Second Edition December 2021

Achieving Efficient Water Management

A Guidebook for Preparing Municipal and Industrial Water Conservation Plans

Image: Glen Canyon Dam. (Reclamation/T.R. Reeve)

U.S. Department of the Interior December 2021

Mission Statement

The U.S. Department of the Interior protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated Island Communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Second Edition December 2021

Achieving Efficient Water Management

A Guidebook for Preparing Municipal and Industrial Water Conservation Plans

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RECLAMATION

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Section One - Introduction

This section provides an overview of what this Guidebook for Preparing Municipal and Industrial Water Conservation Plans is about, including:

- Why Reclamation Prepared this Guidebook?
- Water Conservation Versus Water Management
- Who Should Use this Guidebook?
- What is Good Water Management and Why Should You Care About Water Management Planning?
- Organization of the Guidebook

Why Reclamation Prepared this Guidebook

The Bureau of Reclamation, Lower Colorado Region prepared this Guidebook to help M&I water districts prepare water conservation plans to achieve more efficient water use. The Guidebook is aimed at districts of all sizes and complexities, including water associations, tribes, and non-Reclamation contractors and will be described generally as districts for this guidebook.

Tools such as this manual support Reclamation's overall water management mission. Through tools such as this, Reclamation hopes to cooperatively work with others to improve water resource management and the efficiency of water use throughout the western United States. This manual supports Reclamation's responsibility under the Reclamation Reform Act (Sections 210a and 210b) and other Reclamation law, to encourage more efficient water use by the districts it serves.

Water Conservation Versus Water Management

One objective of this Guidebook is to help districts prepare water conservation plans called for in Section 210 (b) of the Reclamation Reform Act. However, the methods and measures described in the Guidebook are more broadly aimed at helping districts improve their overall water management. Improved water management will often lead to better water conservation. We encourage you to take this broader view as you use this Guidebook.

Who Should Use This Guidebook?

This Guidebook is designed to assist managers and staff of M&I water districts, States, and others to improve water management by the individual customer and at the district level. Throughout this Guidebook, the term 'you' refers to district management and staff members responsible for preparation of water management plans.

What is Good Water Management?

To the urban user, good water management means using sufficient water to maintain or improve quality of life. Success is if this can be accomplished while also reducing the amount of water used.

To the water district, good water management means meeting the water needs of its customers as efficiently as possible, with minimum waste or loss. Good water management is therefore fundamentally important to good overall district management.

To society, good water management means having adequate supplies of good quality water for all municipal, industrial, agricultural, recreational, and environmental needs. Those in charge of operating water supply and delivery systems bear the greatest burden of responsibility for promoting and achieving the good water management demanded by society.

Why Should You Care About Water Management Planning?

Planning is the process of thinking ahead to achieve desired future outcomes and to avoid future problems. It is something we all do at many levels every day of our lives. There are benefits to be gained and risks to be avoided by water management planning.

Benefits of Good Water Management Planning

Water management planning can benefit the water district and their customers, as well as third parties and the environment. The range of potential benefits includes:

- Better water service to customers
- More effective use of available water supply
- Reduced operating costs and improved revenues
- Improved water quality
- Reduced customer costs
- Improved aquatic habitat
- Habitat maintenance for endangered species
- Better documentation of uses and accomplishments
- Education of customers and stakeholders
- Improved system and water supply reliability
- Postponed need for new or expanded water supplies
- Reduced drought impacts and improved reliability of water supplies

Pitfalls Avoided by Good Water Management Planning

There are a variety of problems and pitfalls that can be avoided by good water management planning. Some of these could affect the district and its customers immediately and others could pose future threats.

Some examples of undesirable situations that might be avoided through good planning are:

- Daily and seasonal water shortages (short or long term)
- Excessive losses or spills from water delivery systems
- Insufficient carry-over supplies in reservoirs
- Loss of water rights through waste or abandonment
- Adverse relationships with other water users and publics
- Drainage and erosion control problems
- De-watered streams and wetlands

Organization of this Guidebook

This Guidebook is divided into four main sections.

Section One is this introductory section of the Guidebook.

Section Two describes a step-by-step planning process that will enable you to identify the most effective water management improvements to make first.

Section Three contains brief descriptions of a variety of M&I water management measures. It contains questions and checklists to help you decide which measures might best apply to your situation.

Section Four is a brief guide to preparing a water management plan document for your District. It contains a suggested outline for the document and provides examples of how different types of information might be presented.

At the back of the Guidebook, you will find a Glossary of terms, lists of references, and contacts for further information and assistance.

Image: Cambridge Quail Executive Park converted 1,988 square feet of grass to water-efficient landscaping as part of the SNWA Water Smart Landscape rebate program. (Southern Nevada Water Authority)

Section Two - The Planning Process

This section of the Guidebook will introduce you to the planning process. It will:

- Outline a systematic but flexible planning process
- Help you identify water management problems and goals
- Help you evaluate potential ways to solve problems and achieve goals
- Help you decide what water management improvements should become part of your action plan

Overview

Planning is a logical sequence of decision-making phases or activities that include:

1. Gathering Information & Defining Problems
2. Setting Goals & Priorities
3. Evaluating Options
4. Defining a Plan of Action
5. Implementing & Monitoring

There is nothing unusual or complicated about this sequence of activities. You use this thought process for almost every decision you make. In the context of water management, it is simply used as a framework to ensure a systematic and thorough decision-making process.

The five planning phases described above are shown in sequential, step-by-step order. However, the planning process often requires going back and forth between steps. For example, it is very common to determine, while evaluating options, that further information gathering is needed.

It is this back-and-forth approach that makes planning a process, rather than a product. The product (in this case a water management plan) should be viewed as a "snapshot" of an ongoing process, taken at a specific point in time for the purpose of implementing management measures.

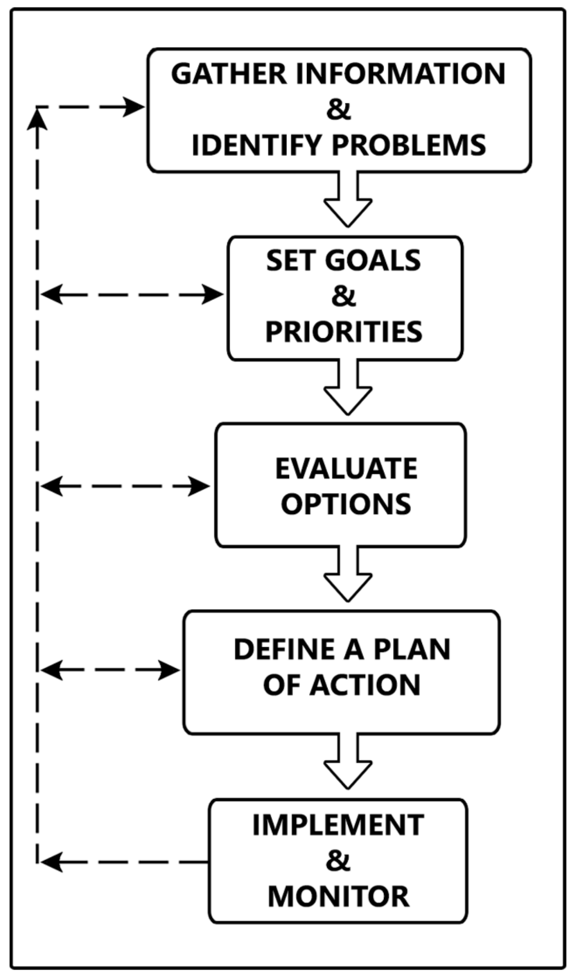

Figure 1: Decision-making Process

Water management planning should be viewed as an ongoing activity and not as a one-time effort. Situations change, new technologies arise, and problems and opportunities may be seen in a new light. As a result, plans become outdated. Water management planning must become a routine part of district management to be effective in the long run.

Each of the five planning phases shown in Figure 1 above is discussed in detail in this section. By the time you have read through the section, you will have a good understanding of the planning process and how it could be applied to your situation.

The Importance of Public Involvement

A basic principle of planning is that it cannot be done effectively in a vacuum. It would be foolhardy to develop new policies, procedures, or requirements and attempt to implement them without involving the people affected by them. In many cases, district or state laws would prohibit such actions.

For plans to be credible and effective, it is important to obtain consensus and support of the district board of directors and from potentially affected parties. The parties that are most obviously affected by water management measures are District customers. Involving your customers in all phases of the planning process is more likely to produce a management plan that addresses real problems in practical ways.

But there are other important “stakeholders” that can also make significant contributions to plan development. Involve community leaders, state and federal agency staff, and representatives of various interest groups in the planning process. Two heads are better than one in providing broader perspectives on issues and thus heading off later obstacles to plan implementation.

For these reasons, it is very important to consider public involvement as an integral part of the water management planning process. The goals of public involvement are:

- To build credibility by establishing an open and accessible planning and decision-making process
- To identify and understand the diverse concerns and values of the parties potentially affected by your decisions
- To develop a consensus among these divergent interests in support of your water management plan

Some methods to provide public involvement opportunities include email or online questionnaires, information sheets, public meetings, workshops, focus groups or advisory committees, and the use of local media. Reclamation has a substantial amount of experience in developing public involvement programs. Additional assistance in developing a public involvement program can be obtained from the Water Conservation Coordinator at Reclamation’s Area or Regional office nearest you.

