



DRAFT
Guidance Document for
Developing a Lake or
Reservoir Management Plan

Prepared by the 2012
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Colorado Lake & Reservoir Management
Association
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- Appendix A: Lake Management Plan Worksheet
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Latest revision: July 20, 2012

Cover photo: Evergreen Lake Recreation: Don’t forget about the winter!

1.0 Purpose

This Colorado Lake and Reservoir Management Plan Guidance Document was produced to assist lake organizations, home owners associations (HOAs), and other organizations that manage water resources in developing a comprehensive lake management plan. This guide discusses the general process, factors to consider, and components to include when developing a lake management plan. It also documents specific resources that can be used by lake organizations for identifying and compiling information to include in a lake management plan.

We gratefully acknowledge the Vilas County, Wisconsin Land & Water Conservation Department for providing a resource framework and documentation for developing a lake management plan, and the Illinois Environmental Protection Agency for their documentation on how to delineate a watershed.

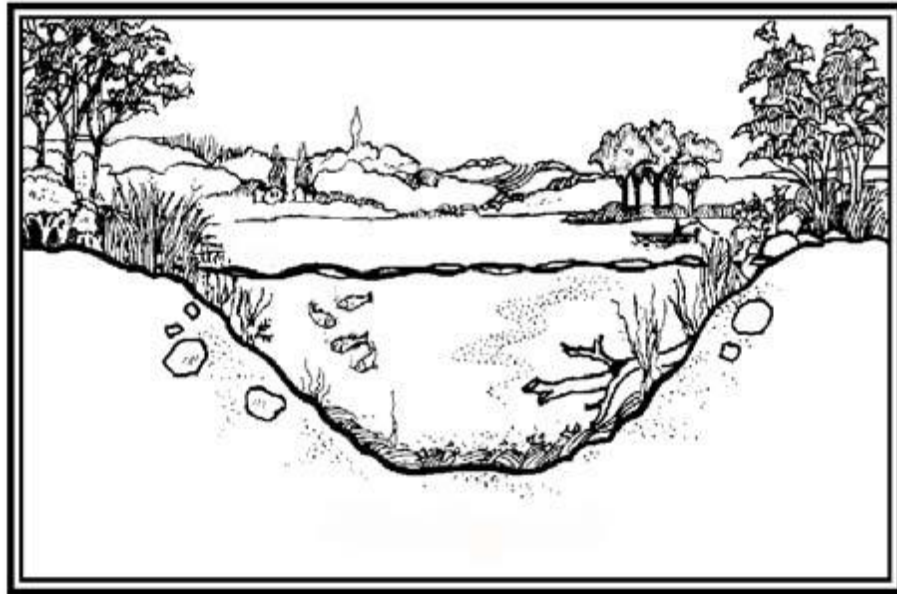
We also sincerely appreciate the editorial effort of Craig Wolf and the reviewer efforts of Laurie Rink, Kevin Tohill, Steve Lundt and Michele Wolf. Their thoughtful comments and suggestions helped make this a better document and provided new information for the next revision.

2.0 Introduction

Lake management plans assess the current condition of a lake (or lakes), including those issues and interests affecting it and provide informed recommendations to protect, manage, or improve the current condition of the lake. Lake management plans should utilize the best available information to set realistic goals, objectives, and actions in order to achieve a desired condition. One of the first steps in planning is to assess the general condition of the lake. This will determine whether the initial goal for the lake should be **protection, management, or restoration** oriented. While your goal may change during plan development, selecting an initial goal provides important guidance early in the process.

2.1 Protection-Oriented Plans

If a lake is generally considered to be in good condition, the initial goal should be to develop a protection-oriented plan. The plan should inventory existing conditions to establish a baseline, analyze the information, and make management recommendations to maintain existing conditions and prevent future degradation of the lake. Protection-oriented plans often focus on education strategies and monitoring as inexpensive implementation strategies.



2.2 Management-Oriented Plans

If a lake is considered to be mostly in a good condition, but has one or a few areas that are in decline or need addressing, the overall goal should be to develop a management-oriented plan. This type of plan should inventory existing conditions to establish a baseline, and do additional inventory work and analysis as needed to address a specific problem area(s). For example, the lake may be in a good condition, but there may be a specific concern with either recreational use, pollution from an inflowing stream, low oxygen levels, or an invasive

species. Additional planning, inventory work, and analysis should be conducted on each specific concern in order to develop more detailed goals and informed management recommendations to address the issue. The plan should include a mixture of management recommendations to protect/maintain existing conditions and to remediate problem areas.

2.3 Restoration-Oriented Plans

If a lake has considerable problems, the overall goal should be to develop a restoration-oriented plan. This type of plan should inventory existing conditions to establish a baseline (if one has not been completed before) and carry out a detailed analysis of the lake's problems. The plan should contain management recommendations that are restorative in nature and that deal with in-lake processes directed at large-scale manipulations to make significant changes or improvements. These types of plans typically require considerable amounts of planning, analysis, and substantial funding for implementation.



Illustration of the restoration project for Duck Pond, Denver, Colorado

3.0 Structuring the Plan

Once the desired type of lake management plan has been agreed upon, the lake organization can determine the level of information and analysis that will be needed and identify the appropriate party or parties to complete the different components. Most lake organizations find it helpful to establish a specific planning committee to work on the details of this effort. Appendix A contains a worksheet for a planning committee to use in deciding what should be included in a particular plan, what information currently exists, what new information needs to be collected, and who is best suited to carry out each component. It is helpful to walk through this worksheet with a Colorado Lake & Reservoir Management Association (CLRMA) volunteer and/or a professional consultant in order to get additional input for the plan. Walking through the worksheet can also be helpful in gauging estimated costs by determining who will be responsible for each component. Some groups choose to use volunteers from the lake organization to compile some of the needed information and then contract with an experienced consultant or utilize other professional assistance for the remainder of the project. In these cases, it is often helpful to set up ‘teams’ or groups of volunteers who are responsible for specific components. Other lake organizations choose to hire an experienced consultant to complete the entire plan, with the planning committee providing input and review. Costs can vary a great deal depending on the scope of work and consultant selected. The plan worksheet can be used for preparing a more detailed work plan and request for proposals that consultants can respond to when solicited.

Keep in mind, planning for lake and reservoir management is a thoughtful and systematic process that results in action. Investment in and attention to details during the preparation and implementation phases will result in attaining your management goals. Although, treat the management plan as a living document, and if at any point during the process certain goals or alternatives need to be reevaluated, take the time to reassess.

4.0 Components of a Lake Management Plan

Lake management plans typically contain the following components:

- Inventory of Relevant Information
- Analysis of the Information and Development of Management Goals
- Management Recommendations and Implementation
- Monitor Progress and Reevaluate the Plan

Depending on the type of lake management plan that will be developed, varying levels of detail should be included in each section. Each of the components is discussed in these resources – “Managing Lakes and Reservoirs” and “The Lake Pocket Book.”

