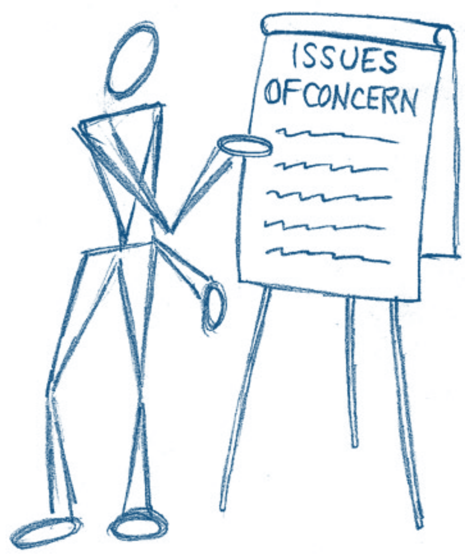
To ensure that your watershed planning effort remains focused, effective, and efficient, defining the *scope* of the effort is critical. The term *scope* is used to describe the boundaries of a program or project, which can be defined in terms of space (the area included in the watershed plan) or other parameters. This handbook defines the scope of your watershed planning effort as not only the geographic area to be addressed but also the number of issues of concern and the types (and breadth) of the goals you want to attain. If your scope is too broad, it will be difficult to "keep it all together" and make the best use of your financial and human resources as you develop and implement the watershed plan. It might also hamper your ability to conduct detailed analyses or minimize the probability of involvement by key stakeholders and, ultimately, successful plan implementation. A scope that is too narrow, however, might preclude the opportunity to address watershed stressors in a rational, efficient, and economical manner. If you define your scope and set preliminary goals early in the planning process, you'll find it easier to work through the later steps in the process.

The issues in your watershed and the geographic scope will also affect the *temporal* scope of the implementation of the watershed plan. Although there are no hard and fast rules, watershed plans are typically written for a time span of 5 to 10 years. Even if you do not achieve your watershed goals in 10 years, much of the information might become out-of-date, and you'll probably want to update the watershed plan.

The stakeholders will provide critical input into the watershed planning process that will help identify issues of concern, develop goals, and propose management strategies for implementation. Information from the stakeholders will help shape the scope of your watershed planning effort.

4.2 Ask Stakeholders for Background Information

The stakeholders will likely be a source of vast historical knowledge of activities that have taken place in the watershed. Ask them for any information they might have on the watershed, including personal knowledge of waste sites, unmapped mine works, eroding banks, and so on. They might have information on historical dump sites, contaminated areas, places experiencing excessive erosion, and even localized water quality sampling data. Stakeholders might be aware of existing plans, such as wellhead or source water protection plans. Collecting this background information will help focus your efforts to identify the issues of concern and solutions. Use Worksheet 4-1 to work with your stakeholders to determine what information is already available. A blank copy of the worksheet is provided in appendix B.



4.3 Identify Issues of Concern

One of the first activities in developing a watershed management plan is to talk with stakeholders in the watershed to identify their issues of concern. These issues will help to shape the goals and to determine what types of data

Worksheet 4-1 *What Do We Already Know?*

[Hand out to stakeholders at the beginning of a meeting, or use as a guide to work through each question as a group]

1. What are the known or perceived impairments and problems in the watershed?
2. Do we already know the causes and sources of any water quality impairments in the watershed? If so, what are they?
3. What information is already available, and what analyses have been performed to support development of a TMDL, watershed plan, or other document?
4. Have the relative contributions from major types of sources of the pollutant or stressor causing impairment been estimated?
5. Are there any historical or ongoing management efforts aimed at controlling the problem pollutants or stressors?
6. Are there any threats to future conditions, such as accelerated development patterns?
7. Have any additional concerns or goals been identified by the stakeholders?

are needed. As a project manager, you might think you already know the problems, such as not meeting designated uses for swimming and fishing. The issues of concern are different in that they are the issues that are important to the community. For example, stakeholders frequently list trash in the streams as an issue even though it doesn't necessarily affect water quality.

Set up a meeting with the stakeholders to gather their input as to what they believe are the major concerns in the watershed, and begin to identify possible causes and sources of these concerns. The stakeholders might provide anecdotal evidence, such as "There aren't any fish in the stream anymore (impact) because the temperature is too warm (stressor) and there is too much dirt going into the stream (stressor) since they removed all the trees along the streambank (source)." This information provides an important reality check for watershed plan sponsors, who might have very different notions regarding problems, and it is the starting point for the characterization step described in chapter 5.

Remember that you should also identify any issues related to conserving, protecting, or restoring aquatic ecosystems. Proactive conservation and protection of such systems can help to ensure that water quality standards will be met. Concepts such as in-stream flow, hydrologic connectivity, and critical habitats (e.g., refugia or stress shelters such as springs and seeps used by species in times of drought) should be considered when identifying issues of concern. Worksheet 4-2 can help you identify the ecosystem-related issues that need to be addressed in your watershed planning effort.

At this stage you can even start to link problems seen in the watershed with their possible causes or sources. For example, stakeholders might say they are concerned about beach closures, which could lead to a discussion of sources of bacteria that led to the closures. As you move through the process and gather more data, these links will become more discernible. Understanding the links between the pollutants or stressors and the impacts in the watershed is key to successful watershed management. In the initial stages of watershed planning, many of the links might not be thoroughly understood; they will more likely be educated guesses that generate further analyses to determine validity.

