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 9. Set Goals and Identify Load Reductions

March 2008

Handbook Road Map

9. Set Goals and Identify Load Reductions

Chapter Highlights

- Setting goals
- Identifying management objectives
- Selecting indicators
- Developing targets
- Determining load reductions needed
- Focusing on load reductions

Read this chapter if...

- You want to select indicators to measure attainment of your watershed goals
- You want to use your watershed goals to identify numeric water quality targets
- You need an approach to determine how much of a load reduction you need to meet your watershed goals
- You want information on how to focus load reductions appropriately

9.1 How Do I Link the Watershed Analysis to Management Solutions?

Once you have analyzed the data, identified the problem(s) in the watershed, and identified and quantified the sources that need to be managed, you'll develop management goals and associated targets. During the scoping phase of planning (chapter 4), you established broad watershed goals (e.g., meet water quality standards, restore degraded wetlands) as a preliminary guide. Now that you have characterized and quantified the problems in the watershed (chapters 7 and 8), you're ready to refine the goals and establish more detailed objectives and targets that will guide developing and implementing a management strategy.

The process of developing specific objectives and targets is an evolution of the watershed goals you identified with your stakeholders. As you proceed through the watershed plan development, you'll gain more information on the watershed problems, waterbody conditions, causes of impairment, and pollutant sources. With each step of the process, you can focus and better define your watershed goals, until eventually you have specific objectives with measurable targets. Figure 9-1 illustrates this evolution. The first step is identifying the broad watershed goals with your stakeholders, answering "What do I want to happen as a result of my watershed plan?" As you do this, you'll also identify environmental indicators that can be used to measure progress toward meeting those goals. Once you have identified the sources contributing to watershed problems, you can refine your watershed goals and develop management objectives targeted at specific pollutants or sources. The management objectives identify how you will achieve your goals. It's important to have indicators that can be measured (e.g., load or concentration) to track progress toward meeting those objectives. You should link some of these indicators to pollutant sources based on their cause-and-effect relationship to then identify the load reductions needed to meet the target. For example, instream levels of dissolved oxygen can be linked to nutrient loads, and you can use various methods to determine what reductions in nutrients will result in the dissolved oxygen target.

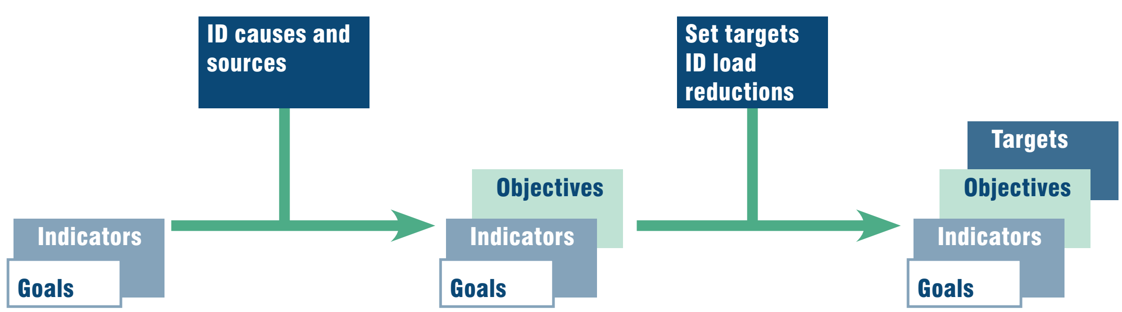


Figure 9-1. Process for Identifying Final Watershed Goals and Targets

Once you have identified your indicators, numeric targets, and associated load reductions, they can be incorporated into the management objectives for the final goals for your watershed plan. These goals will guide the identification and selection of management practices to meet the numeric targets and, therefore, the overall watershed goals, as discussed in chapters 10 and 11.

9.2 Translate Watershed Goals into Management Objectives

You've probably already identified preliminary goals and associated environmental indicators with your stakeholders, as outlined in chapter 4, but now you'll refine the goals on the basis of your data analysis. The data analysis identified the likely causes and sources affecting specific indicators (e.g., temperature, dissolved oxygen, pebble counts). Therefore, you have an idea of what sources need to be controlled to meet your overall watershed goals and can use this information to translate your watershed goals into management objectives. Management objectives incorporate the watershed goals but focus on specific processes that can be managed, such as pollutant loading and riparian conditions.