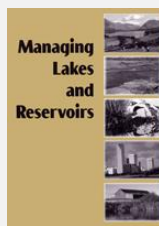
Resource: **Managing Lakes and Reservoirs**. Prepared by the North American Lake Management Society, Madison Wisconsin and the Terrene Institute, Alexandria Virginia in cooperation with the U.S. Environmental Protection Agency, Office of Water, Assessment and Watershed Protection Division, Washington, D.C. 2001.

Resource: **The Lake Pocket Book**. Produced by the Terrene Institute in cooperation with the U.S. Environmental Protection Agency Region 5

Available from: NALMS, P.O. Box 5443, Madison Wisconsin 53705 or the NALMS website:

www.nalms.org/home/publications/nalms-bookstore/book-store-and-subscriptions.cmsx

(accessed July 2012)



4.1 Inventory

Developing an inventory for a lake management plan involves compiling existing information about the lake and its environment, and collecting any new information needed to establish a baseline or address a particular concern. For some lake management plans, it may be necessary to collect additional data for developing more detailed analyses or lake

modeling. For many lakes and reservoirs in Colorado, a comprehensive inventory of the water body has never been completed. In most cases, an inventory should include physical information about the lake and its watershed, as well as social and historical information. A lake management plan can contain all of the information that is compiled or can provide the information as a summary in the plan. For each lake management plan, it will be important to determine what information currently exists and what data still needs to be collected.

4.2 Physical Characteristics/Background

4.2.1 Lake Size and Characteristics

The Colorado Lake and Reservoir Management Association (CLRMA) maintains a dataset that contains information on many Colorado lakes such as *size*, *maximum depth*, *mean depth*, *lake type*, and *known aquatic nuisance species*. The information is based on data compiled from various public records maintained by the U.S. Geological Survey (USGS) National Hydrography Dataset and U.S. Forest Service (USFS). For some lakes, more recent or more accurate data may be available from various fishing guide books. When available, it would also be helpful to include known information on any inflow or outflow streams or other information on the physical characteristics of the lake.

Resource:

Maps: <http://www.epa.gov/waters/enviromapper>

USGS HUC Units: http://water.usgs.gov/wsc/map_index.html

USGS Maps: <http://seamless.usgs.gov/>

Gaged Flows: <http://www.dwr.state.co.us/SurfaceWater/default.aspx>

Bathymetric Maps: <http://www.maxdepthaq.com>
<http://www.ayresassociates.com>

(accessed July 2012)

4.2.2 Shoreline Length

Estimates of shoreline length (miles) can often be obtained using a variety of approaches from USGS Topographical maps, a personal Global Positioning System (GPS), or electronic resources such as Google Earth. Using these resources and tracing the outline of the lake shape can provide an estimate of shoreline length.

4.2.3 Lake Volume

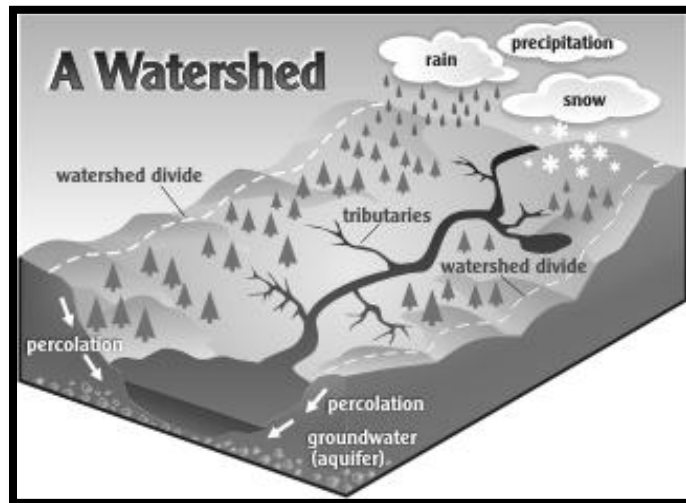
A lake's volume can be approximated by multiplying the lake's surface area by its average depth.

Lake Volume = Lake Surface Area (acres) x Mean Depth (ft)

Example: 500 acre lake x 10 ft. average depth = 5000 acre-ft of volume

4.2.4 Watershed

Identifying a lake's watershed boundary, and the land uses and activities occurring within that watershed is an important part of a lake management plan. The watershed boundary is important for understanding what affects a lake's quality and provides for more effective management.



A watershed is the land area that drains into a body of water.

In most cases, watershed maps for individual lakes have not been created. Watershed maps can be hand-delineated by using a USGS topographic map for the specific area. A watershed boundary can be drawn by connecting the highest elevation points around the lake.

Resource: **USGS Topographic Maps**

Available from: **USGS stores**

[http://store.usgs.gov/b2c_usgs/b2c/start/\(xcm=r3standardpitrex_prd\)/.do](http://store.usgs.gov/b2c_usgs/b2c/start/(xcm=r3standardpitrex_prd)/.do)

USGS Information Services

Box 25286

Denver Federal Center

Denver, CO 80225

Tel: 888-ASK-USGS

(accessed July 2012)

Appendix B contains step-by-step instructions for drawing the watershed and calculating a watershed's area. Since the actual task can be somewhat challenging, it is a good idea to have a CLRMA volunteer or consultant provide assistance or review the completed boundary.

4.2.5 Water Residence Time

Residence time is the length of time that water will reside in the lake or reservoir. There are multiple factors that affect the residence time of a water body such as lake volume, watershed size, and the amount of inflow/outflow which is largely tied to precipitation events. Dry years produce less inflow into the lake, so the residence time is longer than normal. During wet years the opposite is true; more inflow leads to a shorter residence time.

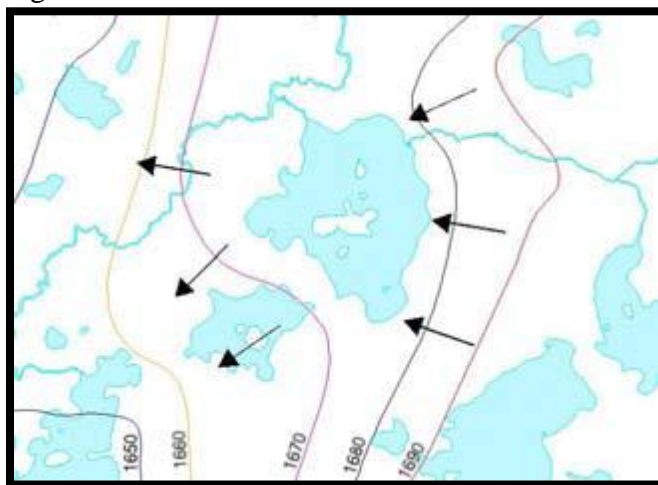
Residence time = Lake volume/Inflow (units are in Time, e.g., months or years)

For example, if a lake has a typical volume of 200 acre/feet and the annual inflow is 300 acre/feet, then the residence time equals 2/3 of a year or 8 months. That means, on average, the volume of the lake is replaced every 8 months. The differences in residence may help explain why the water quality varies from year to year, especially as related to nutrient input and algal growth. For example, if the residence time is short this can result in nutrients being quickly washed out of the lake. On the other hand if the lake has a longer residence time, algae have more of an opportunity to grow, bloom and flourish given adequate nutrient input and sunlight.

Source: see Lake Volume and Watershed sections above.