Worksheet 4-2 *What Ecosystem Issues Need to Be Considered?*

1. What are the sensitive habitats and their buffers, both terrestrial and aquatic?
2. Where are these habitats located in the watershed? Are there any fragmented corridors?
3. What condition are these habitats in?
4. Are these habitats facing any of the following problems?
   a. Invasive species
   b. Changes associated with climate warming
   c. Stream fragmentation and/or in-stream flow alterations
   d. Changes in protection status
5. On what scale are these habitats considered? (e.g., regional, watershed, subwatershed, or site-specific) Are these scales appropriate for the biological resources of concern?
6. Does the variability, timing, and rate of water flow hydrologically support indigenous biological communities?

4.3.1 Draw a Picture

It is often useful to diagram these links as you move through the watershed planning process and present them as a picture, or a conceptual model (figure 4-1). These diagrams provide a graphic representation that you can present to stakeholders, helping to guide the subsequent planning process. In many cases, there will be more than one pathway of cause and effect. You can also present this concept to stakeholders verbally, as if-then links. For example, "*If* the area of impervious surface is increased, *then* flows to streams will increase. *If* flows to streams increase, *then* the channels will become more unstable." Figure 4-2 shows a simple conceptual model based on the construction of logging roads.

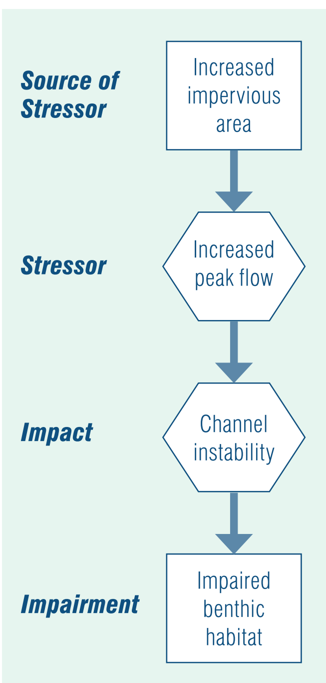


Figure 4-1. Simplified Conceptual Model

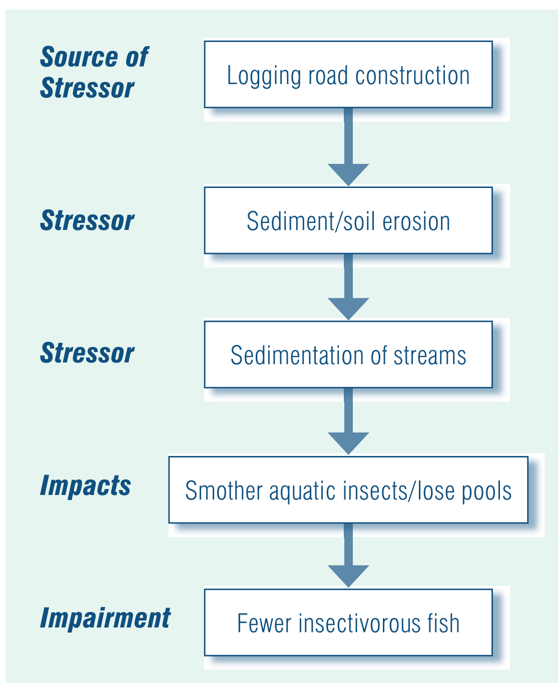


Figure 4-2. Simple Conceptual Model Involving Logging Road Construction Effects on Stream Aquatic Life (adapted from USEPA 1998)