For example, perhaps during the scoping phase you knew that there was a problem with aquatic habitat so you established the preliminary goal "restore aquatic habitat." Now, after the data analysis, you can refine the goal to include a specific management objective, such as "restore aquatic habitat in the upper main stem of White Oak Creek by controlling agricultural sources of sediment." Table 9-1 provides some examples of translating watershed goals into management objectives.

Table 9-1. Sample Goals Linked to the Sources and Impacts to Define Management Objectives

Preliminary Goal	Indicators	Cause or Source of Impact	Management Objective
Support designated uses for aquatic life; reduce fish kills	Dissolved oxygen Phosphorus Temperature	Elevated phosphorus causing increased algal growth and decreased dissolved oxygen Cropland runoff	Reduce phosphorus loads from cropland runoff and fertilizer application
Reduce flood levels	Peak flow volume and velocity	Inadequate stormwater controls, inadequate road culverts	Minimize flooding impacts by improving peak and volume controls on urban sources and retrofitting inadequate road culverts
Restore aquatic habitat	Riffle-to-pool ratio, percent fine sediment	Upland sediment erosion and delivery, streambank erosion, near-stream land disturbance (e.g., livestock, construction)	Reduce sediment loads from upland sources; improve riparian vegetation and limit livestock access to stabilize streambanks
Meet water quality standards for bacteria to reduce beach closures	Fecal coliform bacteria	Runoff from livestock operations, waterfowl	Reduce bacteria loads from livestock operations
Improve aesthetics of lake to restore recreational use	Algal growth, chlorophyll a	Elevated nitrogen causing increased algal growth	Reduce nitrogen loads to limit algal growth
Meet water quality standards for metals	Zinc, copper	Urban runoff, industrial discharges	Improve stormwater controls to reduce metal loads from runoff
Restore wetland	Populations of wetland-dependant plant and animal species; nitrogen and phosphorus	Degradation of wetland causing reduced wildlife and plant diversity and increases in nitrogen and phosphorus runoff because of a lack of wetland filtration	Restore wetland to predevelopment function to improve habitat and increase filtration of runoff
Conserve and protect critical habitat	Connectivity, aerial extent, patch size, population health	Potential impacts could include loss of habitat, changes in diversity, etc.	Maintain or improve critical habitat through conservation easements and other land protection measures

9.3 Select Environmental Indicators and Targets to Evaluate Management Objectives

Once you have established specific management objectives, you'll develop environmental indicators and numeric targets to quantitatively evaluate whether you are meeting your objectives. You identified indicators with the stakeholders when you developed your conceptual model (chapter 4), and the indicators should be refined in this step. The indicators are measurable parameters that will be used to link pollutant sources to environmental conditions. The specific indicators will vary depending on the designated use of the waterbody (e.g., warm-water fishery, cold-water fishery, recreation) and the water quality impairment or problem of concern. For example, multiple factors might cause degradation of a warm-water fishery. Some potential causes include changes in hydrology, elevated nutrient concentrations, elevated sediment, and higher summer temperatures. Each of these stressors can be measured using indicators like peak flow, flow volume, nutrient concentration or load, sediment concentration or load, and temperature.

Don't Forget About Programmatic and Social Indicators

Chapters 4 and 12 discuss the development of a variety of indicators to measure progress in implementing your watershed plan and meeting your goals. Indicators can be environmental, social, or programmatic. This chapter discusses only environmental indicators and how they are used to represent watershed goals and evaluate pollutant load reductions. Social and programmatic indicators are identified as part of the implementation program, discussed in chapter 12.

A specific value can be set as a target for each indicator to represent the desired conditions that will meet the watershed goals and management objectives. Targets can be based on water quality criteria or, where numeric water quality criteria do not exist, on data analysis, reference conditions, literature values, or expert examination of water quality conditions to identify values representative of conditions that support designated uses. If a Total Maximum Daily Load (TMDL) already exists for pollutants of concern in your watershed, you should review the TMDL to identify appropriate numeric targets. TMDLs are developed to meet water quality standards, and when numeric criteria are not available, narrative criteria (e.g., prohibiting excess nutrients) must be used to develop numeric targets.