4.2.6 Groundwater Flow

Generalized groundwater flow direction can be determined using a USGS topographic map of water table elevations. Groundwater generally flows at right angles to the elevation lines, from higher to lower elevations. Generalized groundwater flow directions can be easily drawn on a map of the lake. It should be noted that the water table elevation lines and direction of flow are only approximate and should be identified as such in a lake management plan. More detailed, site-specific groundwater flow information can be obtained by conducting field measurements.



Approximate groundwater table elevations. Arrows indicate approximate direction of groundwater flow.

Resource: **Guide to Colorado Well Permits, Water Rights and Water Administration**
<http://water.state.co.us/groundwater/choice.asp>
(accessed July 2012)

4.2.7 Water Budget

A water budget estimates the relative contributions by percent of all the water inputs and outputs to the lake. Knowing a lake's major sources of water can be very helpful in deciding where to best target management efforts. For example, if a water budget shows that the majority of water coming into the lake is being contributed by an inflow stream, then most of the management efforts to improve the lake's water quality should be directed at the inflow stream. Surface runoff estimates, precipitation, and evaporation data from nearby areas may be easily obtained for a water budget, but actual groundwater and stream flow information may require the installation of monitoring equipment. For this reason, developing a water budget for a lake can be costly and time consuming. If developing a water budget for a particular lake is considered important, it is probably a good idea to contract with a consultant. If there is a culvert on the inflow or outflow stream, it may be fairly easy to collect information on the flow of water into and/or out of the lake. A lake volunteer can periodically measure the level of the water in the culvert, and convert that information into average flow. The local Ditch and Irrigation Company, or the Colorado Division of Water Resources may be able to provide information on inflows and outflows.

Example:

<i>Water Input</i>		<i>Water Output</i>	
<i>Groundwater</i>	25%	<i>Groundwater</i>	10%
<i>Inflow stream</i>	40%	<i>Outflow</i>	70%
<i>Surface runoff</i>	20%	<i>Evaporation</i>	20%
<i>Direct rainfall</i>	15%		

Resource: **Ditch and Reservoir Company Alliance**

1630 A 30th St. #431
Boulder, CO 80301
www.darca.org

Resource: **Colorado Division of Water Resources**

1313 Sherman St. Suite 821
Denver, CO 80203
<http://water.state.co.us/Home/Pages/default.aspx>
(accessed July 2012)

4.2.8 Water Levels

For lakes that experience a fair amount of water level fluctuation, information on water levels may be included in a lake management plan. For lakes that are controlled by a dam, the local dam operator may maintain a record of water levels. If the reservoir is owned by a local Irrigation and Ditch Company, they can provide very detailed information on water levels.

Volunteers can also collect data on water level changes over time by installing a vertical staff gauge in the lake and periodically recording the level of the water. Staff gauges can be purchased from forestry or water resource type of catalogs. Where possible, a staff gauge should be installed on a permanent structure, or the elevation should be referenced with survey equipment to a specific benchmark.

4.2.9 Soils

Understanding soil types found in the watershed is important. Soil types influence surface water runoff – both how much gets to the lake, and its quality. Many soil maps show slope which is helpful to include in a lake management plan. Soil maps have been digitized and are available online through the United States Department of Agriculture, Natural Resources Conservation Service website.

Resource: **Colorado Online Soil Survey Manuscripts**. US Department of Agriculture, Natural Resources Conservation Service
http://soils.usda.gov/survey/online_surveys/colorado/
(accessed July 2012)

Available from: **Colorado NRCS State Office**
Denver Federal Center
Building 56, Room 2604
PO Box 25426
Denver, CO 80225-0426
Tel: 720-544-2810

4.2.10 Lake Bottom

If an aquatic plant survey will be conducted for the lake management plan, information on the lake bottom can be collected at that time, identifying the types and relative percentages of material on the lake bottom (i.e. sand, gravel, rock, muck).

4.3 Water Quality

4.3.1 State Assigned Water Quality Standards

Water quality standards are the foundation of the water quality-based pollution control program mandated by the Clean Water Act. Water quality standards define the goals for a waterbody by designating its uses, setting criteria to protect those uses, and establishing provisions such as antidegradation policies to protect waterbodies from pollutants. In Colorado, water quality standards are assigned to all waterbodies, including lakes and reservoirs. The standard setting process occurs through public hearings conducted by the Colorado Water Quality Control Commission within the Colorado Department of Public Health and Environment. Currently assigned water quality standards are categorized by major drainage basin, and can be found on the Commission's webpage.

The Commission's website also contains information pertaining to the water quality standards setting process in Colorado, including how the public can participate, an explanation of the process, and a form for receiving notifications of the hearings.

It is useful to know what the lake water quality standards are and whether or not those standards are being met. Comparing historical and current water quality data to the standards will provide an idea of whether the lake has historically or is currently experiencing water quality impairments.

Resource: Colorado Water Quality Commission

Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

<http://www.cdphe.state.co.us/regulations/wqccregs/>

<http://www.cdphe.state.co.us/op/wqcc/PubPart/pubpart.pdf>

<http://www.cdphe.state.co.us/op/wqcc/PubPart/wqccrulemakingprocess.pdf>

<http://www.cdphe.state.co.us/op/wqcc/PubPart/RMHdistlistform2010.pdf>

(accessed July 2012)

4.3.2 Historical Quality

It is important to include historical water quality information in a lake management plan if it is available because it can be used to compare to current water quality information. In many cases, historical water quality information may be non-existent for the water body, but there may be other sources to check for historical information. The Colorado Water Quality Control Division maintains water quality information on the state's waters, and it is possible that local Ditch and Irrigation Company's, other water agencies, or a local watershed organization may have limited water quality data on the water body. Sediment core sampling

can be another way to gain information about historical water quality and to make comparisons to current conditions as well as state assigned standards. CLRMA or an experienced consultant may be able to provide some assistance on determining the feasibility and costs of sediment core sampling on a particular lake.

Resource: **Colorado Water Quality Control Division**
Environmental Data Unit
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530
<http://www.cdphe.state.co.us/wq/EDU/home.htm>
(accessed July 2012)

4.3.3 Current Quality

Depending on the amount of water quality information available, some lake organizations choose to collect additional data as part of the lake management plan in order to establish a good baseline of information, to determine if current standards are being met, or to address a specific issue. Data may be for water clarity readings (Secchi disk), or may include water chemistry, temperature, and/or dissolved oxygen information.

Some lakes conduct water quality testing on their own or through other programs offered by the Colorado Department Public Health and Environment Laboratory, through private consulting firms, private testing labs, or other sources. It is important to collect all available water quality information for the management plan.

If there is only a small amount of water quality data for a lake, CLRMA can probably assist in interpreting and explaining the information. For lakes with a large amount of water quality data, however, it is recommended to contract with a consultant to help review and interpret the data.