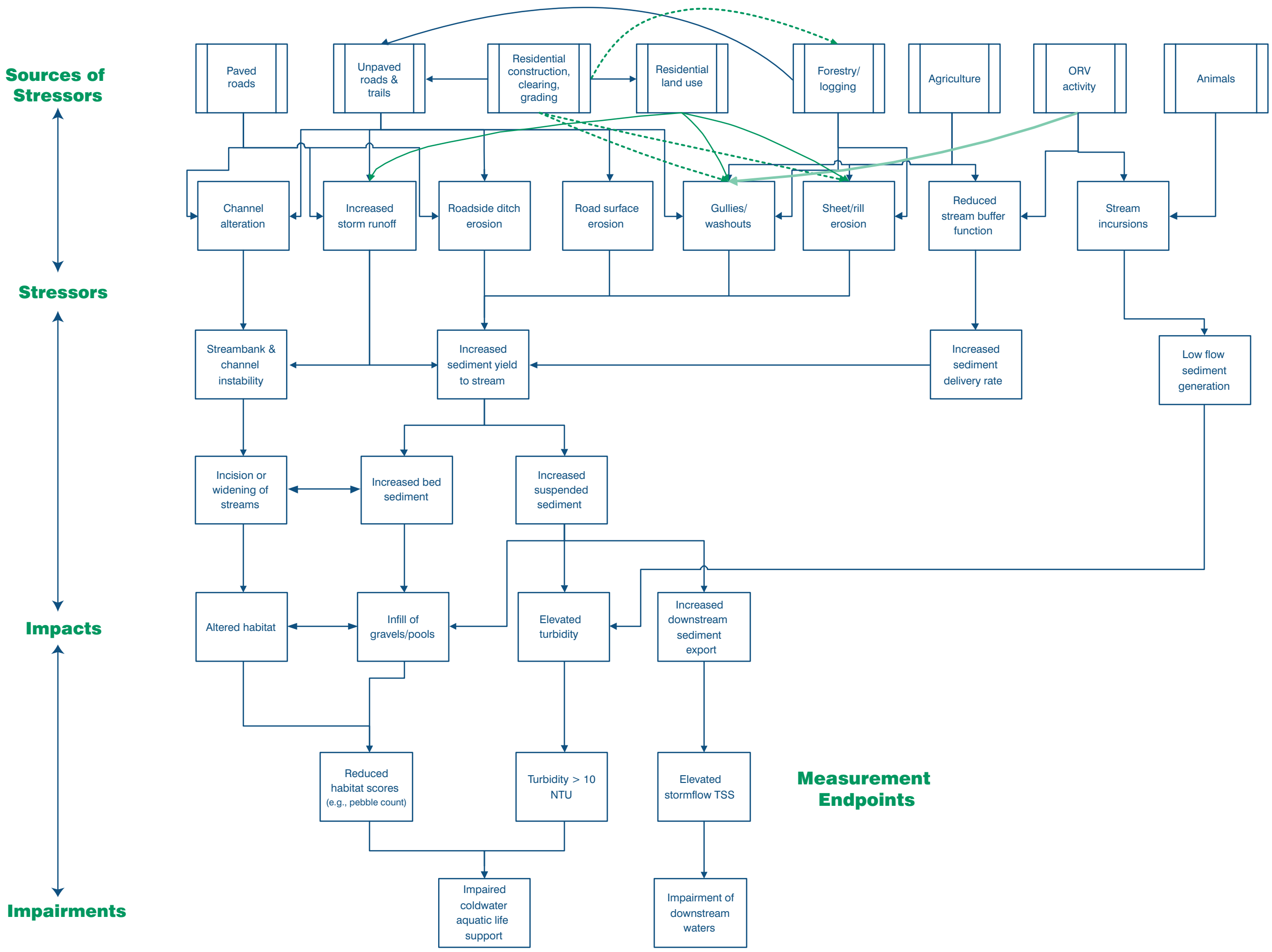


Figure 4-3. Draft Conceptual Model for Greens Creek, North Carolina

The conceptual model can be used to start identifying relationships between the possible causes and sources of impacts seen in the watershed. You don't have to wait until you have collected additional information. In fact, the conceptual model can help to identify what types of data you need to collect as part of the characterization process. Figure 4-3 illustrates a conceptual model that was developed for a watershed planning effort in Greens Creek, North Carolina. The Greens Creek watershed covers approximately 10 square miles in the southwestern part of the state. Greens Creek is classified as a C-trout habitat stream, typical of most of the mountain streams in the region. The watershed is subject to considerable development pressure from vacation homes and has highly erodible soils and steep slopes. Locals have observed significant problems related to road construction and maintenance.

To facilitate identifying the problems and their probable causes, an initial conceptual model of impairment in the Greens Creek watershed was developed. The conceptual model was presented to stakeholders for discussion at a meeting, at which they identified upland loading of sediment and subsequent impacts on water clarity (turbidity) as the key risk pathway for Greens Creek. ↳ For more information on the development of conceptual models as part of the watershed planning process, refer to EPA's *Guidelines for*

Ecological Risk Assessment, which can be downloaded at **http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=12460&partner=ORD_NCEA**.

Build your own conceptual model using Worksheet 4-3, provided in appendix B.

4.3.2 Take Stakeholders Out into the Watershed

Conducting visual watershed assessments with the stakeholders, such as stream walks, "windshield surveys," or flyovers, can provide them with a unique perspective about what's going on in the watershed. They'll be able to make visual connections between sources, impacts, and possible management approaches. Visual assessments show stakeholders the watershed boundaries, stream conditions, and potential sources contributing to waterbody impairment.

Stream surveys can be used at several points in the watershed planning process. Visual assessments might be conducted initially to help stakeholders develop a common vision of what needs to be done in a watershed. Later, they might be used to help identify areas where additional data collection is needed, identify critical areas, or select management measures.

Stream surveys can provide an important means of collecting data for identifying stressors and conducting a loading analysis. For example, streambank erosion can be a considerable source of sediment input to a stream, and illegal pipe outfalls can discharge a variety of pollutants. Both sources might be identifiable only through a visual inspection of the stream or through infrared photography.

In addition to visual assessments, photographic surveys can be used to document features like the courses of streams, the topography of the land, the extent of forest cover and other land uses, and other natural and human-made features of the watershed. Photographs provide valuable pre- and post-implementation documentation. You can make arrangements to take photos, or you might be able to obtain aerial photographs (current and historical) from the U.S. Geological Survey (USGS), the U.S. Department of Agriculture (USDA), or other sources.

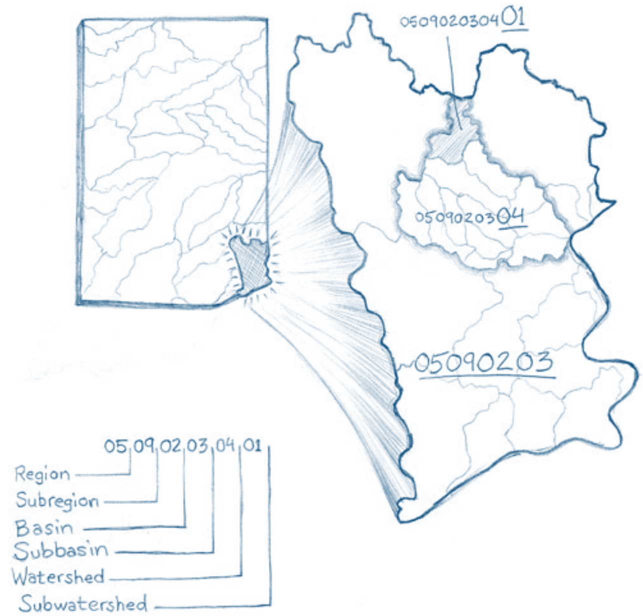
Several protocols for conducting visual assessments are discussed further in section 6.5.1 and are listed in appendix A.