PHASE 1 - INFORMATION GATHERING / PROBLEM DEFINITION

Overview

The first phase of the planning process includes problem definition and information gathering activities. You probably have already identified some water management problems in your district. However, having more or better information will help you define those problems more clearly, and possibly, uncover others. You also probably already have quite a bit of information about water use in your district, but it may be incomplete or not organized in a way that is helpful in problem-solving.

This first phase of the planning process is meant to identify information gaps and uncertainties about problems and to develop a solid foundation for subsequent planning activities. Before you can effectively set goals and evaluate options, you must have a clear definition of the problem you are trying to solve.

Input from customers and others affected by your district's water use will help you identify important issues. You will want to involve a wide range of people at the onset, perhaps at a public meeting.

Checklist of Information Needs

Part of the first phase of the planning process is gathering the information you need to identify and analyze water management problems. You also will need some other descriptive information about the district to include in your water management plan so that people who read it have a clear understanding of the district. The checklist below is provided to help you assemble the information you need.

Physical Setting

Understanding the local hydrology and climate will help you identify the factors which affect district water supplies and landscape irrigation demands. Data that might be useful include:

- Hydrology of source streams, district reservoirs, area wetlands and groundwater
- Water quality of sources
- Climate information such as precipitation and temperature

Sources of hydrologic, climatic, and water quality data include local universities, the National Climatic Data Center, the US Geological Survey, the EPA, Reclamation, and private data publishers.

Water Rights, Permits, and Contracts

The legal and institutional constraints under which your district operates will be a factor in your water management plan. Therefore, it would be useful to understand:

- Rights or permits held by the district
- Contracts with Reclamation or others
- Instream flow requirements or restrictions on water use

- Endangered Species Act compliance needs

Sources of information include district bylaws, articles of incorporation, decrees, contracts, and state water legislation.

Customer and Water use Information

Understanding the water use needs of your customers is key to developing a sound management plan. Data that should be collected include:

- Number of each type of customer (i.e., single family)
- Type and size of landscapes
- Uses of water by each customer type
- Amount of water used during a time period (to allow for assessing seasonal and peak demand)

District Operations and Operating Policies

Your water management plan may involve modifying existing operating policies. Sources of this information include district bylaws, written policies, district rules and regulations, and standard practices. Gather information on:

- Water ordering and delivery procedures
- Water shortage allocation policies
- Inter-district agreements and operations
- Staffing and training of operators

Examples include reservoir operations, timing of use of different water sources, groundwater pumping policies, flood control policies, facilities maintenance, and hydropower operations. Many operating policies may not be written; describing your operations in writing will help you and others better understand how the district works.

Water Pricing and Accounting

To understand relationships between water use and revenues, you will want to compile descriptions of:

- Water accounting procedures
- Water user billing procedures
- Date of last unit rate review and the cost per unit of water

These procedures may be gleaned from standard practices, or they may be codified in bylaws and contracts.

Water Resources Inventory

The infrastructure and water supplies currently in place in your district will be important factors in determining where water use efficiencies can be improved. Records of deliveries and sales will be key to estimating losses and potential savings. The types of data needed include:

- Diversion capacities and diversion records
- Groundwater pumping capacities and pumping data
- Storage capacities, storage and release records, and evaporation data
- Delivery records and data, including peak period deliveries

Reclamation's Monthly Water Distribution sheets contain monthly data for your district, though the accuracy and reliability of these data should be verified. Information from drought years will be particularly useful.

Other Water Uses

There may be opportunities and constraints presented to your district by other water uses. Some of these include:

- Recreational and environmental uses
- Special needs or operations (e.g., sediment flushing)

Existing Water Management and Conservation Programs

You will want to understand what management measures or programs have already been implemented in your district. These could range from system leak detection to education programs to variable rate pricing. Understanding the cost and impact of each measure will help you make informed decisions about future measures. Lessons from programs that have not succeeded are as valuable as from programs that have succeeded.

Identifying Problem Areas

There are a variety of ways to learn about water management problems in your district. The most common way is day-to-day observation and experience. District management and staff members often observe operational problems from a quality standpoint. Staff monitoring customer complaints for trends or holding annual informal "brainstorming sessions" with multiple departments, customers, and other stakeholders can help identify problem areas that may not be immediately noticeable.

Another important way to learn about water management problems is to analyze data. For example, by comparing records of district supply with customer sales you can estimate the amount of water lost to leaks, breaks and slow meters. This type of quantitative analysis can provide quite specific information about problem areas, provided it is based on accurate data. One very useful method of analysis is the water budget.

The Water Budget Concept

The water budget is a convenient tool for analyzing water management problems and opportunities, if you have adequate and reliable data. It is also a useful way to organize quantitative information you have collected.

The water budget concept, simply stated, is that the sum of system inflows must equal the sum of system outflows. Inflows consist of all the sources of water supply to the district. Outflows consist of all the ways that water is removed from the district. The components of inflow and outflow are best presented in the tables provided in the EXAMPLE WATER BUDGET template available from your Reclamation office.

However, a useful water budget is possible only if the records or estimates for all the accounted-for inflows and outflows are accurate and reliable. If any of the records or estimates is unreliable or inaccurate, the water budget will also be unreliable or inaccurate. Thus, it is very important that the data used in water budget analysis is verified and to have documentation explaining the source of data, assumptions, or other variables used in the analysis to ensure consistency over time.

The water budget approach is very flexible and can be applied at different scales. For example, it can encompass the entire district or focus on a specific area. By focusing on smaller areas, it is sometimes possible to identify the specific locations of problems such as leaking pipes. The water budget can also be prepared on an annual basis or a daily basis. A shorter time step sometimes helps identify specific problems. For instance, it might be helpful to prepare a water budget for a wet year and for a dry year to see how usage and losses change with hydrologic conditions. An analysis of several years will increase your confidence in the results.

Checklist of Typical Problem Areas

A "checklist" is provided below to help you start thinking about where there might be opportunities to improve water management in your district. This checklist is organized into problem areas that are common to M&I water purveyors. It may be that your district has unique water management problems and opportunities that could be added to this list.

Adequacy of Data

Good information is fundamental to making good decisions. Informed decisions about water management are based on good water measurement and accounting. Without accurate and reliable information about when, where, and how much water is used, it is difficult to correctly assess the locations and magnitudes of problems. These assessments, in turn, are key to deciding how to allocate scarce district resources.

- Is customers' water usage metered, and do you bill customers based upon their metered use?
- Are all meters in good operating condition and checked regularly?
- Are you utilizing best practice methods for measuring and verification of usage as well as current rates per unit?

Adequacy of Supply

The adequacy of the district water supply should be considered at several levels. In some situations, it will be clear that water demand chronically exceeds available supply. However, it is more common that supply is adequate on the average, but there are shortages in dry years, in the late season, or in certain locations.

- Do you regularly have difficulties meeting overall district water demands?
- Is adequate water supply always a problem in certain areas of the district?
- Do you have supplemental water supplies brought on by drought, infrastructure challenges, or unforeseen policy issues (such as court or state mandates)?

Efficiency of Application

Landscape irrigation water is one of the largest single users of water for most M&I purveyors. The challenge is to deliver the appropriate amount of water to the root zone at the correct time. Evidence of poor landscape management includes dry patches or ponding on turf areas, water running in the streets and excessive peak demand.

- Is Evapotranspiration data easily available and widely used?
- Does the district provide demonstration gardens and workshops for gardeners?
- Does the district have programs to make improved irrigation equipment (low volume emitters, controllers, etc.) accessible to customers?

Environmental Considerations

The development of cites in the dry western states has had impacts on the environment of the region. Construction and operation of water storage and diversion projects have modified and depleted natural flow regimes, created wetlands in areas where they did not exist naturally, and degraded water quality by adding sediments, salts, and chemical residues from industry, fertilizers, and pesticides.

- Are wetlands or critical habitats affected by water use in your district?
- Are there endangered species affected by your district water diversion or use?
- How do your operations affect environmental values?
- How could district operations be modified to improve conditions?

Image: Callville Bay Marina, Lake Mead, showing drought in July 2014. (Reclamation)

PHASE 2 - SETTING GOALS AND PRIORITIES

What Are Goals?

The objective of this second phase of the planning process is to define the goals of your water management planning effort. These goals will help you decide which water management measures make the most sense to implement. They will become the "yardsticks" by which you measure the success of your efforts. They need to state where you are going and why.

Goal Setting

In addition to addressing specific problems within the district, some other areas where you should consider developing specific planning goals include the following:

- Providing leadership in solving regional water problems
- Improving coordination with neighboring water supply entities
- Enhancing the value of the water resource within and outside the district

There are some basic principles to follow when it comes to defining the goal statements that will drive your water management planning effort. These principles are derived from strategies for businesses but they are applicable to any directed activity. The principles are that goals should be:

Relevant

Goal statements need to address actual problems and opportunities faced by the district. The objective of the planning process is to identify and take appropriate actions to address potential water management problems and opportunities. Hopefully, the information-gathering and problem-definition activity of Phase 1 will have illustrated for you where water management problems and opportunities exist. Your goals should build on these findings.

Consistent with Mission Statements and Values

District goals will be more readily achieved if they are consistent with the mission outlining the district's purpose and obligations, and consistent with the values of district customers, staff, and directors. Their values are the basis of their motivation to support your management efforts.

Specific and Clearly Stated

Goals need to be expressed in clear terms and directed at specific activities. This principle is necessary to choose between management options and to gauge your progress. Vaguely stated goals will leave people uncertain about what they should do. If possible, goals should be stated in quantitative terms.

Written Down

It is essential to write down goal statements to communicate them consistently to others. It also makes a commitment that is not present when you just think about them. Use simple, concise, common language when writing goal statements.