Resource: **Colorado Department of Public Health and Environment:**

Laboratory Services Division

<http://www.cdphe.state.co.us/lr/water.htm>

Laboratory Services Division

8100 Lowry Boulevard

Denver, CO 80230

Tel: 303-692-3090

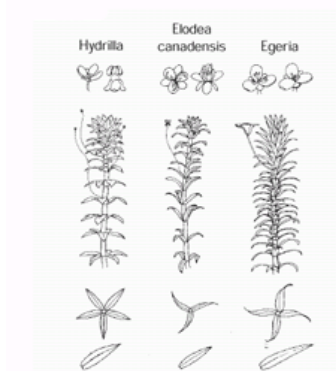
Resource: **Colorado Watershed Assembly** – complete list of watershed organizations

<http://www.coloradowater.org/>

(accessed July 2012)

4.4 Aquatic Vegetation

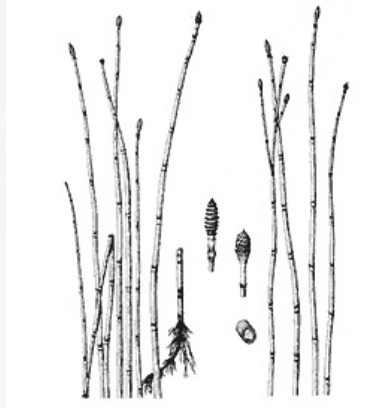
For a few lakes, local water agencies may have already conducted aquatic plant surveys on nearby lakes and reservoirs and can provide the information for the lake management plan. In most cases, however, very little information about the aquatic plant community exists for a lake, so conducting an aquatic plant survey should be considered, in the view of the harmful influence of aquatic nuisance species in Colorado.



Elodea



Purple fanwort



Horsetail

Some lake associations may have a volunteer who is fairly knowledgeable about aquatic plants. With a little help or training from Colorado Parks and Wildlife or NRCS personnel, that person may be able to conduct an aquatic plant survey of the lake. In many cases, however, a lake association will need to contract with a consultant for this portion. An aquatic plant survey which sets up sampling transects around the lake and produces a generalized map of aquatic plants in the lake can be important information to include in a lake management plan. Another option, however, is to simply list the aquatic plants that are present in the lake.

Resource: **Biology and Control of Aquatic Plants: A Best Practices Management Handbook**
<http://www.aquatics.org/bmp.htm>
(accessed July 2012)

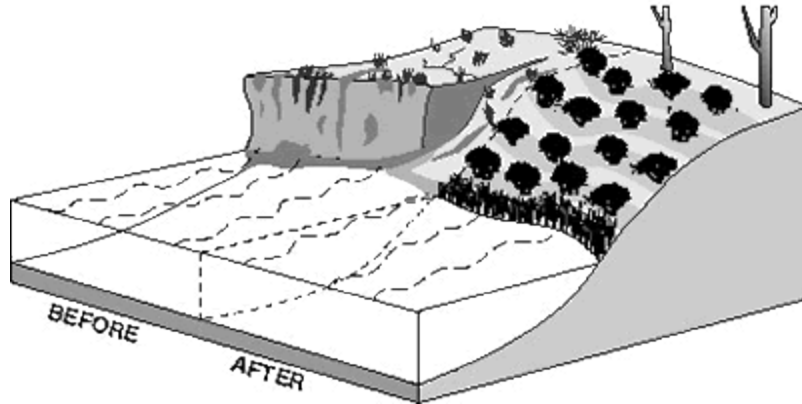
4.5 Shoreline Vegetation

Some lake management plans include an inventory of the shoreline vegetation as a way of documenting existing shoreline conditions. Establishing a baseline allows for future comparisons to be made to prior conditions. There are a number of ways to characterize existing shoreline conditions, some of which are listed below. The method used will depend on the information desired and the necessary level of detail.

Different methods that can be used to inventory existing shore land vegetation:

- Photographic inventory – taking photographs or video of the entire shoreline (done from the lake)
- Estimation of the percent of natural buffer or vegetation present on each lot or section of shoreline (done from the lake)
- Short description of the existing shoreline with observed tree or plant species listed where known (done from the lake)
- Site visits to actual properties to collect detailed information on the amount and types of vegetation present on shore, in water, and on the bank. Site visits also provide the opportunity to collect additional on-site information if needed, such as: slope, soil type, bank height, bottom substrate, structures close to water, distance from septic drain fields to lake, erosion concerns, etc. (usually done from shore)
- Aerial photography

Depending on the method used, a consultant may need to be hired to complete the shoreline vegetation survey, or it may be able to be completed by a lake volunteer with minimal support from a consultant.



Shoreline stabilization incorporating bank vegetation and reshaping the bank

Resource: **Colorado Stream Corridor Guide**

Colorado Riparian Association

<http://coloradoriparian.org/Publications.php>

Resource: **Landscaping for Wildlife and Water Quality**

Nongame Wildlife Program – Section of Wildlife

Minnesota Department of Natural Resources

Minnesota's Bookstore

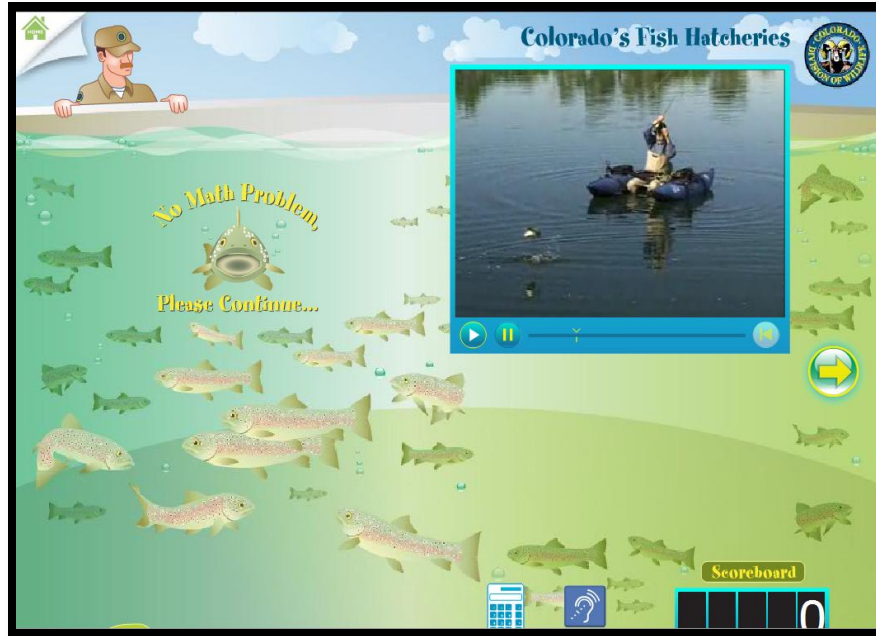
Tel: 1-800-657-3757

<http://www.comm.media.state.mn.us/bookstore/mnbookstore.asp?page=viewbook&BookID=67748&stocknum=310>

(accessed July 2012)

4.6 Fisheries

It is a good idea to include fisheries information in a lake management plan such as fish stockings that have taken place over the years, results of fish population surveys, or creel surveys that have been conducted on the lake. It may also be useful to include known information on any structure modifications to the lake over time, such as the installation of fish cribs, half-logs, etc. Lake association members or longtime lake residents may be the best source of information for this. Some lake associations have chosen to contract with consultants to conduct additional fish surveys if there is little prior data on the fishery. In addition, some lake associations conduct their own informal creel surveys by asking lake property owners to keep track of the type and size of fish caught while angling. Depending on the amount of available fishery data, the Regional Colorado Parks and Wildlife (CPW) Aquatic Biologist or the Colorado Aquaculture Association may be able to help interpret the data and provide management recommendations, or a consultant may need to summarize and interpret the information.