It might be necessary to identify several related indicators and target values to facilitate evaluation of pollutant loads and measure progress. For example, dissolved oxygen is an indicator of the suitability of a waterbody to support fisheries. However, dissolved oxygen is not a specific pollutant and is not typically estimated as a load. Because dissolved oxygen is a waterbody measure that is affected by several parameters, including nutrients, it's appropriate to select other indicators that can be linked to dissolved oxygen and quantified as loads (e.g., phosphorus loading).

Not All Indicators Will Have Associated Load Reductions

It will be difficult or impossible to develop quantifiable indicators for all watershed issues of concern. For example, some goals and associated indicators (e.g., "make the lake more appealing for swimming," or "reduce the prevalence of exotic species") are indirectly related to other indicators that are more easily linked to source loads (e.g., dissolved oxygen, nutrient loads), and trying to link them to one or even a few specific pollutants and source loads is often too difficult or inappropriate. Therefore, these indicators are expected to improve based on identified load reductions for other indicators. They will be directly measured to track overall watershed goals, but they will not have an associated load reduction target.

Table 9-2 provides some examples of indicators and target values associated with management objectives.

9.4 Determine Load Reductions to Meet Environmental Targets

At this point in the watershed planning process, you have already quantified the pollutant loads from sources in your watershed (chapter 8) and identified appropriate environmental indicators and associated targets to meet your watershed goals. The next step is to determine the load reductions needed to meet your targets—how to control watershed sources to meet your goals.

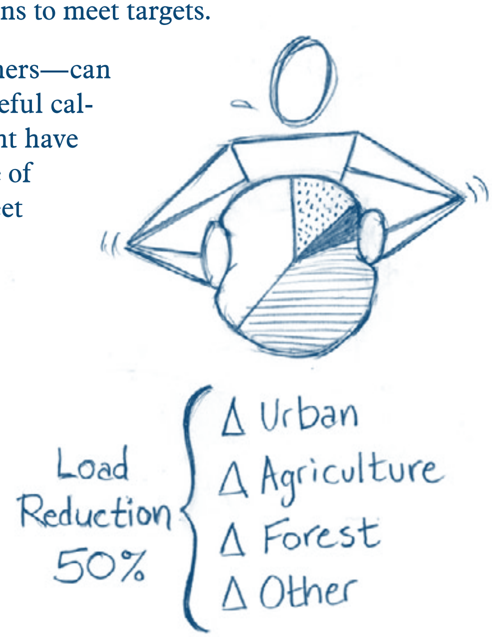
Table 9-2. Examples of Indicators and Targets to Meet Management Objectives

Management Objective	Indicator and Target Value
Reduce phosphorus loads from cropland runoff and fertilizer application	*Dissolved oxygen*: Daily average of 7 mg/L (from water quality standards) *Phosphorus*: Daily average of 25 μg/L (based on literature values)
Minimize flooding impacts by improving peak and volume controls on urban sources and retrofitting inadequate road culverts	*Peak flow volume and velocity*: Peak velocity for 1-yr, 24-hr storm of 400 cfs
Reduce sediment loads from upland sources; improve riparian vegetation and limit livestock access to stabilize streambanks	*Riffle-to-pool ratio*: 1:1 ratio (based on literature values) *Percent fine sediment*: <10 percent of particles <4 mm (based on reference conditions)
Reduce bacteria loads from livestock operations	*Fecal coliform bacteria*: Geometric mean of 200 cfu/100 mL (based on water quality standards)
Reduce nitrogen loads to limit algal growth	*Algal growth*: <10 percent coverage of algal growth (based on reference conditions) *Chlorophyll a*: <1 μg/L (based on literature values)
Improve stormwater controls to reduce metal loads from runoff	*Zinc*: Maximum of 120 μg/L (based on water quality standards) *Copper*: Maximum of 13 μg/L (based on water quality standards)

9 This phase of the watershed planning process should result in element *b* of the nine elements for awarding section 319 grants. Element *b* is "*An estimate of the load reductions expected from management measures.*"

To estimate the load reductions expected from the management measures, you need to understand the cause-and-effect relationship between pollutant loads and the waterbody response. Establishing this link allows you to evaluate how much of a load reduction from watershed sources is needed to meet waterbody targets. The options for establishing such links range from qualitative evaluations to detailed receiving water computer modeling. As with your approach for quantifying pollutant loads, selecting the appropriate approach will depend on several factors, including data availability, pollutants, waterbody type, source types, time frame, and spatial scale. Most important, the approach must be compatible with the method used to quantify loads and must be able to predict the necessary load reductions to meet targets.