Minimal in Number

Having too many goals will diffuse the resources your district can direct toward achieving any one of them. Don't include all the goal statements that you think of - some probably aren't important.

Challenging but Realistic

Motivated people generally respond well to challenges, but unrealistic goals will cause everyone involved to become frustrated and disillusioned. Goal statements should reflect the practical ability of your district to direct money and staff resources at the problem to be solved.

Visualized

Painting mental pictures of your goals is a very powerful technique. It helps you see them as more realistic and achievable. To the degree possible, you should try to share your vision with others on whom you will rely for help.

Long-term

Many water management improvements take time to develop and will not be realized immediately. Attitudes change slowly and voluntary adoption of new practices occurs incrementally. The district must maintain a long-term leadership role.

Achievement-oriented

If people don't see results from their efforts, they eventually lose interest. When developing goal statements, try to think of ways in which progress toward those goals might be recognized and publicized. This is especially important for goals that take a long time to achieve.

Example Goal Statements

Here are example goal statements that reflect the principles stated above:

- "Implement a water measurement improvement program by the end of the year that outlines district use and management"
- "Reduce system losses to less than 8% by the end of next year."
- "Improve water management to create 2,000 acre-feet of surplus supply for future development."

Setting Priorities

Chances are that you will identify several, perhaps many, goals for water management improvement. There may be more things you want to do than you have the resources to accomplish. If this is the case, you will have to decide which goals are the most important.

There are a variety of ways to set priorities among competing goals. Priorities might emphasize goals that are perceived to be important to the greatest number of people. Priorities might emphasize goals that have the least cost or the greatest financial return. Priorities might emphasize goals that enhance the physical performance of your supply system. Priorities might emphasize goals that are most in harmony with existing rules and regulations and with neighboring water management agencies. Priorities might emphasize goals that contribute more to improved water quality or habitat.

One way to assess the relative importance of problems and goals is to hold workshops or discussion groups with staff and customers. After describing the water management problems and you have identified and the possible goals you have defined, you can ask for a ranking of priorities. You might list all the possible goals or problems on large sheets of paper, hang them on the wall, and ask participants to vote on the five most important ones.

Your Board of Directors will obviously play an important role in assigning priorities to the goals of your water management plan.

Given the importance of good information to good decision-making, it is probably safe to say that having good water measurement and accounting should be a top priority in every district. Without good water measurement it is difficult to quantify and evaluate water management problems and opportunities. It is also impossible to base accounting or pricing on actual water delivery unless those deliveries are measured. Accordingly, every district should consider adopting planning goals that include improved water measurement and accounting.

Image: The Bureau of Reclamation and the Water Resources Agency of Taiwan participate in the 31st anniversary meeting between the two agencies in Washington D.C. in 2018. (Reclamation)

PHASE 3 - EVALUATING WATER MANAGEMENT OPTIONS

Overview

This phase of planning activity involves identifying candidate measures for water management improvement and investigating how well each option might contribute to achieving the goals you defined in Phase 2. Usually this means that you will need to make rough assessments of costs, water savings, political acceptability, etc., of each of the measures being considered.

The evaluation process involves going back and forth between evaluation steps. You may decide, for example, that certain effects of a candidate measure are unacceptable but that the measure could be re-defined to avoid those effects. You would then go through the evaluation process for the modified measure. Hopefully, each time you go through this exercise you get more precise and confident in your evaluation.

Later in the planning process (in Phase 4) you will select from the most promising options to define an action plan. The basic objective of Phase 3 is to develop enough information about potential water management improvements to support later decisions.

Identifying Candidate Water Management Measures

District staff are probably the people best qualified to identify potential water management improvements for the district. It is important to take a little time, think about the "big picture," and involve experienced peers from various stakeholder teams within the organization to better define opportunities and arrive at the best solutions.

The focus in defining potential water management measures for consideration should be the goals you defined in Phase 2. If your goal statements are specific enough, they will "suggest" certain types of measures. Brainstorming in workshops and focus groups of staff members or customers is also a good way to generate ideas about potential water management improvements. Thinking of possibilities is a very creative process. But you should always come back to your goal statements as the guiding principles.

To help you get the creative juices flowing, Section Three of this Guidebook contains descriptions and discussions of a variety of potential water management measures (there are many other potential measures). The general areas covered in these descriptions include:

- Improvements to water measurement and accounting
- Changes in water pricing and billing methods
- Education and training programs
- Operational and facility improvements to reduce water losses
- Incentives for improved customer water use and regulatory requirements (landscape development codes, prohibitions on wasting water)
- Development of contingency plans for shortage periods

Describing the Effects of Candidate Measures

Once you have identified some specific measures you think could help achieve your water management goals, the next step is to describe the effects of those measures. A wide variety of effects should be considered. Some of the more important ones include cost to the district and customers, changes in use patterns, and environmental effects. The discussions of specific measures in Section Three provide you with some ideas about how to estimate the effects of various types of water management measures.

Costs

Most water management improvements will have costs of some type. There may be material costs for the following: equipment or construction, labor for operation and maintenance of the system, financing if money is borrowed to pay for the improvements, or more detailed studies, contract negotiations, and public information campaigns (particularly for community-wide conservation efforts.)

Another important matter to be resolved is how the costs of improvements will be financed. Financing might be available from existing capital or maintenance funds. Some improvements might logically be paid for through user fees. Borrowing and levying taxes are other methods of financing available to some districts.

While implementation may have costs, it's also important to integrate cost savings for the short and long-term. For example, if you are unable to achieve the goal, what are the costs of the potential consequences? Does the program eliminate or defer the need for new infrastructure? Sometimes spending one million dollars on demand management avoids five million dollars spent on future supply issues.

Each of the measures you are considering should be evaluated in terms of costs, cost savings, and financing requirements. Detailed cost estimates and financing strategies are probably not needed for the early stages of planning but will likely be required later for some types of improvements.

Environment

Conservation measures can impact water operations and water quality. For example, altering the timing and quantity of diversions may have environmental effects. These effects are likely to be related to changes in stream flows and reservoir storage. Other examples to consider is that lower demand can increase stored water aging or that assigning specific watering days can impact operational efficiency.

Legal and Institutional Considerations

The implementation of water management and conservation measures must be done within the context of state water law and, for some districts, Reclamation law and contracts. Furthermore, some conservation measures may have environmental implications that require local, state, or federal permitting or mitigation activities.

Water management measures that have been identified as having potential application in your district should be reviewed considering these legal and institutional considerations before final decisions are made regarding their implementation. The advice of district counsel may be helpful in this regard.

Displaying and Comparing Your Evaluations

You will need to obtain input from customers, staff, the Board of Directors, and others about the alternative water management measures you are considering. It will be important to do this before you decide to go ahead with specific measures in your action plan.

There may be quite a bit of information available about the alternatives you have evaluated. This can make it difficult to display the effects of the alternatives in a concise way. One approach that may be helpful is to use an evaluation matrix. A simple evaluation matrix format is shown below as Table 1.

To use this simple and familiar display method, first list the alternatives down the side and the effect categories across the top. You can make these lists and categories as simple or as complex as you want to get your points across. Then, in each "cell" of the matrix, put an indicator of the effect of each alternative. These indicators might be numerical estimates of costs or amounts of water, but they can also be simple terms like "good, neutral or bad," or "high, medium or low."

If more detail is needed to display the information, create one matrix for cost information, another for water savings, another for environmental effects, etc. This general approach is very flexible and can be easily adapted to suit your needs.

Table 1: Evaluation Matrix

Effects	Cost		Savings			Environment		
Alternative	Construct.	O&M	Water	Energy	Sewage	Wetlands	Water Quality	Fish / Wildlife
Measure 1								
Measure 2								
Measure 3								
Measure 4								

PHASE 4 - DEFINE A PLAN OF ACTION

Overview

In this phase of the planning process, you will decide which of the measures evaluated in Phase 3 you want to implement. While you may feel that you already know what you want to do, it is a good idea to take a little time to systematically review the information developed and be sure you are starting out with the most useful and effective management improvements.

You may ultimately want to combine various management improvement measures into programs. A program is simply a logical set of activities. You might, for example, define a water measurement improvement program that includes three measures: meter installation, seasonal rates to control a peaking problem and a toilet rebate program to reduce wastewater flows.

Your action plan will consist of one or more water management improvement programs. A schedule and budget to support the activities in each program should be defined.

Selecting Measures for Implementation

Comparing Measures with Goals

The most important indicator of whether a measure should be selected and incorporated into your action plan is how well that measure contributes to achieving the goals defined in Phase 2. Measures that do a better job of achieving your goals obviously are preferable to those that do a poorer job of achieving your goals.

If some of the goals are expressed in quantitative terms, you should be able to make a very precise comparison of measures relative to those goals.

Comparing Measures by Implementation Cost

Another approach to deciding which measures to implement is to rank them based on implementation cost. These costs should be expressed in comparable terms, such as annual or capitalized cost, and they should address both initial costs and ongoing maintenance costs. The timing of costs may be important if the district has other special financial requirements or situations.

Comparing Measures by Ease of Implementation

Clearly, some water management measures are easier to implement, politically, institutionally and technically, than others. Another approach to deciding which measures to implement is to rank them according to "ease of implementation" criteria. However, it is difficult to adopt this approach on anything other than a subjective basis. It may be more desirable to use subjective factors as "fatal flaw" screening criteria for elimination of alternatives that pose insurmountable political, institutional, or technical problems.