4.4 Define the Geographic Extent of the Watershed

As the stakeholders identify concerns in the watershed, their findings will help to define the geographic extent of the watershed that the plan will address. The plan might address a small urban watershed with wide-ranging stressors and sources or a large river basin with only a few problem parameters. If your plan addresses a small drainage system within a watershed covered by a separate plan, make sure your planned activities are integrated with those broader-scale efforts.

One way to identify the geographic extent of your watershed planning effort is to consult the USGS map of hydrologic units. A hydrologic unit is part of a watershed mapping classification system showing various areas of land that can contribute surface water runoff to designated outlet points, such as lakes or stream segments. USGS designates drainage areas as subwatersheds (including smaller drainages) numbered with 12-digit hydrologic unit codes (HUCs), nested within watersheds (10-digit HUCs). These are combined into larger drainage areas called subbasins (8 digits), basins (6 digits), and subregions (4 digits), which make up the large regional drainage basins (2 digits).

Another way to identify watershed boundaries more precisely is to use a topographic map. These maps are available at USGS map centers and outdoor supply stores and at **http://topomaps.usgs.gov**. When working in very small watersheds of just a few square miles, it's better to obtain more detailed topographic information from city or county planning departments. From these maps, lines can be drawn following the highest ground between the waterways to identify the watershed boundaries, or ridge lines. In areas with storm sewers, maps that show how this "plumbing" might have changed watershed boundaries are often available from local or municipal government offices.



Most watershed planning efforts to implement water pollution control practices occur at the 10- or 12-digit HUC level, although smaller drainage areas within subwatersheds might be used if they represent important water resources and have a significant variety of stressors and sources. It is still helpful to factor in large-scale basin planning initiatives for strategic planning efforts that address interjurisdictional planning and solutions to widespread water quality problems. The key to selecting the geographic scope of your planning effort is to ensure that the area is small enough to manage but large enough to address water quality impairments and the concerns of stakeholders. More information on delineating watershed boundaries is provided in section 5.4.1.

What Happened to 11- and 14-Digit HUCs?

If you're confused by the new numbering, don't worry. The Federal Geographic Data Committee (FGDC) released the *Federal Standards for Delineation of Hydrologic Unit Boundaries* in October 2004 to delineate hydrologic unit boundaries consistently, modify existing hydrologic units, and establish a national Watershed Boundary Dataset (WBD). The guidelines establish a new hierarchy for hydrologic units that includes six levels and supersedes previous numbering schemes. Go to **www.ncgc.nrcs.usda.gov/products/datasets/watershed** for more information.

Breaking Down the Watershed

Watershed Boundary Definition	Example
A region, the largest drainage basin, contains the drainage area of a major river or the combined drainage areas of several rivers.	Mid-Atlantic (02)
Subregions divide regions and include the area drained by a river system.	Chesapeake Bay watershed (0207)
Basins divide or may be equivalent to subregions.	Potomac River watershed (020700)
Subbasins divide basins and represent part or all of a surface-drainage basin, a combination of drainage basins, or a distinct hydrologic feature.	Monocacy watershed (0207009)
Watersheds divide subbasins and usually range in size from 40,000 to 250,000 acres. Subwatersheds divide or may be equivalent to watersheds and usually range in size from 10,000 to 40,000 acres.	Monocacy River watershed (0207000905)
Subwatersheds divide or may be equivalent to watersheds and usually range in size from 10,000 to 40,000 acres.	Double Pipe Creek subwatershed (020700090502)

4.5 Develop Preliminary Goals

After stakeholders provide information on issues of concern, they will begin to identify the vision or goals for the watershed that they would like to see addressed in the watershed plan. Getting this input is critical to ensuring that you address the issues important to them and keep them involved in the planning and implementation effort. In some cases you'll also incorporate goals from other watershed planning activities. For example, if a TMDL has already been developed in your watershed, you can include the goals outlined in the TMDL, such as the required loading targets to be achieved. These goals are very specific.

Often stakeholders will recommend very broad goals such as "Restore lake water quality," "Protect wetlands," or "Manage growth to protect our water resources." These goals might start out broad, but they'll be refined as you move through the watershed characterization process (↳ chapters 5, 6, 7, and 8). For each goal identified, specific management objectives should be developed (↳ chapter 9). The objectives should include measurable targets needed to achieve the goals and specific indicators that will be used to measure progress toward meeting the objectives.

Example Preliminary Goals

- Meet water quality standards for dissolved oxygen.
- Restore aquatic habitat to meet designated uses for fishing.
- Protect drinking water reservoir from excessive eutrophication.
- Manage future growth.
- Restore wetlands to maintain a healthy wildlife community.
- Protect open space.

The more specific you can make your goals at this stage, the easier it will be to develop concrete objectives to achieve the goals. You should also set goals and objectives to guide the process of engaging and informing those who contribute to water quality degradation and motivating them to adopt more appropriate behaviors. For example, a goal for a river might be to restore recreational uses (fishing and swimming). This goal might be further defined as improving cold-water fisheries by reducing sediment in runoff, increasing dissolved oxygen concentrations, and reinstating swimming by lowering bacteria counts during the summer. A wide range of specific objectives should be developed and implemented to support each aspect of the goal. Make sure that the goals link back to the issues of concern.