A number of techniques—some more rigorous and detailed than others—can be used. Sometimes models or analytic techniques that allow for careful calculation of appropriate loading are used, but at other times you might have only limited data to estimate loadings. This section includes a range of approaches you can use to identify the load reductions needed to meet targets. Remember that the load estimates can be updated over time as more information and data are collected. The options discussed in this section include



- Qualitative linkages
- Mass balance approach
- Empirical relationships
- Statistical or mathematical relationships
- Reference watershed approach
- Receiving water models

Table 9-3 presents some example approaches for the linkage analysis for typical waterbody-pollutant combinations. Many of these approaches are discussed in the following sections.

Table 9-3. Example Approaches for Linking Indicators and Sources

Waterbody–Pollutant Combination	Example Linkage Approach
River–Pathogens	Instream response using HSPF (data collection consideration)
Lake–Nutrients	Lake response using BATHTUB More detailed option using CEQUAL-W2 or EFDC
River–Nutrients	Stream response using mass balance, QUAL2E low-flow model, or WASP
River–Pesticides/Urban	Allowable loading determination based on calculation from identified target at design flow or a range of flows
River/Estuary–Toxic Substances	Allowable loading determination based on calculation from identified target at design flow or a range of flows
River–Sediment	Load target determined from comparison with desired reference watershed Geomorphic/habitat targets derived from literature
River–Temperature	SSTEMP or SNTEMP stream flow and temperature analysis QUAL2E stream flow and temperature analysis
River–Biological Impairment	Comparison of estimated watershed/source loads with loads in reference watershed
Estuary–Nutrients	Estuary response using Tidal Prism, WASP, EFDC, or similar model
Coastal Pathogen	Response using WASP, EFDC, or similar model Alternatively, determine correlation of coastal impairment with tributary loading

9.4.1 Qualitative Linkages Based on Local Knowledge or Historical Conditions

If you have only limited data for your watershed and the sources and causes are not well documented or characterized, it might be appropriate to use a theoretical linkage to explain the cause-effect relationship between sources and waterbody conditions. You might have to rely on expert or local knowledge of the area and sources to identify coarse load reduction

What if Load Reductions for My Watershed Have Already Been Established by a TMDL?

An existing study (e.g., TMDL) might already have identified the allowable loading for one or more pollutants in your watershed. You might be able to use these studies for your targets or at least incorporate them into your analysis.

Keep the following in mind when incorporating TMDL results:

- Pollutants: What pollutants were considered? How do they relate to your goals?
- Time frame: Have conditions changed from the time of TMDL development?
- Data availability: Are more data available now to update the analysis?
- Management efforts: Have any management activities been implemented since the TMDL was developed that should be taken into account?
- Source level: At what level did the TMDL assign load allocations and reductions? Do you want more detailed or more gross distributions?

targets. If you do this, remember to incorporate a schedule for updating your watershed plan and load reductions as more information and data are collected.

An example of a qualitative linkage is an assumed linkage between instream sediment deposition and watershed sediment loading. The expected problem is fine sediment filling in pools used by fish and cementing the streambed, prohibiting the fish from laying eggs. Although it is known that sediment loading increases the deposition of fine sediment, you have no documented or quantified link between the two. You can estimate a conservative load reduction, accompanied by plans for additional monitoring to evaluate instream conditions.

Another example of a qualitative linkage is the assumption that loading is directly proportional to the instream response. That is, a percent increase in loading will result in an equal percent increase in instream concentrations. Assuming this, you can use observed data to calculate the needed reduction in waterbody concentration to meet your target and assume that it is equal to the necessary percent reduction in loading. Although a 1-to-1 relationship between loading and concentration likely does not exist, you might not have the data needed to support identification of a more accurate linkage.

9.4.2 Mass Balance Approach

A mass balance analysis represents an aquatic system through an accounting of mass entering and exiting the system. This analysis simplifies the representation of the waterbody and does not estimate or simulate detailed biological, chemical, or physical processes. It can, however, be a useful and simple way to estimate the allowable loading for a waterbody to meet water quality standards or other targets. The approach includes tallying all inputs and outputs of a waterbody to evaluate the resulting conditions. To successfully apply a mass balance, it's important to understand the major instream processes affecting water quality, such as decay, background concentrations, settling, and resuspension. Many of these factors can be estimated based on literature values if site-specific information is not available.