Comparing Measures on Cost-Efficiency Basis

In this approach to evaluating alternative water management measures, the district would consider programs that have the highest benefits relative to costs. The ranking of programs by benefits and costs ensures that the district pursues those programs that are economically beneficial. The benefit-cost evaluation may be based on a variety of values. An evaluation based on saved water would involve two components:

> **Evaluating the benefit of saved water:** analyze the value of water that your district saves through improved management and how that water can best be used. For example, your district might use the additional supply to avoid buying an expensive new supply. The benefit of the saved water in this case would be the avoided cost of the new supply.
>
> **Evaluating the cost of saved water:** compare the cost of management improvements on a dollars-per-acre-foot basis. This is done by estimating the annual cost of the measure divided by the estimated amount of water saved annually. Measures can be ranked from lowest cost per acre-foot to highest cost per acre-foot. Don't forget to include infrastructure, treatment, practice lifespans, and distribution costs to your model for a more accurate depiction. For example, a district may pay $16,000 for a landscape rebate to save one acre-foot per year which seems exorbitant, but the lifespan of the project is 30 years, so the actual cost per acre-foot per year would be $533.

Comparing Measures by Environmental Effects

Environmental effects are often the hidden costs and benefits of improved water management. Some measures will have more environmental consequences than others. A preliminary comparison of measures on the basis of environmental effects will help you anticipate what permits will be required, which government agencies will be involved, and what kind of support you will receive from the community.

Other General Considerations

Complementary and Conflicting Measures

Another thing to consider is the possibility that some water management measures may be complementary or conflicting. Complementary measures are measures that, when implemented together, would enhance the effectiveness of each other. Conflicting measures are those for which the successful implementation of one measure diminishes the potential effectiveness of another measure; such measures should not be considered for implementation together.

Water measurement and incentive-pricing are examples of complementary measures. Clearly, without good measurement of customer deliveries it is impossible to know how much water a customer used during a given billing period. Accordingly, incentive pricing cannot be considered unless development of adequate water measurement and accounting systems is considered also.

An example of conflicting measures would be distributing toilet retrofit devices and offering a toilet rebate program. Since rebate programs are the preferred measure because they offer reliable long-term savings, each customer that installed a retrofit device would be a missed opportunity for more reliable savings.

Projecting Results of Selected Measures

Once you have decided which measures and programs will be part of your water management action plan, you develop estimates of program water savings and other benefits, cost, and environmental consequences. You should be able to make these estimates from the information you developed in evaluating alternative measures.

Water Savings

The projected water savings might be derived by simply adding the projected savings of the measures included in the plan (unless there are significant interactions between these measures). The water savings associated with some measures may be predicted fairly accurately. For example, toilet rebate programs yield very predictable savings. The water savings associated with some other measures will be more difficult to predict, particularly if the measures rely on voluntary adoption of methods by individual customers. Some measures may not have water saving effects.

The timing of water savings should also be considered. For some measures, savings will be immediate once the measure is implemented, while for others the savings will only be realized over a period of time.

Cost

The cost of program implementation should be estimated in terms of initial costs and ongoing costs. The projected useful life of facilities or equipment should be considered here, since maintenance and replacement will be required over the long run.

By mapping these costs out over time, you can create a cash-flow requirements table. A comparable cash-flow table should be developed for any revenues the district contemplates saving or receiving in connection with the measures (e.g., reduced pumping costs). These cost and revenue schedules will then facilitate development of net-annual-cost or net-capitalized-cost equivalents for budgeting purposes.

Environmental Consequences

You made some preliminary assessments of the environmental consequences of various plan elements in Phase 3 and made some relative comparisons of possible measures in Phase 4 of the planning process. Once you have decided on the elements that are to be part of your overall plan, you should prepare a written summary description of the probable environmental consequences of the plan.

It is not expected that this description be a formal environmental assessment or impact statement, or a substitute for such documents. It should simply alert readers to the generally anticipated effects of the selected program of conservation measures. Specific benefits or impacts of consequence, as well as areas of uncertainty, should be highlighted. You may also wish to contact your local Reclamation Water Conservation Coordinator for further assistance.

PHASE 5 - IMPLEMENTATION AND MONITORING

Implementation Schedules and Budgets

To make your water management plan a reality, you need to define the sequence of activities and then allocate the necessary funds to support those activities.

Schedule

The implementation schedule for your plan should reflect the time required to develop the measures included in the plan. Certain changes may need to be presented to users as proposals first, allowing for some educational time before implementing actual changes. There also may be time required to develop necessary information and control systems and for district staff training.

Measures involving equipment acquisition or construction will almost certainly require more detailed feasibility study than they have been given in this management plan.

Budget

The district budget for implementing the management plan will be based on the cash-flow requirements of the plan and the net-capitalized or net annual cost of the plan. Depending on the contents of the plan, it may be possible to allocate funds from existing revenue streams for plan implementation.

If additional revenues are needed, the budgeting process will be dependent on the potential sources of that revenue. Some possibilities are increases in water service charges or water rates and issuance of revenue or general obligation bonds. It is possible that revenues from some of these sources will not develop immediately; if so, the plan implementation schedule will need to reflect the time required for this revenue development.

Staffing

Some aspects of the management plan may require additional effort by district staff. The plan should describe how duties would be assigned or how additional staff would be recruited and supported.

Monitoring the Plan

An important part of your water management plan is identifying and quantifying the water savings and other effects it achieves. This should take the form of an ongoing monitoring program because the effects of some measures will not be immediately evident.

It will typically not be possible to measure these effects directly. Water savings may be evident in reductions in deliveries, quantity of wastewater treated, etc. These quantities have substantial natural variation from year to year, and you may need to accumulate several years of data to determine whether there has been a significant change.

The parameters you originally examined in constructing your district water budget are the same ones you need to monitor to identify water savings. Monitoring effects may involve installation of measuring devices, better observation of existing measurements, more frequent spot checks, etc.

Your water management and conservation plan will not be complete without a description of the approach you intend to take to monitor its success.

Image: Western High School Football Field comparison images. The Clark County School District replaced 2.4 million square feet of grass with artificial turf at two dozen high school athletic fields as part of the SNWA Water Smart Landscapes rebate program. (Clark County School District/Reclamation)

Section Three - Potential Water Management Measures

This section of the Guidebook will help you evaluate potential water management improvements that might be applicable to your district. It will:

- Describe a variety of types of water management problems and measures
- Ask you questions about how these problems and measures are relevant to you
- Help you think of water management measures that best fit your situation

FUNDAMENTAL WATER MANAGEMENT MEASURES

Reclamation has identified four fundamental water management measures that should be considered in any water management program. They are:

1. Adequate Water Measurement & Accounting
2. Water Pricing Structure that Incentivizes and Encourages Efficiency
3. Information & Education Services for Water Users
4. Designation of a Water Conservation Coordinator Responsible for Program Management.

Water Measurement and Accounting Systems

Effective water measurement and accounting is necessary for developing a sound water management program. A district's measurement and accounting systems should be capable of tracking the amount of water delivered to individual water users. These systems are effective water management tools because they help inform both the water user and the district about the quantity, timing, and location of water use.

From the district's perspective, water measurement will help with:

- Assembling information needed for a detailed water budget
- Identifying areas where additional efficiency can be achieved
- Implementing a billing system based on individual customer use

For the customer, water measurement provides the information necessary to identify interior and exterior inefficient water use and will help:

- Improve customer understanding of their usage.
- Identify potential leaks or unexplained consumption.
- Manage long term customer costs by ensuring efficient use of resources.
- Reduce irrigation runoff and the resulting road-surface damage

- Reduce district costs for potable treatment and system pressurization
- Reduce wastewater treatment quantities and costs
- Increase storage and reliable water supply

An effective water measurement system includes measurement of each water user - each home, apartment, business, park, etc. Many water purveyors now install a separate measuring device for landscape use at commercial, industrial, institutional, and multi-residential accounts. A few purveyors now also install landscape measuring devices at single-family residential accounts.

The typical water measurement system has measurement devices at each point of supply (including each district groundwater well), at potable water and wastewater treatment plants, and at some points in the delivery system. The actual number of measurement devices required depends on the size and complexity of the delivery system.

Water use accounting systems will vary between districts, depending on the number of types of customers. Water use should be tracked by customer, customer type, and billing frequency (preferably monthly), and allow records to be stored for several years. The appropriate accounting system must be determined at the district level, but in general, should allow for tracking of water deliveries to individual users either by automated meter reading (AMR) or advanced metering infrastructure (AMI).

Water Pricing Structure

To encourage efficient water use, a district's pricing and billing procedures should be based, at least in part, on the quantity of water delivered. Quantity-based charges can be incorporated into various existing pricing structures to provide some degree of economic incentive for efficient water use. Fairness in water billing by ending above-average user subsidies is a major benefit of quantity-based pricing structures. Disincentives to efficient water use include situations where the unit price of water declines as the volume of water used increases (declining block structure) or where a fixed charge per customer is assessed regardless of the quantity of water used. Both examples can lead to excessive water use. By contrast, pricing structures such as increasing block rates or uniform rates provide an economic incentive for more efficient use.