As you move through the watershed planning process, you should build onto your goals, developing indicators to measure progress toward achieving your goals, developing specific management objectives to show *how* you will achieve your goal, and finally, developing measurable targets to determine *when* you have achieved your goals (figure 4-4).

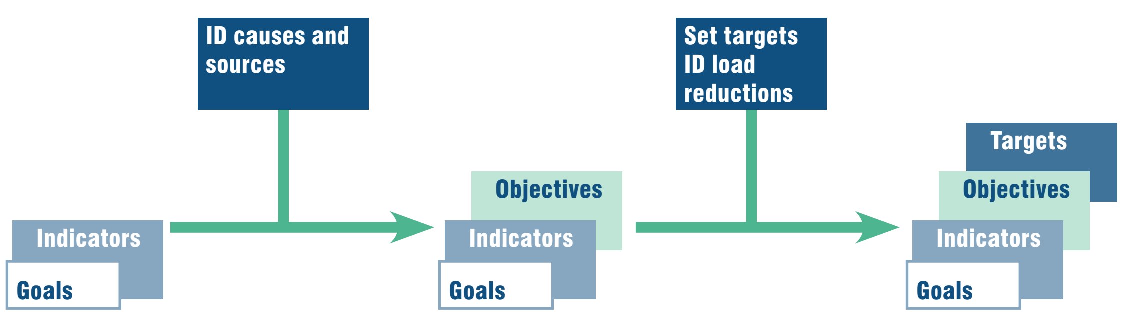


Figure 4-4. Evolution of Goals Throughout the Watershed Planning Process

4.6 Select Indicators to Measure Environmental Conditions

The stakeholders will help to select indicators that will be used to measure the current health of the watershed and to provide a way to measure progress toward meeting the watershed goals. Indicators are direct or indirect measurements of some valued component or quality in a system. Indicators are also extremely useful for assessing and communicating the status and trends of the health of a watershed. Indicators, however, do not tell you the cause of the problem. For example, you might use a thermometer to measure stream temperature. An elevated temperature might indicate a problem, but it does not specifically tell you what the problem is, where it is, or what caused it. Your stakeholder group will begin by identifying the indicators that will be used to quantify existing conditions in the watershed.

Indicators are selected, refined, added to, and modified throughout the watershed planning and implementation process. As you complete the characterization phase and develop goals and management objectives, you'll shift your indicators from those which assess current conditions to those which quantitatively measure progress toward meeting your goals. For example, in the Coal Creek watershed, the goal is to reduce sediment loadings to meet water quality standards and support all beneficial uses. Table 4-1 shows the indicators used and the target values for measuring progress toward reducing the sediment load. You'll learn how to develop these target values in chapter 9.

Table 4-1. Coal Creek Sediment Loading Indicators and Target Values

Sediment Loading Indicator	Target Value
5-year mean McNeil core percent subsurface fines < 6.35 mm	35 percent
5-year mean substrate score	≥ 10
Percent surface fines < 2 mm	< 20 percent
Clinger richness	≤ 14

Be aware that you might have to refer back to this section as you develop your watershed plan to develop additional indicators to measure performance and the effectiveness of plan implementation. Table 4-2 illustrates where indicators are used to develop and implement your watershed plan.

Table 4-2. Use of Indicators Throughout the Watershed Planning and Implementation Process

Planning Step	How Indicators Are Used
Assess Current Conditions	Indicators are used to measure current environmental conditions, e.g., water quality, habitat, aquatic resources, land use patterns
Develop Goals	Indicators are used to determine when the goal will be achieved, e.g., reducing nutrient loads to meet water quality standards
Develop Pollution Load Reduction Targets	Indicators are used to measure the targets for load reductions, e.g., phosphorus concentration
Select Management Strategies	Indicators are used to track the implementation of the management measures, e.g., number of management practices installed
Develop Monitoring Program	The monitoring program measures the indicators that have been developed as part of the management strategies and information/education program
Implement Watershed Plan	Indicators are used to measure the implementation of the watershed plan, tracking dollars spent, resources expended, management practices implemented, and improvements in water quality

4.6.1 Select Quantitative Indicators

In developing the watershed plan, you'll conduct watershed assessments and analyses to quantify source loads, characterize impacts, and estimate the load reductions needed to meet your goals and objectives. Sometimes the source loads and load reductions will be expressed in slightly different terms, such as the number of miles of eroded banks and the miles of vegetated buffers needed to address the problem. Regardless of the approach, the important point to remember is that *quantification is the key to remediation*. If you can't somehow measure the problems you're facing, it will be almost impossible to know whether you're making any headway in addressing them.

Factors to Consider When Selecting Indicators

Validity

- Is the indicator related to your goals and objectives?
- Is the indicator appropriate in terms of geographic and temporal scales?

Clarity

- Is the indicator simple and direct?
- Do the stakeholders agree on what will be measured?
- Are the methodologies consistent over time?

Practicality

- Are adequate data available for immediate use?
- Are there any constraints on data collection?

Clear Direction

- Does the indicator have clear action implications depending on whether the change is good or bad?