The mass balance approach is versatile in its application, allowing for varying levels of detail. In addition, it requires loading inputs but does not require that the loads be calculated by particular methods. Because of this, you can use a mass balance in conjunction with a variety of approaches for calculating watershed loads. You can use loads calculated from a watershed model, as well as those from a simple analysis using loading rates and land use distribution. You can apply mass balance equations at various places in the watershed, depending on the resolution of your loading analysis.

Using a Mass Balance Equation to Evaluate Phosphorus Loading in Pend Oreille Lake, Idaho

The Pend Oreille Lake TMDL uses a mass balance approach for identifying existing loading and allowable loading for nutrients in the nearshore area of the lake. The nearshore area was identified as impaired on the basis of stakeholder concerns over algae and "slimy rocks" in the area. A mass balance approach was used to identify current watershed phosphorus loading based on observed lake concentrations and allowable loading based on an in-lake phosphorus target concentration. Several of the mass balance factors were based on site-specific data (e.g., lake "cell" volume calculated using Secchi depths) and literature values (e.g., settling velocity of phosphorus, first-order loss coefficients).

For more details on how this TMDL used mass balance, go to **www.tristatecouncil.org/documents/02nearshore_tmdl.PDF**.

9.4.3 Empirical Relationships

In some cases, depending on the indicators and pollutants of concern, you can use documented empirical relationships to evaluate allowable loading and load reductions to meet watershed targets. Empirical relationships are relationships based on observed data, and an empirical equation is a mathematical expression of one or more empirical relationships.

One example of an empirical relationship that can be used in evaluating allowable loading is the Vollenweider empirical relationship between phosphorus loading and trophic status. The Vollenweider relationship predicts the degree of a lake's trophic status as a function of the areal phosphorus loading and is based on the lake's mean depth and hydraulic residence time. For example, the Lake Linganore, Maryland, TMDL for nutrients used the Vollenweider relationship to identify the allowable loading and necessary loading reductions to return the lake to mesotrophic conditions, represented by Carlson's Trophic Status Index (TSI of 53 and chlorophyll a of 10 μg/L). The existing nutrient loading to the lake was calculated using land use areas and phosphorus loading rates obtained from the Chesapeake Bay Program. The Vollenweider relationship was then used to identify the allowable annual phosphorus loading rate to meet the trophic status targets. The existing loading and allowable loading were compared to identify the necessary load reductions.

Tip Check the assumptions used in developing empirical equations. They usually predict an "average" condition or are based on conditions specific to certain regions. Is your waterbody unusual (e.g., narrow and deep)? Sometimes the unique features of your waterbody or watershed make a difference and require more sensitive analyses or models.

Another example of an empirical relationship is the Simple Method (Schueler 1987), discussed in section 8.2.2. The Simple Method calculates pollutant loading using drainage area, pollutant concentrations, a runoff coefficient, and precipitation data. If your watershed target is a pollutant concentration, you can apply the Simple Method using your concentration target to estimate the allowable loading to meet that target.

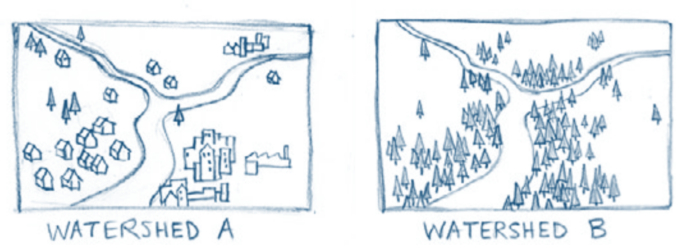
Use care when applying empirical relationships because although they are based on observed data, they might not be representative of your watershed or be applicable to your purposes. When using empirical relationships, it's important to review the documentation and literature to understand on what data the relationship is based and any related assumptions or caveats for applying the relationship or equation.