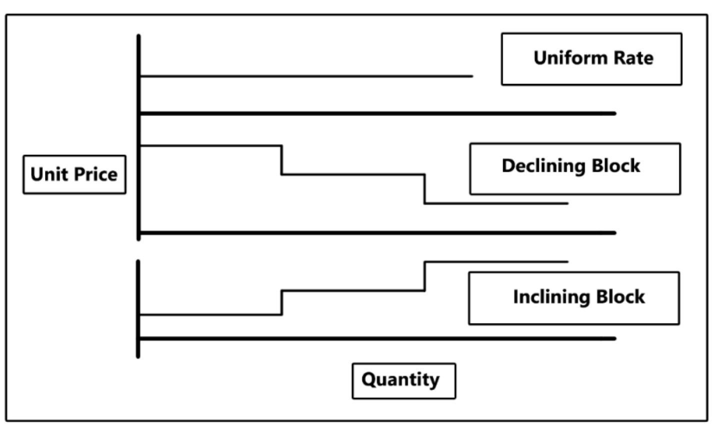

Figure 2: Types of Water Pricing Structures

Effective rate structures provide incentives to customers to reduce average or peak use, or both. Such pricing includes rates designed to recover the cost of providing service; and bill for water and sewer service based on metered water use. Conservation pricing is also characterized by one of more of the following components:

1. Rates in which the unit rate increases as the quantity used increases (increasing block rates) or is constant per unit regardless of the quantity used (uniform rates)
2. Seasonal rates or excess-use surcharges to reduce peak demands during summer months
3. Rates based upon the long-term marginal cost or the cost of adding the next unit of capacity to the system

Districts can encourage efficient water use by increasing the unit price of water as deliveries increase. With incentive pricing, a base price per unit of water is charged for all water deliveries up to a certain amount, or block. Water use in excess of this block is then charged at a higher unit price. One or more pricing levels (or "tiers") may exist within a pricing structure. The specific design of these structures will depend on individual district objectives.

Non-conserving pricing provides no incentives to customers to reduce use. Such pricing is characterized by one or more of the following components:

1. Rates in which the unit price decreases as the quantity used increases (declining block rates)
2. Rates that involve charging customers a fixed amount per billing cycle regardless of the quantity used

When evaluating water pricing structures, it is important to consider potential effects on revenues generated through water sales. Determine whether the new pricing system will provide sufficient revenues to cover district operating costs or if it will result in supplemental revenues that could be used to fund improvements.

The irrigation water need within a water district is based on climate and varies by region and season. The water need for interior uses by residential, commercial, industrial, and institutional customers varies by scale and the technology used to conserve supplies. The change in water use in response to a change in water price is termed "demand elasticity." Factors affecting demand elasticity include:

- Customer awareness of water cost
- Degree of customer efficiency
- Cost of water relative to other consumer costs

Typically, water is so inexpensive relative to other consumer costs that changes in water prices lead to only small changes in the quantity of water used. Thus, water demand has been considered fairly "inelastic." Potential changes in water demand and the resulting change in district revenue are important considerations in evaluating the design of incentive pricing structures.

To evaluate incentive pricing and other rate structures for your district, contact the American Water Works Association (AWWA) or the Alliance for Water Efficiency for the latest information and publications on rate design.

Educational Programs

An important component of any water management program is providing information to customers about efficient water use and water management services available through the district or other organizations. Educational programs can be effective because many water users are unaware of potential benefits from improvements in water use efficiency. Examples of educational programs include landscape and irrigation design workshops, landscape irrigation scheduling real-time evapotranspiration (ET) information, school and community educational programs, and technical and financial assistance programs. Information on the following topics could be made available to customers:

- Costs and potential water savings of water management measures
- Climate-appropriate landscape designs and plants
- Efficient irrigation equipment
- Determining irrigation timing and quantity based on ET data
- Efficient plumbing fixtures and district give-away / rebate programs
- Pool and spa covers and maintenance
- Commercial, industrial and institutional efficiency programs

There are a variety of ways the district could convey this information to its customers. For example, a district can sponsor workshops, share information on websites, utilize email blasts, create billing inserts and monthly water bills that provide water use data and previous year comparisons. Various local, state, and federal agencies provide technical assistance and cooperative programs. Districts should take advantage of these resources when developing their own programs.

Demonstration projects are another useful technique for customers. In these projects, specific measures are implemented in a controlled setting to allow precise determination of the effects. The results from monitoring demonstration projects are then presented to district customers, along with cost and implementation information.

Water Conservation Coordinator

Designating a district water conservation coordinator serves two primary functions: it allows the district to assign water conservation responsibilities and it provides a contact person for district customers and staff. Responsibilities of a water conservation coordinator may include:

- Prepare a water conservation plan, with budget and staff requirements
- Design the district's water conservation programs
- Train the staff necessary to implement the programs
- Arrange cooperative programs with other districts and agencies
- Monitor the impacts of programs and recommend improvements

AWWA, Alliance for Water Efficiency, Reclamation, and other agencies provide formal training in water conservation program management. Such resources allow conservation coordinators to keep up to date with conservation programs, services, and technological developments.

ADDITIONAL WATER CONSERVATION MEASURES

Reclamation has identified nine additional water management measures that may be suitable for improving water management and water use efficiency within the district.

The applicability and feasibility of additional measures, either individually or in combination, will depend on the specific conditions in each district. Potentially applicable water conservation measures should be analyzed and evaluated to determine whether they are feasible or practical for the district to implement. Base the evaluation on factors such as technical feasibility, quantity of water to be saved, environmental effects (positive and negative), legality under Federal and State law, and the cost and practicality of implementation.

A district should evaluate the measures listed below, and any other water conservation measures that may be applicable to its circumstances. This evaluation is key to the water conservation planning process.

1. Residential and governmental audit and incentive programs
2. Commercial and industrial audit and incentive programs
3. Landscape programs
4. Distribution system audit program
5. A drought/water shortage contingency plan
6. Wastewater reclamation and recycling programs
7. Plumbing regulations
8. Fixture replacement programs
9. Conjunctive use

Residential and Governmental Audit Programs

This water conservation measure involves audits of interior and exterior residential and governmental water uses with the district providing various incentives to encourage program participation and the implementing audit recommendations. Audits are to be provided as a service to the customer on a repeating cycle to identify water-saving potential and to provide information and services to improve efficiency and reduce waste.

The scope of this measure includes single and multi-family residential use as well as governmental uses. Governmental uses include such things as: schools, colleges and universities, prisons, public hospitals, government buildings, and military facilities.

The district should identify the top 20% of water users in each sector; directly contact them with an offer of a free audit; provide incentives sufficient to ensure that at least two-thirds of the offers are accepted.

The district can either train staff to perform audits or contract with private companies or other agencies for audit services. Many districts are now hiring and training unemployed individuals from diverse cultural backgrounds to implement conservation programs in neighborhoods that have had below average participation in past conservation efforts.

The district will want to carefully consider the complexity of some of the governmental sites to be audited. For instance, a university may operate multiple food service facilities equivalent to large restaurants, housing facilities of several kinds, recreational facilities, laboratories, hospital facilities, and various "industrial" types of operations, in addition to large landscapes and botanical and agricultural research.

The following variables and factors should be employed to estimate water use and savings potential.

Scope of Audit

- training of auditors
- time spent per home/site
- elements and incentives

Marketing Approaches

- email and mail
- door to door
- phone

Incentives Offered

- showerheads
- toilet dams
- dual-flush devices
- sprinkler timers for hoses
- pistol-type hose nozzles
- information and instruction appropriate to each sector

Leak Detection/Repair Activities

- system pressure
- toilets leaks (flapper and overflow)
- diverter spouts (tub spout leak rate when diverted for shower)
- plumbing (general leaks)
- water softeners (setting for softness, regeneration cycles, and valve
- check)
- reverse osmosis (RO) units

Fixtures, Devices, Appliances, and Other Elements Audited for Consumption

- showerheads
- diverter spouts
- toilet
- faucets
- sprinklers/irrigation system components
- irrigation timers
- plant types, landscaped area, slope
- soil types
- pool - leaks, covers, backwash

Additional Elements Covered by Governmental Audits

- general cooling systems functioning
- cooling towers cycles
- single pass cooling systems
- production systems

A typical residential audit would include: installation of free high-efficiency showerheads and faucet aerator; toilet-leak test, minor toilet-leak repairs, water pressure check, leak and automatic-shutoff-valve check; adjustment for reverse osmosis and water-softening equipment; soil-type and root-structure check, irrigation timer instructions with a recommended lawn watering schedule, an irrigation-system check, as well as recommendations for drip-irrigation systems; pool covers, and other water efficiency measures. Additional incentives could include irrigation timers, soil-polymer, and moisture sensing devices.

Governmental audits usually include the elements listed above as well as fixture modifications, recommendations for better maintenance practices, flow and pressure controls, and cooling system recirculation.

Commercial and Industrial Audit Program

This water conservation measure involves audits of interior and exterior water uses by commercial and industrial accounts with the district providing various incentives to encourage program participation and the implementing audit recommendations. Audits are to be provided as a service to the customer on a repeating cycle. The purpose of each audit is to identify the water conservation potential at each site and offer technical assistance to implement conservation practices.

The district should identify the top twenty percent of water users in each sector; business types known to use large amounts of water (laundromats, carpet manufacturers, chemical and petroleum complexes, etc.) and directly contact them with an offer of a free audit.

The district can either train staff to perform audits or contract with private companies or other agencies for audit services.

The district will want to carefully consider the complexity of some of the industrial sites to be audited. For instance, a factory or refinery uses specialized equipment that may only be understood by a process engineer. Many districts co-fund audits by specialized consulting process engineers to ensure that the greatest possible savings are identified. Due to the rapid advancement of water treatment and process equipment, most districts offer follow-up audits at least once every five years.