For watershed planning purposes, indicators should be quantitative so that the effectiveness of management measures can be predicted. For example, if one of the goals identified by stakeholders is "restore aquatic habitat to meet designated uses," and you believe the habitat has been degraded because of elevated levels of nutrients entering the waterbody, what indicators will you use to measure progress toward achieving that goal? A specific value should be set as a target for the indicator, representing desired levels. For example, phosphorus can be used as an indicator to directly measure the reduction in loadings. Table 4-3 provides examples of environmental indicators and possible target values, or endpoints. Targets can be based on water quality standards or, where numeric water quality standards do not exist, on data analysis, literature values, or expert examination of water quality conditions to identify values representative of conditions supportive of designated uses. Chapter 9 goes into more detail on how to develop targets for your goals and objectives.

If a TMDL exists, important indicators have already been defined and you can incorporate them when selecting appropriate management actions to implement the load reductions cited in the TMDL. If no TMDL exists, select indicators that are linked to your water quality restoration or protection goals, such as pollutant concentrations or other parameters of concern (e.g., channel instability, eroding banks, channel flow, flow cycles). The indicators selected should consider the impacts, impairments, or parameters of concern in the waterbody and the types and pathways of watershed stressor sources that contribute to those impacts.

Regardless of the approach, the important point to remember is that quantification is the key to remediation. If you can't somehow measure the problems you're facing, it will be almost impossible to know if you're making any headway in addressing them.

4.6.2 Select a Combination of Indicators

You'll use different types of indicators to reflect where you are in the watershed management process and the audience with which you are communicating. You'll first select environmental indicators to measure the current conditions in the watershed and help to identify the stressors and the sources of the pollutants. As you develop your management objectives and actually assemble your watershed plan (chapter 12), you'll add performance indicators,

Table 4-3. Example Environmental Indicators Used to Identify Relationships Between Pollutant Sources and Environmental Conditions

Issue	Indicator	Example Target Value	Why You Would Use It
Sediment	Pebble counts (% surface fines < 2 mm)	< 20%	Pebble counts provide an indication of the type and distribution of bed material in a stream. Too many fines can interfere with spawning and degrade the habitat for aquatic invertebrates.
	Stream channel stability	No significant risk of bank erosion	Channel stability uses a qualitative measurement with associated mathematical values to reflect stream conditions.
	Total suspended solids (TSS)	Monthly avg. concentration < 40 mg/L	Solids can adversely affect stream ecosystems by filling pools, clogging gills, and limiting the light penetration and transparency critical to aquatic flora.
	Turbidity	< 25 NTU	Turbidity measures the clarity of water and can also be used as an indirect indicator of the concentration of suspended matter.
Eutrophication	Chlorophyll *a* (benthic)	Maximum < 100 mg/m^2	In flowing streams, most algae grow attached to the substrate. Too much benthic algae can degrade habitat; alter the cycling of oxygen, nutrients, and metals; and result in unaesthetic conditions.
	Chlorophyll *a* (water column)	Geometric mean < 5 μg/L	Chlorophyll *a* is an indirect measure of algal density. Excess levels might result in harmful swings in dissolved oxygen (DO) concentrations, decrease water clarity, and alter the natural food chain of a system.
	Nitrate + nitrite	Monthly average < 1.5 mg/L	Elevated levels of nitrate + nitrite are good indicators of runoff from irrigation, residential lawn care fertilizers, and effluent waste streams. These parameters can indicate leaching from septic systems and erosion of natural deposits. Nitrogen is a limiting nutrient to algal production in many estuarine and arid freshwater systems.
	Orthophosphate	Monthly average < 0.05 mg/L	Orthophosphate measures the form of phosphorus that is readily available to aquatic systems. Too much phosphorus can often cause excessive aquatic vegetation growth in freshwater systems.
	Total nitrogen	Monthly average < 5 mg/L	Total nitrogen (often measured as the sum of nitrate + nitrite and total Kjeldahl nitrogen) measures the total ability of the waterbody to supply nitrogen to support algal growth after microbial processing.
	Ammonia	< 15 mg/L	Excess ammonia can cause toxicity in fish. The toxicity of ammonia is dependent on pH and temperature.
	Total phosphorus	Monthly average < 0.10 mg/L	Total phosphorus includes phosphorus that is bound to sediment particles or in organic compounds, some of which can become available in the water column. It is often the limiting nutrient for growth of aquatic vegetation in freshwater systems.
Pathogens	Fecal coliform bacteria	30-day geometric mean of < 200/100 mL	This bacterial indicator is often used to monitor for the presence of human/animal waste in a waterbody, which might lead to sickness in human populations. It also indicates compromised sanitary discharge and septic systems.
	E. coli bacteria	30-day geometric mean of < 125/100 mL	This bacterial indicator is often used to monitor for the presence of human/animal waste in a waterbody, which might lead to sickness in human populations. It also indicates compromised sanitary discharge and septic systems.
Metals	Copper	< 7.3 μg/L	Many metals are toxic to various forms of aquatic life, and water quality criteria have been developed. Criteria for most metals vary with the hardness of the water.
	Lead	< 82 μg/L	
	Zinc	< 67 μg/L	

Table 4-3. Example Environmental Indicators Used to Identify Relationships Between Pollutant Sources and Environmental Conditions (continued)