9.4.4 Statistical or Mathematical Relationships

You can use statistical or mathematical analyses to estimate allowable loadings and subsequent load reductions based on available data for your watershed. This approach assumes some relationship between key factors in the watershed (e.g., loading, percent land use) and instream conditions (e.g., concentration) based on observed data. A load duration curve, discussed in detail in section 7.2.4, is one of the most common of these types of linkages. This approach can be applied to diagnose and evaluate waters (e.g., dominant types of sources, critical conditions) and can help to determine specific load reductions. A limitation of this approach is that it does not explicitly describe where the loads are coming from or how they are delivered. The technique is well suited to areas where robust monitoring records are available but data are too limited to use more detailed watershed loading models. The analysis does not identify load reductions by source type, but it can be applied at any location in the watershed with sufficient data.

9.4.5 Reference Watershed Approach

If you don't have an appropriate water quality or loading target, another technique for linking your indicators to source loads is to compare your watershed with another one that is considered "healthy." The reference watershed approach is based on using an unimpaired watershed that shares similar ecoregion and geomorphological characteristics with the impaired watershed to identify loading rate targets. Stream conditions in the reference watershed are assumed to be representative of the conditions needed for the impaired stream to support its designated uses and meet the watershed goals.



You should select a reference watershed on the basis of conditions that are comparable with the watershed requiring management. The reference watershed should be similar to your watershed in size, land use distribution, soils, topography, and geology. To set the loading rate target, predict the loading for each watershed through modeling or another method and then determine the allowable loading rate based on the reference watershed loads and areas. The loading rate from the reference watershed can be calculated at a level comparable to the sources you identified in your watershed. For example, you can model specific land uses or crop types in the reference watershed to identify loading rates or identify a gross rate based on the loading from the entire watershed. The reference loading rates are then multiplied by the appropriate areas of the watershed to identify allowable loads for the impaired watershed. The load reduction requirement is the difference between this allowable loading and the existing load (estimated in chapter 8).

This approach is best suited to waters not meeting biological or narrative criteria (e.g., criteria for nutrients and sediment), where instream targets are difficult to identify. Selecting a reference watershed can be extremely difficult, and not all areas have appropriate watershed data or sufficient monitoring data to support selection.

9.4.6 Receiving Water Models

Sometimes it will be appropriate or even necessary to use detailed receiving water modeling to relate watershed source loads to your watershed indicators. The following are typical situations in which you should use a model instead of a simpler approach:

- Locally significant features or conditions (e.g., groundwater interaction) affect the waterbody's response.
- Chemical and biological features are complicated and affect the waterbody's response to pollutant loads (e.g., nutrient loads affecting algal growth and subsequent dissolved oxygen).
- Unique physical characteristics of the waterbody must be considered (e.g., long and narrow lake).
- There are localized impairments and impacts due to the location of sources (e.g., discharge from a feedlot affects a small segment of stream).
- Cumulative impacts occur from pollutants (e.g., metals) that can accumulate in sediment and organisms.

Table 9-4 provides a summary of many of the receiving water models available to support linkage of sources and indicators for watershed planning. For more details on the models, go to EPA's Council for Regulatory Environmental Modeling (CREM) Web site at **http://cfpub.epa.gov/crem/**.