The district will also want to ensure that appropriate plan reviews of proposed water uses for new commercial/industrial water service are conducted. This usually involves working with the local building department and results in the issuance of recommendations for improved water use efficiency before completion of the building permit process.

Landscape Programs

It is estimated that between 40 and 60 percent of municipal water use is for landscape irrigation. A significant portion of that water is used on large landscapes at parks, golf courses, commercial properties, cemeteries and educational institutions. Districts should identify landscapes with high gross application rates per acre and prioritize services to the least efficient facilities. Many districts have trained their conservation staff to perform landscape audits and provide this service free to district customers.

Landscape audits provide recommendations for modifications to irrigation systems to improve distribution uniformity and maintenance. Audits are also used to determine irrigation schedules that can be used in conjunction with weekly weather data.

When to irrigate and how much water to apply are the two basic questions each irrigator and homeowner must answer during the irrigation season. The answer depends on plant type, climate conditions, soil type, and previous water applications. Improving landscape irrigation scheduling to better match actual plant need, thereby reducing over-application of water, is a very effective water management measure. Real-time information on actual evapotranspiration is essential for effective irrigation scheduling. For ET to be widely used it is necessary that the information be easily available. A district and their local irrigators can utilize smart irrigation control systems to monitor ET data which can then be shared via outreach methods like a district website.

The district should offer cost-effective incentives (irrigation timers that are compatible with low-volume emitters, hose nozzles, discounts on climate appropriate plants, etc.) sufficient to achieve large (3+ acre) landscape customer participation at least once every five years. Similar incentives should be offered to residential customers to achieve similar participation rates by the 20 percent of customers with the largest water use.

The district should also aim to:

- provide information on climate-appropriate landscape design, plant material and efficient irrigation equipment / management to new customers and change-of-customer accounts and offer the materials to all existing single family residential accounts annually.

- offer landscape audits to as many customers as viable, prioritizing where conservation has the largest impact.
- install appropriate landscaping at district facilities, phased in over the five years before the next plan revision.
- conduct an annual pre-irrigation season media campaign to notify Single Family Residential customers of district-provided landscape assistance (audits, materials, special offers, etc.).

The district, in cooperation with other water purveyors, government agencies and/or private organizations, should also:

- participate in the development / maintenance of a demonstration garden.
- participate at local and regional landscape fairs and garden shows.
- conduct cooperative education and marketing campaigns with local nurseries.
- conduct an annual irrigation season landscape media campaign.
- provide multi-lingual landscape gardener training and information.

The district should also enact and implement landscape water conservation ordinances through their service rules, or if the supplier does not have the authority to enact ordinances, cooperate with cities, counties, and the green industry to develop and implement a landscape water conservation plan requiring climate appropriate plant material, efficient landscape design and irrigation systems, limited use of turn on median strips and on slopes, and restricted irrigation during peak evaporation hours.

Distribution System Audit Program

A system audit is a thorough examination of the accuracy of water district equipment and system control processes.

Leak detection is the systematic method of using listening equipment to survey the distribution system, identify leak sounds, and pinpoint the exact location of hidden underground leaks. An annual system audit / leak detection program allows water districts to conduct cost-effective system repair programs.

An effective way to conserve water is to detect and repair leaks in municipal water systems. This controls loss of water that water districts have paid to obtain, treat, and pressurize. If water leaks from the system before it reaches the consumer, water districts lose revenue and incur unnecessary costs.

A water audit and leak detection program has benefits in addition to the value of water control. Meter testing performed as a part of the water audit will frequently identify customer meters that inaccurately record water use. Recalibrating inaccurate meters results in increased revenues to the water district. Early detection of leaks will reduce the chances that the leaks will cause major property damage to the water district or its customers. Better knowledge of the locations of valves and mains will allow the water district to react quickly when emergencies occur.

Water industry standard system audit / leak detection methodology is detailed in the American Water Works Association's "Manual of Water Supply Practices: Water Audits and Leak Detection." This document is commonly called M-36. AWWA technical experts indicate that audits should be performed annually to be effective.

A water audit and leak detection program can include provisions to inform customers whenever it appears possible that leaks exist on the customers' side of the meter.

Water Shortage Contingency Plan

Water shortage response is most effectively accomplished through a combination of focused water conservation programs and an emergency preparedness / contingency plan. Generally, development of new supplies is a long-term project not related to an individual drought or shortage event. The basic objectives of a water shortage plan include:

- Hydrologic forecasting to predict water supply
- Definition of water allocation procedures to be used during water shortage periods
- Definition of water use restriction procedures to be used during water shortage periods
- Identification of methods to increase reliability and use efficiency of existing water supplies
- Identification of alternative or supplemental water supplies

Hydrologic forecasting can help the district assess when to begin limited water deliveries, when to move from stage to stage of the shortage plan, and how to communicate the shortage to its customers.

Water allocation procedures used during normal water supply conditions are usually not appropriate during times of shortage. For example, uncontrolled landscape use may later result in economic losses due to water constraints on business. Water rationing techniques include percentage reductions, increased rates, and restrictions on specific uses. Defining allocation procedures before a shortage will allow the district and its customers to plan in a non-crisis atmosphere.

An important component of a water shortage contingency plan is the identification of alternative water sources to use in emergency situations. The plan should define "triggers" that initiate use of these alternative sources and estimate the amount and timing of supplies from these sources. Potential alternative sources or techniques that might be used to supplement a district's water supply during drought periods include:

- Interruptible supplies (temporary transfers or dry-year options)
- Intra-district transfers
- Exchange arrangements
- Water banks
- Storage hedging, carryover storage and conservation storage
- Integrated operations with other water suppliers

If your district already has a plan, it is important to review and update the plan to reflect changes in population, customer type, forecasting technology, and potential alternative water supplies. Some questions to consider when establishing, developing, or updating a water shortage contingency plan include:

- Does your district have a water shortage contingency plan and is it up to date in terms of operating procedures, water allocation schemes, emergency supplies and forecasting methods?
- Has a water shortage contingency plan ever been implemented due to shortage conditions and if so, how well did the plan work?
- Are water users in the district aware of existing shortage contingency policies and water allocation procedures?

Wastewater Reclamation Program

Water reclamation is often an effective way to increase district efficiency. In addition to reducing the required potable supply, reclamation can provide water quality benefits to receiving waters.

It is often most efficient to treat reclaimed water at several “satellite” locations to reduce distribution system costs and increase efficiency. Reclaimed water that is produced at a central treatment location may be unavailable to potential customers due to distributed system cost.

To evaluate the relevance of these management measures, you should consider the following questions for your district:

- Does your district project the need for increased water supplies?
- Is the wastewater from your district service area of adequate quality?
- Is their landscape, industrial or interior non-potable uses in the district that could be met with reclaimed water?
- Would the reuse of wastewater within your district provide environmental benefits?
- Would a reclamation system provide additional supply reliability and flexibility to your district during water shortages?

Plumbing Regulations

One section of the Federal Energy Policy Act of 1993 set national water efficiency standards for plumbing products. These standards apply to the sale and installation of toilets, showerheads, and faucets. Many states have also adopted efficiency standards for plumbing fixtures.

To ensure that new and remodeled homes, and replaced existing fixtures, use only the new efficient models, districts need on on-going program to:

- communicate with and provide information to local building departments and inspectors
- contact major developers and plumbing supply outlets to ensure that only efficient fixtures are sold and installed

- ensure that district water auditors verify that new and replaced fixtures meet the federal, state, and local requirements.

Continuing support of the existing standards and new proposals will also be important to the future efficiency of the district. New water efficiency standards are being proposed for clothes washers, dish washers, and water softeners. The district can initiate and support local standards and/or state standards for car washes, laundromats, and other commercial / industrial / institutional water using fixtures and devices.

Fixture Replacement Program

Interior water uses are highly dependent upon the efficiency of toilets, showerheads, and faucets in each building. Plumbing fixtures manufactured before the early 1990's often uses two to three times as much water to provide the same service as modern fixtures. Fixtures prior to the Energy Policy Act (EPAct) of 1992 was 3.5 gals/flush or higher. Replacing these old high-water-using fixtures is usually one of the most cost-effective conservation programs a district can implement.

The district should:

- identify pre-1994 residences and commercial, institutional and industrial buildings
- deliver retrofit kits to pre-1994 buildings that have not yet installed efficient fixtures
- provide the kits containing showerheads, faucet aerators, leak detection tablets and devices to reduce toilet flush volume for each fixture at the building
- offer to install the devices and follow up at least three times
- offer incentives so that a minimum of ten percent of identified customers install the kits annually.
- retrofit low consumption toilets and/or high efficiency showerheads in all existing buildings

Conjunctive Use

Where appropriate, increase conjunctive use of surface and groundwater within the district, and work with appropriate entities to develop a groundwater management plan.

Conjunctive use is the coordinated operation of surface water and groundwater resources to meet water requirements. Conjunctive use may provide an opportunity to increase the firm water supply to a district or to use the existing supply more efficiently. In the former case, groundwater is used during periods when surface water supplies are less than demands. Such a situation may or may not result in a net depletion of the groundwater resources, depending on how the aquifer is recharged.

When conjunctive use is used to better regulate supplies, surface water available in excess of demands is intentionally used to recharge the underlying aquifer. This is followed by aquifer pumping when the surface supply is less than demands. In this case, the underlying aquifer becomes an underground reservoir. Recharge systems include injection wells, spreading basins, sump areas, and recharge pits constructed in areas with high permeability. The feasibility of a groundwater pumping system will be a function of the local hydrogeology and specific water needs. A conjunctive use system may have automated controls to coordinate the groundwater component with flow conditions in the surface system and with water demands.