Colorado Parks and Wildlife's Fish Hatchery Game

Resource: **Colorado Parks and Wildlife:** Fishery Management
<http://wildlife.state.co.us/Fishing/Reports/ManagementandSurveys/Pages/FisheryWaterSummaries.aspx>

Resource: **Colorado Aquaculture Association**
<http://www.colaqua.org/>

Resource: **Colorado Parks and Wildlife:** Fish Hatchery Game
<http://wildlife.state.co.us/Education/TeacherResources/FishHatcheryGame/Pages/HatcheryManager.aspx#>
 (accessed July 2012)

4.7 Wildlife

Limited information often exists about the amount and types of wildlife present in and around lakes. The CPW Wildlife Manager, or US Forest Service, may be sources of additional wildlife information such as eagle, osprey, or other wildlife in the area. In addition, the CPW maintains a listing of known endangered, threatened or rare animals, plants, mollusks, or other natural communities by geographic area. Lastly, another good source of information may be wildlife sightings collected by lake residents. Lake residents can provide very useful and interesting data by keeping a log of wildlife observations over time.

4.8 Invasive Species

Invasive Species are non-native animals, fish, plants and pathogens that have a harmful effect on our natural resources and the human use of those resources. Aquatic invasive species are commonly called Aquatic Nuisance Species (ANS) and were defined in 2008 by the Colorado State Legislature as any exotic or nonnative wildlife or any plant species that have been determined by the board to pose a significant threat to the aquatic resources or water infrastructure of the state. Invasive species often create an imbalanced ecosystem by out-competing many native species for the available resources. Invasive species not only cause harm to the aquatic ecosystem but also can cause harm to human health as well as economic harm.

Both the New Zealand mudsnail and the Eurasian milfoil are examples of invasive species that have been found in Colorado's water. In 1999, Eurasian milfoil was first recorded in Colorado and has quickly spread throughout many front-range reservoirs. The CPW maintains resources for the identification of Aquatic Nuisance Species (ANS) known to occur in the Rocky Mountain region. More up-dated information should also be available from the CPW regarding aquatic nuisance plant identification by 2013. Information on ANS species is also available through the CLRMA website.



Eurasian water milfoil

Resource: **Colorado Parks and Wildlife: Aquatic Nuisance Species**

<http://www.parks.state.co.us/NATURALRESOURCES/PARKSRESOURCESTEWARDSHIP/AQUATICNUISANCESPECIES/Pages/AquaticNuisanceSpeciesHome.aspx>

Resource: **CLRMA: Invasive Species**

<http://www.clrma.org/invasivespecies.shtml>

(accessed July 2012)

4.9 History, Lake Issues, and Activities

4.9.1 Human History

Many lake management plans include a section on the human history of the lake. Researching and compiling information on the settlement of the lakeshore and surrounding area is often best done by a local volunteer(s). Local libraries and longtime residents are often sources of interesting stories, photos, and information. Tape-recording oral histories of long-time lake residents can be an outstanding project developed as part of the planning effort.

4.9.2 Property Owners

For some lakes it is helpful to include the number of lakefront properties that currently exist along the shoreline. The County Assessor's Office maintains a complete listing of current properties and ownership. If the lake is small enough, it may be possible to determine the number of undeveloped versus developed properties, the number of residential, commercial, or other properties, and those that are seasonal versus year-round use properties. For large lakes, this information may be too difficult to compile, but Geographic Information System (GIS) mapping may make this task easier.

4.9.3 Demographics

Information on historic population levels, development trends, and predictions of future population are important to include in a lake management plan. Future population trends can be used in anticipating the expected level of development in the area. Population information is available from the State Demography Office.

Resource: **Colorado State Demography Office** (Department of Local Affairs)
1313 Sherman Street, Room 521
Denver, CO 80203
Tel: 303-866-2156
<http://www.colorado.gov/cs/Satellite/DOLA-Main/CBON/1251590805419>
(accessed July 2012)

4.9.4 Land Use

Identifying a lake's watershed boundary and the land uses and activities occurring within that watershed should be part of a lake management plan. This information can be used to understand what currently affects a lake and what might affect it in the future. Once a watershed map is drawn, the existing land uses within the watershed can be identified on the map. Local maps of existing land uses can usually be obtained from communities that have conducted local land use planning. Municipal offices should have a copy of the map in their local land use plan. For other towns, generalized land uses can probably best be identified

based on local knowledge using volunteers driving the watershed area and conducting a “windshield” survey of residential, commercial, industrial, and other land uses. If a community has completed a local land use plan, it may be possible to also include information or a map of future preferred land uses in the watershed. This information or map can show expected changes in how land in the watershed may be used over time. A lake management plan should take these land uses into consideration and develop appropriate management recommendations to address projected changes.

4.9.5 Lake Organization History

Compiling information about when the lake organization formed and major events or accomplishments is may be include in a lake management plan. Lake organization records or minutes are a good source for this information.

4.9.6 Past Lake Management Activities

Past lake management activities can include activities conducted by the lake organization, local and state agencies, private groups such as sports or fish and game organizations, or individuals. Records of these activities may be included in lake organization’s records or other government files. Long-time lake property owners may also be a good source of this information.

4.9.7 Stakeholder Survey

An important part of a lake management plan can be to conduct a survey of lake property owners. A survey assesses the needs and concerns of lake residents and can identify problems, values, and expectations that should be considered when developing the lake management plan. A survey helps answer the question of “what residents want from the lake” and can help in developing more effective and appropriate management recommendations. Surveys can be cost and time intensive, so they require a strong pool of volunteers or a consultant to prepare mailings and compile results.

4.9.8 Lake Use/Boating Activity

If lake use and boating activities are a concern on a lake, the amount and type of boating activity that takes place on the lake should be quantified. In some cases, the results can be quite different from public perception. Knowing the amount and types of boating activity that take place on a lake can help better assess boating issues and help develop more accurate management recommendations for the waterbody. An easy way to quantify boating activity is to conduct random boat counts over one or more summers. This can be easily done by a lake volunteer who periodically records the number and type of each watercraft out on the lake at various days and times, and the number of vehicles at boat landings. While the information may not be statistically representative, it can provide a relative measure of the watercraft use and a general picture of lake activity. If a creel survey has been done on the lake, the data often includes some lake use information that can be included in the lake management plan.