Table 9-4. Overview of Various Receiving Water Models

Model	Source	Type			Level of Complexity			Water Quality Parameter							
		Steady-state	Quasi-dynamic	Dynamic	1-dimensional	2-dimensional	3-dimensional	User-defined	Sediment	Nutrients	Toxic substances	Metals	BOD	Dissolved oxygen	Bacteria
AQUATOX	USEPA	—	—	●	●	—	—	—	●	●	●	—	●	●	—
BASINS	USEPA	—	●	●	●	—	—	●	●	●	●	●	●	●	●
CAEDYM	University of Western Australia	—	—	●	●	●	●	●	●	●	—	●	●	●	●
CCHE1D	University of Mississippi	—	—	●	●	—	—	—	●	—	—	—	—	—	—
CE-QUAL-ICM/ TOXI	USACE	—	—	●	●	●	●	●	—	●	—	●	●	●	—
CE-QUAL-R1	USACE	—	—	●	●	—	—	—	●	●	—	●	●	●	●
CE-QUAL-RIV1	USACE	—	—	●	●	—	—	—	—	●	—	●	●	●	●
CE-QUAL-W2	USACE	—	—	●	—	●	—	—	—	●	—	—	●	●	●
CH3D-IMS	University of Florida, Dept. of Civil and Coastal Engineering	—	—	●	●	●	●	—	●	●	—	—	●	●	—
CH3D-SED	USACE	—	—	●	●	●	●	—	●	—	—	—	—	—	—
DELFT3D	WL | Delft Hydraulics	—	—	●	●	●	●	●	●	●	●	●	●	●	●
DWSM	Illinois State Water Survey	—	—	●	●	—	—	—	●	●	●	—	—	—	—
ECOMSED	HydroQual, Inc.	—	—	●	●	●	●	—	●	—	—	—	—	—	—
EFDC	USEPA & Tetra Tech, Inc.	—	—	●	●	●	●	●	●	●	●	●	●	●	●
GISPLM	College of Charleston, Stone Environmental, & Dr. William Walker	—	—	—	—	—	—	—	—	●	—	—	—	—	—
GLLVHT	J.E. Edinger Associates, Inc.	—	—	●	—	—	●	—	●	●	—	—	●	—	●
GSSHA	USACE	—	—	●	—	●	—	—	●	—	—	—	—	—	—
HEC-6	USACE	—	—	●	●	—	—	—	●	—	—	—	—	—	—
HEC-6T	USACE	—	—	●	●	—	—	—	●	—	—	—	—	—	—
HEC-RAS	USACE	—	—	●	●	—	—	—	—	—	—	—	—	—	—
HSCTM-2D	USEPA	—	—	●	—	●	—	—	●	—	—	—	—	—	—
HSPF	USEPA	—	—	●	●	—	—	●	●	●	●	●	●	●	●
LSPC	USEPA & Tetra Tech, Inc.	—	—	●	●	—	—	●	●	●	●	●	—	—	●

Table 9-4. Overview of Various Receiving Water Models (continued)

		Type			Level of Complexity			Water Quality Parameter							
Model	**Source**	Steady-state	Quasi-dynamic	Dynamic	1-dimensional	2-dimensional	3-dimensional	User-defined	Sediment	Nutrients	Toxic substances	Metals	BOD	Dissolved oxygen	Bacteria
MIKE 11	Danish Hydraulic Institute	●	—	●	—	●	—	—	—	—	—	—	—	—	—
MIKE 21	Danish Hydraulic Institute	—	—	●	—	●	—	—	●	●	●	●	●	●	●
MINTEQA2	USEPA	●	—	—	—	—	—	—	—	—	—	●	—	—	—
PCSWMM	Computational Hydraulics International	—	—	●	●	—	—	●	●	●	●	●	—	—	●
QUAL2E	USEPA	—	●	—	●	—	—	●	—	●	—	—	●	●	●
QUAL2K	Dr. Steven Chapra, USEPA TMDL Toolbox	—	●	—	●	—	—	●	—	●	—	—	●	●	●
RMA-11	Resource Modelling Associates	—	—	●	●	●	●	●	●	●	—	—	●	●	—
SED2D	USACE	—	—	●	—	●	—	—	●	—	—	—	—	—	—
SED3D	USEPA	—	—	●	●	●	●	—	●	—	—	—	—	—	—
SHETRAN	University of Newcastle (UK)	—	—	●	●	—	—	—	●	—	—	—	—	—	—
SWAT	USDA-ARS	—	●	—	●	—	—	—	●	●	●	●	●	●	—
SWMM	USEPA	—	—	●	●	—	—	●	●	●	●	●	—	—	●
Toolbox	USEPA	—	●	●	●	●	●	●	●	●	●	●	●	●	●
WAMView	Soil and Water Engineering Technology, Inc. (SWET) & USEPA	—	—	●	●	—	—	—	●	●	—	—	●	●	●
WARMF	Systech Engineering, Inc.	—	—	●	●	●	—	—	●	●	●	●	●	●	●
WASP	USEPA	—	—	●	●	●	●	●	●	●	●	●	●	●	—
WinHSPF	USEPA	—	—	●	●	—	—	●	●	●	●	●	●	●	●
WMS	Environmental Modeling Systems, Inc.	—	—	●	●	●	—	●	●	●	●	●	●	●	●
XP-SWMM	XP Software, Inc.	—	—	●	●	—	—	●	●	●	●	●	—	—	●

Note: BOD = biochemical oxygen demand.