There are potential consequences associated with excess groundwater pumping that should be considered by the district. Groundwater mining, pumping in excess of recharge rates, results in higher pumping costs, reduced water availability and aquifer depletion. Pumping may also affect nearby surface water rights if the surface supplies are hydrologically connected to the groundwater. Groundwater pumping may affect the yields of other groundwater wells and salt-water intrusion may be a consequence in coastal areas. In cases of long-term groundwater mining land subsidence can become a serious problem.

Questions to help you evaluate this measure include:

- Is the groundwater quality adequate for direct use or is blending possible?
- What is the minimum quality of recharge water that could be utilized without degrading the native groundwater quality beyond use?
- What is the amount of groundwater storage capacity currently available?
- How much additional storage could be available by extracting groundwater for use?
- Are there existing and potential recharge sites (spreading basins, injection wells, etc.) with high percolation rates?
- Does hydraulic continuity exist between the possible recharge and extraction areas?
- Are there possible sources of recharge water with the quantities, qualities and time of availability necessary?

Image: Hoover Dam is located on the Colorado River on the borders of Arizona and Nevada and forms Lake Mead behind it. (Reclamation/Alex Stephens)

Section Four - Assembling a Water Management Plan

This section of the Guidebook will help you prepare a document describing your water management action plan. It will:

- Describe the reasons for preparing a plan document
- Suggest how the document should be organized

WHY DO YOU NEED A WATER MANAGEMENT PLAN DOCUMENT?

There are many good reasons to prepare a document or report describing your water management plan, but the basic one is so you can explain your plan to others. Some of the other people who will need to understand your water management plan include:

- Members of the district Board of Directors who will approve the plan
- Members of the district staff who will implement the plan
- District customers who will want to know how the plan will affect them
- Agencies and lenders from whom the district might be seeking financing assistance
- Other local and regional water organizations with whom the district wishes to establish more cooperation
- Agencies from whom the district seeks permits or approvals
- Agencies and groups who may be unaware of the district's efforts to improve water management

For some of these people the plan will be mainly an information document. But for others, the plan may be a "sales pitch" used to convince them of the wisdom of cooperating with the district, lending money to the district, etc. Especially in this latter case, the plan document will need to be prepared in a professional way, well-organized and complete, with easy-to-read text, tables, and figures.

Beyond being a description of what you want to do, putting your plan in writing means that you are making a commitment to do something. It puts the district on record as moving to solve problems in a progressive way. This can be very important in dealing with potential future threats to district water rights and supplies from competing uses.

You will probably also find that the process of writing your plan down will help you see where it is deficient and could be improved.

SUGGESTED OUTLINE FOR THE PLAN DOCUMENT

Your water management plan document can be thought of as a compilation and synthesis of the information developed in Phases 1 through 5 of the planning process. A suggested outline for the plan document is provided below. Each outline item might be constructed as a separate chapter or section in your management plan.

Management Plan Document - Suggested Outline

1. Description of District
2. Inventory of Water Resources and Water Budget
3. Problems, Opportunities and Goals
4. Existing Water Management Measures and Programs
5. Evaluation of Fundamental Water Management Measures
6. Evaluation of Additional Water Management Measures
7. Selected Measures and Projected Results
8. Environmental Review
9. Implementation Schedule and Budget

The objective of **Item One** of the plan document is to provide sufficient background information on district organization, facilities, and operations so that your reader can understand the opportunities and constraints that exist for water management improvements in the district. This is especially important if your plan document is going to be read by people who are not familiar with the district, such as bankers or lending agencies.

It may not be necessary to write a lot of prose for this part of the document. Some of the information can be conveniently displayed in tabular form. You may also be able to incorporate existing materials, such as policies and organizational charts. Often, a simple paragraph will suffice.

A district map is also a good idea for an easy-to-read management plan document. The map should show diversion points, treatment plants, mains, measurement locations, pump stations, wastewater treatment plants and any identified problem areas.

In addition to those items, a comprehensive district description would include the following:

- District Enabling Legislation (formation authority) and Governance
- Voting and taxing authorities
- Organizational structure and personnel
- Historical population and trends

Item Two is documentation of the water resources inventory that you assembled in Phase 1 of the planning process. Much of this information can be displayed in tables or graphs. On the district map, you should also indicate the location of district wells, recharge basins and other facilities.

Water budget tables and pre-formatted spreadsheet were provided with the Plan Assistance materials. You may find that graphical display methods help you visualize the various components of district inflows and outflows.

Item Three should be a complete description of the water management problems you identified and the district's water management goals.

Item Four is a description of current water management practices and discussion of past management efforts.

Item Five is a discussion of the evaluation you have made of the fundamental water management measures.

Item Six is a discussion of the evaluation you have made of the additional water management measures. No doubt you will have determined that some of the measures in the Criteria (plus others not listed) are not relevant to your situation. For these measures provide a brief explanation of how you came to this conclusion. For those measures that you did evaluate in more detail, include a summary of the evaluation process and tabulations of any quantitative data analyses you conducted.

Item Seven is a discussion of the environmental issues that may arise from the water management measures under consideration. This section of your document should contribute to and supplement the technical and financial evaluations described in Item Six.

Item Eight should be a description of the elements that make up the water management plan you adopted. The programs and measures to be implemented should be described in detail, as should the expected effects and implications of those programs and measures. You should describe as clearly as possible how those measures will help you achieve your goals.

Finally, for **Item Nine** you should present a detailed schedule for implementing the plan and a description of the budget and financing that will be required. The schedule and budget should address both money and labor required to implement the plan.

In most cases, it should be possible to incorporate into the plan document the tables and descriptions developed earlier in the planning process. It is also possible that some parts of the plan document can be created from available district documents and data summaries. We encourage you to use such resources to reduce the amount of effort required to complete your plan.

GLOSSARY

Acre-foot: A volume of water that would cover one acre to a depth of one foot, or 325,851 gallons of water.

Application efficiency: The ratio of the average depth of irrigation water infiltrated and stored in the root zone to the average depth of irrigation water applied, expressed as a percent.

Applied water: Water delivered to a user. Also called delivered water. Applied water may be used for either inside uses or outside watering. It does not include precipitation or distribution losses. It may apply to metered or unmetered deliveries.

Aquifer: Underground water-bearing geologic formation or structure.

Arable: Having soil or topographic features suitable for cultivation.

Artificial drains: Man-made or constructed drains.

Available capacity: The amount of water held in the soil that is available to the plants.

Check dam: Small barrier constructed in a gully or other small watercourse to decrease flow velocity, minimize channel scour, and promote deposition of sediment.

Conduit: Any open or closed channel intended for the conveyance of water.

Conjunctive use: The coordinated use of surface water and groundwater resources.

Conservation: Increasing the efficiency of energy use, water use, production, or distribution.

Consumptive use (evapotranspiration): Combined amounts of water needed for transpiration by vegetation and for evaporation from adjacent soil, snow, or intercepted precipitation. Also called: Crop requirement, crop irrigation requirement, consumptive use requirement.

Continuous-flow irrigation: System of irrigation water delivery where each irrigator receives his allotted quantity of water at a continuous rate.

Contour ditch: Irrigation ditch laid out approximately on the contour.

Contour farming: System of farming used for erosion control and moisture conservation whereby field operations are performed approximately on the contour.

Contour flooding: Method of irrigation by flooding from contour ditches.

Contour furrows: Furrows plowed approximately on the contour on pasture or rangeland to prevent soil loss and increase infiltration. Also furrows laid out on the contour for irrigation purposes.

Control structure: Water regulating structure, usually for open conduits.

Conveyance loss: Loss of water from a channel or pipe during conveyance, including losses due to seepage, leakage, evaporation, and transpiration by plants growing in or near the channel.

Conveyance system efficiency: The ratio of the volume of water delivered to users in proportion to the volume of water introduced into the conveyance system.

Critical habitat: Areas that contain essential habitat features important for the conservation of a species. Designated critical habitat may require special management or protection under Section 7 of the Endangered Species Act.

Crop irrigation requirement: Quantity of water, exclusive of effective precipitation, that is needed for crop production.

Crop root zone: The soil depth from which a mature crop extracts most of the water needed for evapotranspiration. The crop root zone is equal to effective rooting depth and is expressed as a depth in inches or feet. This soil depth may be considered as the rooting depth of a subsequent crop, when accounting for soil moisture storage in efficiency calculations.

Cropping pattern: The acreage distribution of different crops in any one year in a given farm area such as a county, water agency, or farm. Thus, a change in a cropping pattern from one year to the next can occur by changing the relative acreage of existing crops, and/or by introducing new crops, and/or by cropping existing crops.

Crop water requirement: Crop consumptive use plus the water required to provide the leaching requirements. Cubic feet per second (ft3 /s): A rate of streamflow; the volume, in cubic feet, of water passing a reference point in 1 second.

Deep percolation: The movement of water by gravity downward through the soil profile beyond the root zone; this water is not used by plants.

Demand scheduling: Method of irrigation scheduling whereby water is delivered to users as needed and which may vary in flow rate, frequency and duration. Considered a flexible form of scheduling.

Distribution efficiency: Measure of the uniformity of irrigation water distribution over a field.

Distribution loss: See conveyance loss.

Distribution system: System of ditches, or conduits and their appurtenances, which conveys irrigation water from the main canal to the farm units.

District: An entity that has a contract with the Reclamation for the delivery of irrigation water. Such entities include, but are not limited to: canal companies; conservancy districts, ditch companies, irrigation and drainage districts, irrigation companies, irrigation districts, reclamation districts, service districts, storage districts, water districts, and water users associations.