4.10 Pollution Sources and Loadings

If there are any direct discharges (point sources of pollution), such as municipal or industrial discharges, to the lake, its tributaries, or surrounding wetlands, information on the amount and type of discharge should be included in the lake management plan. Copies of discharge permits can be obtained from the Colorado Water Quality Control Division. These permits will contain information on which water quality and water quantity parameters are monitored by the discharging entity. Non-point sources of pollution within the watershed, such as runoff from residential, commercial, industrial, agricultural, transportation, and recreational land uses, construction activities, septic systems, and other nonpoint pollution sources should also be included in the plan. Lake models can be used to estimate pollutant loadings from each point and non-point source and to develop a nutrient budget for the lake showing areas within the lake's watershed that are contributing the highest pollutant loads to the lake. Once a model has been applied to a lake, hypothetical changes in land uses or pollutant loadings can easily be made to determine what effect any potential changes will have on the lake's water quality. This is a very useful technique to use in developing appropriate management recommendations for the lake. Because some lake models can be quite technical and require detailed information, an experienced consultant can provide guidance in determining feasibility and costs of conducting a lake modeling process.

Resource: **Colorado Water Quality Control Division: Records**
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530
Tel: 303-692-3600

4.11 Other Information

There may be other specific areas of interest for a particular lake that are important to include in a lake management plan. CLRMA volunteers or a consultant can provide assistance in obtaining a source for the necessary information. Because there will always be new technologies emerging in the field of lake management, it is encouraged that lake organizations seek out the best available technologies, tools, and ideas when developing a lake management plan. The Colorado Lake and Reservoir Management Association and North American Lake Management Society meetings are good places to learn about new techniques and ideas, talk to lake managers, and meet with private consultants.

Resource: **Colorado Lake and Reservoir Management Association**
www.clrma.org
Resource: **North American Lake Management Society**
www.nalms.org
(accessed July 2012)

5.0 Analysis and Management Goals

Analyzing the information that has been collected is a crucial part of any lake management plan. It shows how a lake is doing and provides the framework to set management goals and meaningful recommendations for the lake. Information collected on existing conditions is usually analyzed by comparing it to: historical conditions, established standards or guidelines, other similar lakes in the area, or simulated conditions using computer lake models. Based on the analysis of the information, meaningful goals should be developed for each aspect of the plan. The types of goals should be tailored to the type of lake management plan being developed.

Protection-oriented plans

Goals should focus on maintaining existing conditions as identified in the inventory portion of the plan. For example:

- *maintain existing water quality*
- *prevent the introduction of non-native species*
- *protect current natural shorelines*

Management-oriented plans

Goals should focus on achieving certain conditions based on the results of detailed analyses. For example:

- *increase oxygen levels to prevent winter fish kills*
- *decrease the extent of Eurasian milfoil*
- *increase the amount of natural shorelines on the lake*

Restoration-oriented plans

Goals should focus on large-scale changes to achieve new conditions based on the results of very detailed analyses. For example:

- *reduce in-lake phosphorus levels to a certain amount*
- *re-establish a balanced fishery in the lake*

5.1 Management Recommendations and Implementation

Management recommendations are developed in order to achieve specific goals for a lake. They should be tailored to the particular lake, they should be measurable, and they should take into consideration such things as:

- Stakeholder sentiment
- Feasibility of implementation
- Level of effort required
- Cost and funding sources

Management recommendations that are specific in nature are usually easier to implement than general recommendations and provide a good way to measure plan accomplishments over time. Some examples of specific management recommendations include:

- Install an educational sign at the boat landing about Aquatic Nuisance Species
- Continue to regularly monitor water clarity (Secchi disk) through the volunteer monitoring program
- Conduct more-detailed water quality testing once every five years
- Sponsor a demonstration site for shoreline restoration
- Install hazard buoy on shallow rock bar after obtaining proper approval
- Organize a work day to remove Eurasian water milfoil or purple loosestrife from specified areas
- Update aquatic plant survey information periodically
- Participation in local community or watershed planning efforts

Once management recommendations have been drafted, the lake organization may want to seek review and input on the recommendations from CLRMA volunteers or WQCD staff. If multiple alternatives are developed for the management recommendations, final management recommendations will need to be selected. Some lake organizations choose to present all of the management alternatives to the full membership so the members can select the final recommendations to include in the plan, other organizations use the planning committee to select appropriate management alternatives, while others use a consultant or other source of assistance to select the most appropriate recommendations. After a management plan has been developed, the selected recommendations should be carried out. Where possible, the management plan should include specific details about how to implement the selected recommendations. An implementation timeline and/or targeted dates for specific strategies should be included and can serve as important benchmarks for the lake organization.

Remember, the management plan is a living document and needs to be revisited from time to time to evaluate whether original goals were achieved and whether new management goals need to be established.

6.0 References

- Holdren, C, W. Jones, and J. Taggart. 2001. *Managing Lakes and Reservoirs*. Third Edition. Produced by the North American Lake Management Society, Madison, WI, the Terrene Institute, Alexandria, VA, and in Cooperation with the Office of Water, Assessment and Watershed Protection Division, Washington, D.C.
- Lynden, T. 2001. *Vilas County Lake Resource Guide*. Prepared by Vilas County Land & Water Conservation Department, WI.
- Philips, N., M. Kelly, J. Taggart, R. Reeder. 2000. *The Lake Pocket Book*. Produced by Terrene Institute, Alexandria, VA, and in Cooperation U.S. Environmental Protection Agency Region 5.

Appendix A

Lake Management Plan Worksheet

Components	What Exists	What is Needed	Who
Physical Characteristics Lake Size and Characteristics Shoreline Length Lake Volume Watershed Map Residence Time Groundwater Flow Water Budget Water Levels Soils Geology Lake Map Lake Bottom			
Water Quality Historical Current			
Aquatic Vegetation Plant identification Mapping Density of growth			
Shoreline Vegetation Existing vegetation, Typical species			
Fisheries Fish survey data Creel census data Fish mgmt. activities (stocking, cribs, etc.)			
Wildlife Wildlife populations and habitats, endangered/ threatened species, other birds, mammals, amphibians, & reptiles			
Invasive Species			
History, Lake Issues, Activities Human History Property Owners Demographics			

Components	What Exists	What is Needed	Who
Land Use Lake Organization History Past Lake Management Activities Stakeholder Survey Lake Use/Boating Activity Lake Access			
Pollution Sources and Loadings			
Other Information			
Compilation of Information/ Report Writing			

Appendix B

How Do You Fit into a Watershed?

Protecting Colorado lakes requires more than shoreline diligence. Even if you don't live on a lakeshore, you may be contributing pollution to lakes, or the streams, or groundwater that feed them. In essence, a lake extends beyond its shoreline. It's part of a bigger system; it's part of a *watershed*. Wherever you are, you're in a watershed! A particular watershed may contain just one land use or a combination of land uses – such as houses, farmland, shops, factories, and forests. Each land use and the activities associated with it can affect the quality of water within that watershed. That's because any pollutants originating from a specific land use have the potential to be carried into lakes by surface runoff from the point of origin.

What is a Watershed?

A watershed is the land area that drains into a body of water. A watershed can be as small as a back yard draining into a puddle, or as large as the area that drains into the Great Lakes or the Colorado River. Substances that can be transported by water can eventually reach a waterbody, no matter how far away. Anything that you and all the other people do who live, work, and play in the watershed can have an affect on water quality. Common activities such as lawn care, automotive maintenance, construction, farming, and many others can contribute excess soil, nutrients, and pollutants to waterbodies in your watershed, including your lake!