Issue	Indicator	Example Target Value	Why You Would Use It
Habitat	Temperature	Instantaneous < 33 ºC, daily avg. < 29 ºC	Many aquatic organisms are adapted to survive and prosper within specific temperature ranges.
	Physical habitat quality	Rapid Bioassessment Protocol (RBP) value	The assessment of physical habitat quality can be used to determine the potential of waterbodies to sustain healthy aquatic systems.
General Water Quality	Total dissolved solids (TDS)	700 mg/L	TDS is a direct measurement of the dissolved mineral content in stream ecosystems. High TDS can be harmful to aquatic organisms and can restrict the beneficial use of water (e.g., for irrigation).
	Conductivity	< 1,000 μS/cm	Conductivity is a good indicator of the dissolved mineral content in stream ecosystems. Also, it is a good measure of the salinity of the water.
	Dissolved Oxygen (DO)	> 5.0 mg/L	DO is an important measure of the quality of the habitat and overall health of the ecosystem. Oxygen depletion can indicate a number of undesirable physical, chemical, and biological activities in the watershed.
	pH	6 < pH < 9	pH is a measure of the acidity (hydrogen/hydroxide ion concentration). Most aquatic organisms have a preferred pH range, usually pH 6 to 9. Beyond that range aquatic organisms begin to suffer from stress, which can lead to death. High pH levels also force dissolved ammonia into its toxic, un-ionized form, which can further stress fish and other organisms.
	Oil and grease	Minimize	Oil and grease indicate impacts from general vehicular impervious surfaces and illicit disposal activity.
Flow	Dry weather flows	95% of daily flows > 5 cfs	As impervious surface area increases, often stream base flow decreases, resulting in decreased aquatic habitat and exacerbating problems with high temperature and low dissolved oxygen.
	Frequency of overbank flood events	< 1 in 2 years	The frequency and magnitude of flood events is influenced by increased urbanization and can affect channel stability. This indicator is also easily understood by the public.
	Peak flow	Achieve pre-development conditions for response to 2-year storm	Urbanization often leads to increased storm flow peaks, which in turn set off instability in the stream channel.
Biology	Biological indexes	Varies by index, assemblage, stream size, ecoregion	Several indexes under various acronyms (IBI, ICI, SCI, RIVPACS) have been developed to directly measure the health of fish, macroinvertebrate, and periphyton assemblages. See Barbour et al. (1999) for an introduction to the use of these indexes.
	EPT richness	Varies by stream type and ecoregion	This metric is the richness of the sample in taxa that are mayflies (Ephemeroptera), stoneflies (Plecoptera), or caddisflies (Trichoptera). Invertebrates that are members of these groups are generally understood to be sensitive to stressors in streams, whether the stressors are physical, chemical, or biological. Consequently, these taxa are less common in degraded streams. Component of most macroinvertebrate biological indexes.
	DELT anomalies	< 0.1%	The percentage of fish in a sample with external **d**eformities, fin **e**rosion, **l**esions, or **t**umors. These anomalies increase with both conventional organic pollution and toxic pollution. Component of some fish biological indexes.

Table 4-3. Example Environmental Indicators Used to Identify Relationships Between Pollutant Sources and Environmental Conditions (continued)

Issue	Indicator	Example Target Value	Why You Would Use It
Biology (continued)	Beck's Biotic Index	> 11.0	A weighted sum of the number of pollution-sensitive macroinvertebrate species in a standardized sample. Highly sensitive taxa receive 2 points; sensitive taxa receive 1 point. Similar to EPT richness, but more appropriate in low-gradient streams. Component of some macroinvertebrate biological indexes.
	Hilsenhoff Biotic Index (HBI)	< 3.8	The abundance-weighted average tolerance of all taxa in a macroinvertebrate sample. The HBI score increases with pollution and degradation as tolerant taxa replace intolerant (sensitive) taxa. See Barbour et al. (1999). Component metric of many macroinvertebrate biological indexes.
	Observed taxa/ expected taxa (O/E)	> 0.8	This is the measurement endpoint of what are termed RIVPACS, or predictive model indexes. This indicator measures the macroinvertebrate taxa actually observed at a site in relationship to those expected to occur under undisturbed conditions, adjusted for site-specific features (e.g., stream size, elevation). See Wright et al. (2000).

such as social and programmatic indicators, to help measure progress toward meeting your goals. Table 4-4 provides examples of indicators used throughout the watershed plan development and implementation effort.

The Audience

Keep in mind that indicators provide a powerful means of communicating to various audiences about the status of the watershed, as well as demonstrating the progress being made toward meeting goals. Select indicators that will help to communicate these concepts to nontechnical audiences. For example, using a 30-day geometric mean for *E. coli* bacteria to demonstrate reduction in pathogens to the waterbody won't mean much to most people. But using the number of shellfish beds that have been reopened because of the reduction of pathogen inputs is easier to understand. Or being able to count the number of failing septic systems that have been located and repaired shows people how the sources of pathogens are being reduced.

Environmental Indicators

Environmental indicators are a direct measure of the environmental conditions that plan implementation seeks to achieve. The indicators should be directly related to the indicators selected for your management objectives. By definition, the indicators are measurable quantities used to evaluate the relationship between pollutant sources and environmental conditions. Target goals are defined by the values of the selected indicators. Frequently these targets reflect water quality standards for designated uses. In other cases, qualitative standards for water quality and habitat protection need to be interpreted to establish the criteria. For example, if the indicator was phosphorus, the target could be a reduction of the instream concentration value or a total allowable load that is expected to protect the resource.