— Not supported ● Supported

Source: USEPA. 2005. *TMDL Model Evaluation and Research Needs*. EPA/600/R-05/149. U.S. Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Cincinnati, OH. *www.epa.gov/nrmrl/pubs/600r05149/600r05149.htm*

9.5 Focus the Load Reductions

Regardless of what approach you use to estimate your allowable loadings or necessary reductions, it's likely that several scenarios or combinations of source reductions will meet your targets. Depending on the magnitude of your load reductions, you might be able to distribute them among your sources or you might have to focus on one dominant source to meet your targets. Table 9-5 illustrates how different target reductions can meet the same overall goal. In addition, the location of the proposed reductions can affect the distribution and magnitude of load reductions. If you calculate the load reduction only at the mouth of the watershed, a large number of scenarios will meet the load reduction target—at least on paper. Sometimes impacts from load reductions are not adequate to meet targets at downstream locations. Although the upstream reductions will no doubt improve downstream conditions, they might be such a small portion of the overall load that they won't have a measurable effect on the overall watershed loading. In addition, the load reductions calculated at the bottom of the watershed might not capture the more significant reductions needed in smaller upstream subwatersheds. Be sure to estimate your load reductions at a few key locations in the watershed to capture the major problem areas and sources and to support efficient and targeted management.

Table 9-5. Examples of Different Scenarios to Meet the Same Load Target

Source	Existing Phosphorus Loading (kg/yr)	Scenario 1		Scenario 2	
		% Load Reduction	Allowable Load (kg/yr)	% Load Reduction	Allowable Load (kg/yr)
Roads	78	26	58	20	62
Pasture/Hay	21	26	16	10	19
Cropland	218	26	162	55	98
Forest	97	26	72	0	97
Landfill	7	26	5	0	7
Residential	6	26	5	0	6
Groundwater	111	26	83	0	111
Total	**539**	**26**	**400**	**26**	**400**

Note: Scenario 1 represents an equitable distribution of load reduction among sources. Reductions are applied so that the resulting loads are the same percentage of the total as under existing conditions. Scenario 2 represents a more feasible scenario, in which controllable sources (e.g., roads, cropland, pasture) are targeted to meet the load reduction target.

If you used a receiving model to evaluate your load reductions, you should use a "top-down" approach to evaluating necessary load reductions. Begin by identifying necessary load reductions to meet waterbody targets in upstream portions of the watershed. The model then allows you to then evaluate the effect of the upstream load reductions on downstream conditions. Starting at the top of the watershed and moving down, you can evaluate the cumulative effects from upstream controls. In many cases, the upstream reductions will significantly decrease or even eliminate the necessary reductions for the lower watershed.

By this point, you should have identified the overall load reductions needed to meet your targets and determined generally how you want to focus reductions among sources.

The activities discussed in chapters 10 and 11 will help you to more specifically identify and select the reductions for each source.

9.6 Summarize Watershed Targets and Necessary Load Reductions

9 Now that you have identified the pollutant load reductions needed to meet your watershed goals, you should have the information needed to satisfy element *b* of the nine minimum elements. At this point you should prepare a summary to be included in your watershed plan documenting the source loads, numeric targets to meet the watershed goals and management objectives, and load reductions needed to meet the targets. The reductions should be calculated and presented at the same time and spatial scales as the source load estimations (discussed in chapter 8). As with the source loads, there are a variety of ways you can present the load reduction requirements, including bar graphs and watershed maps.

You should also include in the summary other watershed targets—the indicators and numeric targets that could not be linked to specific pollutant loads (e.g., cobble embeddedness, percent fine sediment). Even though the response of these targets could not be predicted and linked to source loads, they're important for measuring the success of your watershed plan and the attainment of your watershed goals. These targets will be integrated into the implementation and monitoring plan (discussed in chapter 12).

State-Supported Modeling Tools

Some states are supporting modeling tools for conducting current load analyses and BMP load reduction projections. For example, Pennsylvania has merged the ArcView GWLF model with companion software developed for evaluating the implementation of both agricultural and non-agricultural pollution reduction strategies at the watershed level. This new tool, called PredICT (Pollution Reduction Impact Comparison Tool), allows the user to create various scenarios in which current landscape conditions and pollutant loads (both point and nonpoint) can be compared against future conditions that reflect the use of different pollution reduction strategies. This tool includes pollutant reduction coefficients for nitrogen, phosphorus and sediment, and it also has built-in cost information for an assortment of pollution mitigation techniques. For more information, visit **http://www.predict.psu.edu/**.