The edge or boundary of your lake's watershed is defined by the highest points and ridges of land around the lake. Rain falling or snow melting on the near side, or "inside," of the ridge flows by gravity, over the ground and into streams and groundwater, to your lake. Rainfall or snowmelt on the far side of the ridge flows away from your lake and into a different watershed. Other names you might hear for watershed are drainage basin, drainage area, or catchment. This is why it's important to look beyond the lake and its shoreline and examine the entire watershed when working on lake management issues. Knowing your lake's watershed boundary and the land uses and activities going on within that boundary can increase your understanding of your lake's quality and help you better manage your lake. A lake's watershed often includes other waterbodies such as streams, rivers, ponds, and wetlands. Each of these waterbodies also has its own, smaller watershed called a subwatershed or subbasin.

Determining Your Lake's Watershed Boundary

Reading a USGS Topographic Map

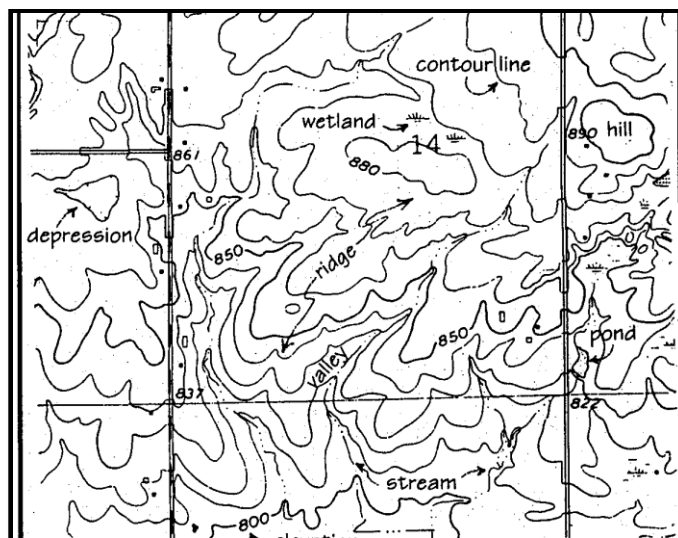
Since water naturally flows downhill, watersheds are defined by topography or the land's physical features. To draw a watershed boundary, you connect high points and ridges on a topographic map. While this concept sounds simple, the actual task can be quite challenging for people who are unfamiliar with interpreting topographic maps, especially if the watershed lies in an area of varied and complex terrain, or in extremely flat areas.

Some basic concepts to be aware of when reviewing topographic maps:

- Contours represent lines of equal elevation. Contour lines never cross each other.
- Colors help to distinguish features: contour lines are brown; water features are blue; cleared areas (fields, developed areas, farmland) are white; woods, scrub, orchards, and vineyards are green; urban areas are pink; roads are red or black; buildings and other cultural features are black; and revisions are purple.
- The elevation, in feet above sea level, is usually indicated on the dark brown (thick) contours, and on certain light brown (thin) contours. Elevations of certain points also are given ("spot" elevations).
- The difference in elevation between two adjacent contours is called the contour interval. It is usually specified in the map legend.

Obtaining Maps

First, check to see whether a government agency has already done the work for you – such as your municipality, county planning department, regional planning commission, local soil and water conservation district (SWCD) or Natural Resource Conservation Service (NRCS) office, Region 8 EPA (303-312-6312), or Colorado Division of Water Resources (see Section 4.2.7). At the least, they may have maps showing the boundaries of major lake or river watersheds that could provide some guidance. For most lake watersheds, however, you'll likely need to draw the boundaries yourself. To do this, you will need to obtain one or more U.S. Geological Survey (USGS) topographic maps, called quadrangle or "quad" maps, preferably in a 1:24,000 scale (one inch on the map represents 2,000 feet on the ground). These can be ordered from the USGS (1-800-HELP-MAP, or order on-line at <http://www.usgs.gov>). Each quad map costs \$4 plus shipping. You also can search the USGS web site for the names of the quad maps in your area of the state. USGS quad and other topographic maps also can be purchased at some map stores, college bookstores, outdoor recreation stores, and engineering supply houses.



Recognizing Features on the Map

- **Slopes:** Contour lines that are closely spaced represent steep slopes, and those that are widely spaced represent flat areas.
- **Valleys and Ridges:** Contour lines that represent a valley usually are V-shaped, with the tips of the Vs pointing toward higher elevations. Contour lines that show a ridge are V- or U-shaped, but point toward lower elevations.
- **Hills:** Hills and mountains appear as a series of successively smaller, irregularly shaped concentric circles. The smallest circle represents the highest elevation.
- **Depressions:** Low areas or depressions (also called depressional areas) appear as closed contours with "tick marks" pointing inward.
- **Water flow:** Water flows perpendicularly to contour lines. Streams tend to form in the V-shaped contours on sideslopes, with the Vs pointing in the direction of higher ground (i.e., upstream). When two streams converge, the V formed by the point where the two come together points downstream.

If you live in an urban/suburban area, it's important to review a map of the storm sewer system (contact your municipality) and adjust your watershed boundary accordingly. Storm sewers may route stormwater runoff in a different direction (i.e., either toward or away from your lake) than you would otherwise predict by looking at the ground's topography.

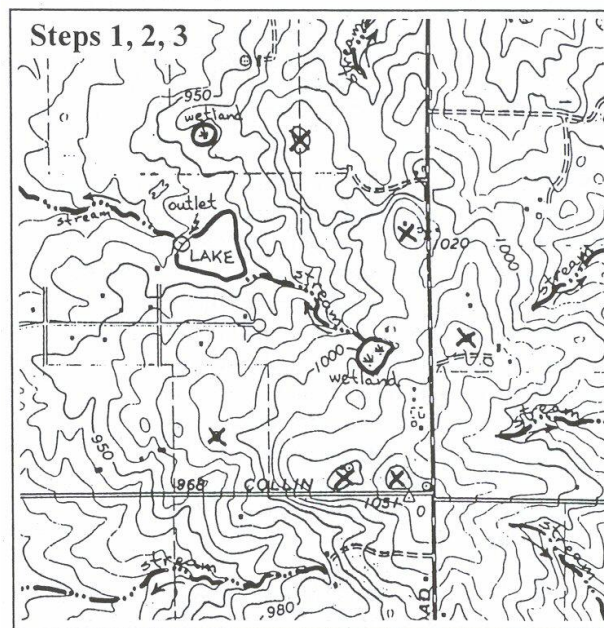
If you are not familiar with reading and interpreting a topographic map, the USGS Quickstart Guide has information on downloading and reading topographic maps.