Programmatic Indicators

Programmatic indicators are indirect measures of resource protection or restoration (e.g., the number of management practices or the number of point source permits issued). These don't necessarily indicate that you're meeting your load reductions, but they do indicate actions intended to achieve a goal. When you develop the implementation plan (chapter 12), look

Table 4-4. Example Indicators Used throughout Watershed Plan Development and Implementation

Concern: No fish in stream due to heavy sedimentation
Goal: Reduce sedimentation into stream to meet designated uses
Objective: Install management practices streamside to reduce sedimentation by 15 percent

Type of Indicator	Example Indicators	Methods
Environmental (baseline conditions)	Turbidity, flow, total suspended solids (TSS), channel stability	Direct water quality measurements, photographs, watershed surveys
Programmatic	Number of brochures mailed for management practice workshop	Mailing lists
Programmatic	Number of participants at management practice workshop	Attendance lists
Social	Number of follow-up phone calls requesting information	Phone records
Social	Increased awareness of watershed issues	Pre- and post-project surveys, focus groups
Social	Number of landowners requesting assistance to install management practices	Phone records
Social	Number of landowners aware of technical and financial assistance available for management practice installation	Pre- and post-project surveys, interviews
Programmatic	Number of management practices installed	Tracking database
Environmental (measure implementation progress)	Turbidity, flow, TSS, channel stability	Direct water quality measurements, photographs, watershed surveys

for important programmatic actions that can be tracked over time. Programmatic indicators include measures such as recording the number of people attending workshops, the number of projects approved, the number of monitoring samples taken, and dollars spent.

Social Indicators

Social indicators measure changes in social or cultural practices, such as increased awareness of watershed issues, and behavior changes that lead to implementation of management measures and subsequent water quality improvements. Indicators may include the percentage of landowners along the stream corridor that know what a watershed is or the number of homeowners that sign a pledge to reduce fertilizer use. Consider the methods you'll use to collect this information, such as pre- and post- surveys, focus groups, and one-on-one interviews. Table 4-5 provides several examples of indicators that can be used to measure progress or performance.

Regardless of the types of indicators and targets you develop, you should establish some means for storing data (e.g., database) and for tracking and reporting progress against these values. Section 12.10 describes various tracking systems that can be used to manage this information.

Table 4-5. Examples of Performance Indicators That Can Be Used to Develop Targets to Measure Progress in Meeting Watershed Goals

Environmental	Programmatic	Social
• Number (or percentage) of river/stream miles, lake acres, and estuarine and coastal square miles that fully meet all water quality standards • Number (or percentage) of river/stream miles, lake acres, and estuarine and coastal square miles that come into compliance with one or more designated uses • Number (or percentage) of river/stream miles, lake acres, and estuarine and coastal square miles that meet one or more numeric water quality standards • Demonstrated improvement in water quality parameters (e.g., DO, pH, TSS) • Demonstrated improvement in biological parameters (e.g., increase in numbers or diversity of macroinvertebrates) • Demonstrated improvement in physical parameters (e.g., increased riparian habitat) • Reduction in the number of fish consumption advisories, beach closures, or shellfish bed closures • Number of river/stream miles, lake acres, and estuarine and coastal square miles removed from the "threatened" list • Reduction in pollutant loadings from nonpoint sources • Reductions in frequencies of peak flows in developing areas • Increase in the number of acres of wetlands protected or restored • Reduction in the amount of trash collected in stormwater drains	• Number of management measures implemented in a watershed (e.g., number of stream miles fenced, number of riparian buffers created) • Number of approved or certified plans (e.g., sediment and erosion control plans, stormwater plans, nutrient management plans) • Number of ordinances developed • Number of hits on watershed Web site • Number of residents requesting to have their septic systems serviced • Number of illicit connections identified and corrected • Number of permits reissued • Elapsed time from permit violation reports to compliance • Number of public water systems with source water protection plans • Reduction in the amount of impervious surface area directly connected to buildings	• Rates of participation in education programs specifically directed to solving particular nonpoint source pollution problems • Increase in awareness, knowledge, and actions designed to change behavior patterns • Rates of participation in various nonpoint source activities, such as citizen monitoring and watershed restoration activities • Increase in participation at watershed stakeholder meetings • Increase in the number of residents signing watershed stewardship pledge • Number of homeowners requesting an inspection of their septic systems

4.7 Link Concerns with Goals and Indicators

It's important to help stakeholders to link their concerns with goals. It's also important to develop indicators that measure the current conditions in the watershed, as well as to identify possible indicators to measure progress once the watershed plan is implemented. Work with the stakeholders to fill out ✎ Worksheet 4-4 to link the concerns with the goals they have identified. For each of the concerns they identify, ask them to write down the potential causes of the problem. Ask them how they would measure the current conditions in the watershed. Then for each goal selected, they should develop the indicators they want to use to measure progress in meeting those goals. The more specific you can be at this stage, the more focused your data-gathering efforts will be in the next phase. ↳ A blank copy of the worksheet is provided in appendix B.

Worksheet 4-4 Identifying Concerns, Causes, Goals, and Indicators

What are the problems/ concerns in the watershed?	What do you think caused the problems?	How can we assess current conditions? (Indicators)	What would you like to see for your watershed? (Goals)	How will we measure progress toward meeting those goals? (Indicators)
No more fish in the stream	Sedimentation from eroding streambanks	Visual assessment of eroding banks, turbidity	Meet designated uses for fishing	Turbidity, TSS, fish assemblages
E. coli contamination	Failing septic systems	Fecal coliform concentrations	Meet water quality standards for pathogens	30-day geometric mean concentration of fecal coliforms, number of failing septic systems repaired
Trash in the stream	Stormwater runoff, people littering	Photographs of trash	Reduce trash found in stream	Pounds of trash removed, comparison of photographs taken before and after implementation