<http://nationalmap.gov/ustopo/quickstart.pdf>

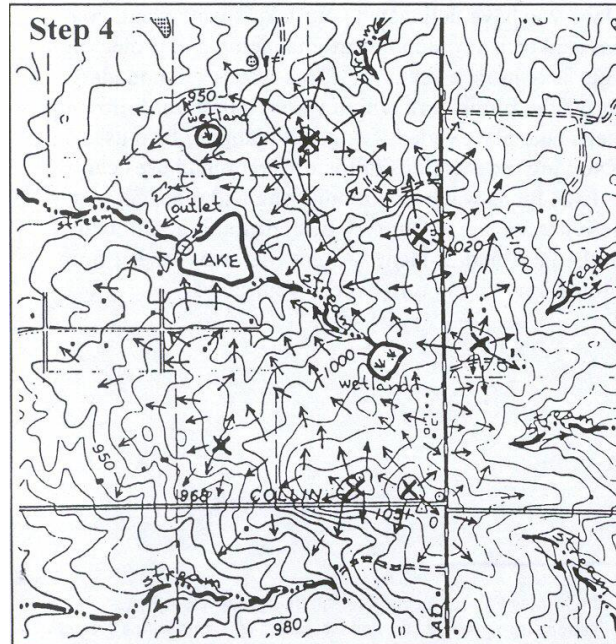
Delineating Watershed Boundaries

Once you've obtained topographic maps of your area, follow the steps below to draw or "delineate" your lake's watershed boundaries. Use a pencil so you can easily erase and revise your work as you go along. The accompanying figures provide an example.

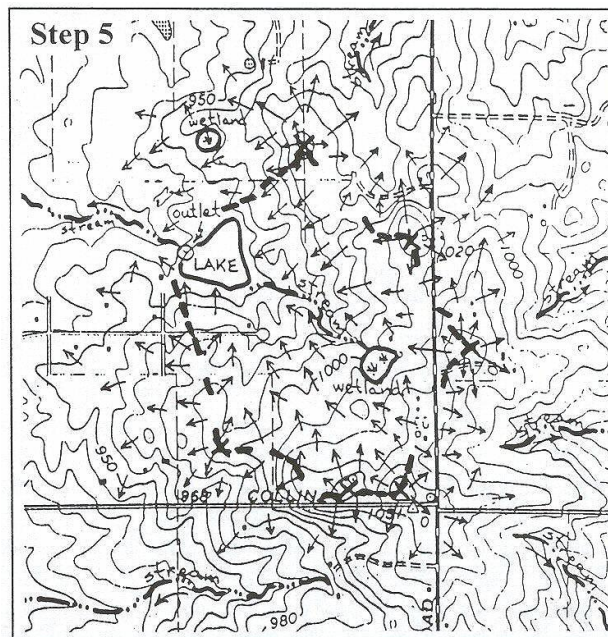
- 1) Locate and highlight your lake and circle the lake's outlet.
- 2) Locate and highlight all water features (streams, wetlands, ponds, other lakes and reservoirs) in the vicinity of your lake. Work outward from your lake, starting with streams and wetlands "tributary" (connected) to your lake, then highlighting other water features that don't appear directly connected. Use arrows to mark the direction of stream and wetland flow. To determine if a stream is flowing toward or away from another waterbody, compare the elevation of land features around the stream to that of the other waterbody. With these water features identified, this forms a general picture of where to look for the watershed boundaries.
- 3) Examine the contour lines surrounding the lake and the tributary waters and mark each high point (hills, ridges) with a small "X."



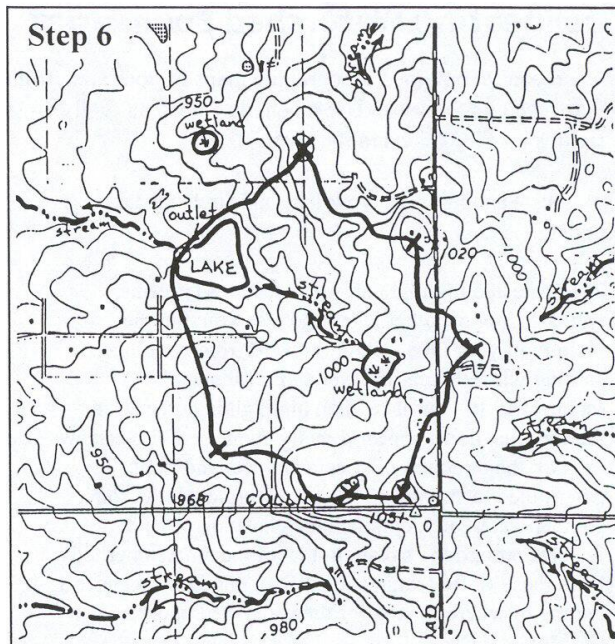
- 4) Determine the direction of drainage from the high points and ridges by drawing arrows perpendicular to a series of contour lines that decrease in elevation. Water running off the land seeks the shortest distance between two contour lines and thus follows a route perpendicular to those lines.



- 5) Mark the break point on each contour line with a dash. Each break point marks the spot where the runoff on one side of the break point would drain toward the lake, and the runoff on the other side of the break point would drain away from the lake.



- 6) Connect the high points and break points with a solid line following the highest elevations in the area. Remember that the watershed boundary line will always be perpendicular to each contour line it crosses. This completed line represents the boundary of the watershed. If desired, subwatersheds can be delineated by locating internal drainage divides that are bounded by ridges within the primary watershed boundary.



Some of the steps outlined above for delineating a watershed are easier said than done. For the inexperienced, expert guidance is strongly recommended. Your local Conservation District

<http://www.colorado.gov/cs/Satellite?c=Page&cid=1167928216288&pagename=Agriculture-Main%2FCDAGLayout>

or NRCS office is a source of ready help. Field checking the boundaries also is a good idea. Going out into the field allows you to identify human alterations, such as road ditches, storm sewers, and culverts that could change the direction of water flow and thus change the watershed boundaries. Finally, bear in mind that delineating a watershed is an inexact science. Any two people, even if both are experts, will come up with slightly different boundaries.

An alternative approach for delineating a watershed boundary may be Geographic Information System (GIS) maps if this digital resource is available. Local governments may have GIS data sets that include your watershed area and may be able to provide assistance in delineating your watershed. Private engineering or survey firms may also be able to delineate your watershed using ArcGIS software if elevation data for the area is available. ArcGIS has applications to delineate watersheds and basins in the Hydrology tools in Spatial Analyst.

(Note: These same steps also are used for delineating a stream or river watershed, with the outlet being the furthest downstream point you're interested in.)

Next Steps

Once you have delineated your lake's watershed, you have taken a key step toward managing and protecting your lake more effectively. This watershed boundary forms the framework within which important follow-up steps take place: identifying and mapping land uses. Knowing the locations of the different land uses can help 1) focus watershed monitoring and management activities on areas that may be contributing pollutants to the lake, and 2) identify areas that may benefit from protection and in turn benefit your lake!

Measuring Watershed Area

Now that you know your lake's watershed boundary, you can measure the watershed's area. Two methods include using a dot grid or a small device called a planimeter. Again, your local Conservation District or NRCS office can provide assistance. You may also be able to estimate the watershed's area using Google Earth to trace the watershed boundary and use Google's measurement tools to estimate the area.

Collaborating With Others in Your Watershed

Just as water within a watershed is shared among the various users within the watershed, problems with water quality can travel across a watershed. Communicating with other water users and lake managers within a watershed can help identify problems that are common to the watershed and reveal solutions that may have been successfully used by other lake managers. Cooperation between entities in a watershed can also allow for cost sharing and allocation of tasks to entities that are best equipped to carry them out. If problems in a lake are related to inputs from the watershed, it is likely that taking a watershed-wide approach will be necessary to address the problems.