Ditch: Constructed open channel for conducting water. See canal, drain.

Diversion (water): Removal of water from its natural channels for human use.

Diversion (structure): Channel constructed across the slope for the purpose of intercepting surface runoff; changing the accustomed course of all or part of a stream.

Drainage: Process of removing surface or subsurface water from a soil or area.

Drainage system: Collection of surface and/or subsurface drains, together with structures and pumps, used to remove surface or groundwater.

Drip (trickle) irrigation: An irrigation method in which water is delivered to or near each plant in small-diameter plastic tubing. The water is then discharged at a rate less than the soil infiltration capacity through pores, perforations, or small emitters on the tubing. The tubing may be laid on the soil surface, be shallowly buried, or be supported above the surface (as on grape trellises).

Drought: Climatic condition in which there is insufficient soil moisture available for normal vegetative growth.

Erosion: A gradual wearing away of soil or rock by running water, waves, or wind.

Evaporation: Water vapor losses from water surfaces, sprinkler irrigation, and other related factors.

Evapotranspiration: The quantity of water transpired by plants or evaporated from adjacent soil surfaces in a specific time period. Usually expressed in depth of water per unit area.

Fallow: Land plowed and tilled and left unplanted.

Farm consumptive use: Water consumptively used by an entire farm, excluding domestic use. See irrigation requirement, consumptive use, evapotranspiration.

Farm distribution system: Ditches, pipelines and appurtenant structures which constitute the means of conveying irrigation water from a farm turnout to the fields to be irrigated.

Farm loss (water): Water delivered to a farm which is not made available to the crop to be irrigated.

Field capacity: Depth of water retained in the soil after ample irrigation or heavy rain when the rate of downward movement has substantially decreased, usually one to three days after irrigation or rain, expressed as a depth of water in inches or feet. Also called field moisture capacity.

Fixed amount-frequency scheduling: Method of irrigation scheduling that involves water delivery at a fixed rate or a fixed volume and at constant intervals. Examples include rotation and continuous flow methods. Considered a rigid form of scheduling.

Flood control pool: Reservoir volume reserved for flood runoff and then evacuated as soon as possible to keep that volume in readiness for the next flood.

Flood irrigation: Method of irrigating where water is applied from field ditches onto land which has no guide preparation such as furrows, borders or corrugations.

Frequency demand scheduling: Method of irrigation scheduling similar to demand scheduling, but typically involves a fixed duration of the delivery, such as 24 hours. This method is considered flexible, although somewhat less so than demand scheduling from the water users perspective.

Gate (irrigation): Structure or device for controlling the rate of flow into or from a canal or ditch.

Gated pipe: Portable pipe with small gates installed along one side for distributing irrigation water to corrugations or furrows.

Gauge: Device for registering water level, discharge, velocity, pressure, etc.

Gauge height: Elevation of water surface measured by a gauge.

Gauging station: Specific location on a stream where systematic observations of hydrologic data are obtained through mechanical or electrical means.

Gravity irrigation: Irrigation method that applies irrigation water to fields by letting it flow from a higher level supply canal through ditches or furrows to fields at a lower level.

Groundwater: (1) Water that flows or seeps downward and saturates soil or rock, supplying springs and wells. The upper level of the saturated zone is called the water table. (2) Water stored underground in rock crevices and in the pores of geologic materials that make up the earth's crust. That part of the subsurface water which is in the zone of saturation; phreatic water.

Groundwater mining (overdraft): Pumping of groundwater for irrigation or other uses, at rates faster than the rate at which the groundwater is being recharged.

Groundwater recharge: The flow to groundwater storage from precipitation, infiltration from streams, and other sources of water.

Groundwater table: The upper boundary of groundwater where water pressure is equal to atmospheric pressure, i.e., water level in a bore hole after equilibrium when groundwater can freely enter the hole from the sides and bottom.

Growing season: The period, often the frost-free period, during which the climate is such that crops can be produced.

Hydraulic efficiency: Efficiency of a pump or turbine to impart energy to or extract energy from water. The ability of hydraulic structure or element to conduct water with minimum energy loss.

Hydrology: Science dealing with the properties, distribution and flow of water on or in the earth.

Infiltration rate: The rate of water entry into the soil expressed as a depth of water per unit of time in inches per hour or feet per day. The infiltration rate changes with time during irrigation.

Instream flows: Water flows for uses within a defined stream channel e.g., flows intended for fish and wildlife.

Irrigated acreage: Irrigable acreage actually irrigated in any one year. It includes irrigated cropland harvested, irrigated pasture, cropland planted but not harvested, and the acreage in irrigation rotation used for soil building crops.

Irrigation check: Small dike or dam used in the furrow alongside an irrigation border to make the water spread evenly across the border.

Irrigation efficiency: The ratio of the average depth of irrigation water that is beneficially used to the average depth of irrigation water applied, expressed as a percent. Beneficial uses include satisfying the soil water deficit and any leaching requirement to remove salts from the root zone.

Irrigation frequency: Time interval between irrigations.

Irrigation requirement: Quantity of water, exclusive of effective precipitation, that is required for crop production.

Land classification: Reclamation's systematic placing of lands into classes based on their suitability for sustained irrigated farming. Land classes are defined by productivity, with class 1 being the most productive. For other classes, the equivalent acreage to class 1 for the same productivity is defined (class 1 equivalency).

Land leveling: Process of shaping the land surface for better movement of water and machinery over the land. Also called land forming, land shaping, or land grading.

Land retirement: Permanent removal of land from agricultural production.

Land-use planning: Development of plans for the use of land that will, over a long period, best serve the general public.

Leaching: Removal of soluble material from soil or other permeable material by the passage of water through it.

Leaching requirement: Quantity of irrigation water required for transporting salts through the soil profile to maintain a favorable salt balance in the root zone for plant development.

Lining: Protective covering over the perimeter of a conduit, reservoir, or channel to prevent seepage losses, to withstand pressure, or to resist erosion.

Lysimeter: An isolated block of soil, usually undisturbed and in situ, for measuring the quantity, quality, or rate of water movement through or from the soil.

Neutron probe: An instrument used to estimate soil moisture. Relates the rate of attenuation in pulsed neutron emissions to soil water content.

Non-consumptive water uses: Water uses that do not substantially deplete water supplies, including swimming, boating, water-skiing, fishing, maintaining stream related fish and wildlife habitat, and generating hydropower.

On-farm: Activities (especially growing crops and applying irrigation water) that occur within the legal boundaries of private property.

On-farm irrigation efficiency: The ratio of the volume of water used for consumptive use and leaching requirements in cropped areas to the volume of water delivered to a farm (applied water).

Operational losses: Losses of water resulting from evaporation, seepage, and spills.

Operational waste: Water that is lost or otherwise discarded from an irrigation system after having been diverted into it as part of normal operations.

Pan evaporation: Evaporative water losses from a standardized pan. Pan evaporation is sometimes used to estimate crop evapotranspiration and assist in irrigation scheduling.

Parshall flume: A calibrated device, based on the principle of critical flow, used to measure the flow of water in open conduits. Formerly termed the Improved Venturi Flume.

Percolation: Downward movement of water through the soil profile or other porous media.

Percolation rate: (1) The rate at which water moves through porous media, such as soil; and (2) intake rate used for designing wastewater absorption systems.

Perforated pipe (sprinkler): Pipe designed to discharge water through small, multiple, closely spaced orifices or nozzles, placed in a segment of its circumference for irrigation purposes.

Permanent wilting point: Soil water content below which plants cannot readily obtain water and permanently wilt. Sometimes called "permanent wilting percentage."

Permeable: Having pores or openings that permit liquids or gasses to pass through.

Permeability:

1. **Qualitative:** The ease with which gases, liquids, or plant roots penetrate or pass through a layer of soil or porous media.
2. **Quantitative:** The specific soil property designating the rate at which gases and liquids can flow through the soil or porous media.

Permeameter: Device for containing the soil sample and subjecting it to fluid flow in order to measure permeability or hydraulic conductivity.

Phreatophyte: Water plant.

Potential evapotranspiration: Rate at which water, if available, would be removed from soil and plant surfaces. Pump-back system: A return flow system in which tailwater is pumped back to the head of an irrigation ditch for reuse.

Reservoir: Body of water, such as a natural or constructed lake, in which water is collected and stored for use.

Return flow: That portion of the water diverted from a stream which finds its way back to the stream channel, either as surface or underground flow.

Return-flow system: A system of pipelines or ditches to collect and convey surface or subsurface runoff from an irrigated field for reuse. Sometimes called a "reuse system."

Reuse system: See return-flow system.

Riparian: Of, on, or pertaining to the bank of a river, pond, or lake.

Root zone: That depth of soil which plant roots readily penetrate and in which the predominant root activity occurs.

Runoff: The portion of precipitation, snow melt, or irrigation that flows over the soil, eventually making its way to surface water supplies.

Saline: The condition of containing dissolved or soluble salts. Saline soils are those whose productivity is impaired by high soluble salt content. Saline water is that which would impair production if used to irrigate sensitive crops without adequate leaching to prevent soil salinization.

Second-foot: See cubic feet per second.

Sediment load: Amount of sediment carried by running water.

Sedimentation: Deposition of waterborne sediments due to a decrease in velocity and corresponding reduction in the size and amount of sediment which can be carried.

Seepage: The movement of water into and through the soil from unlined canals, ditches, and water storage facilities.

Seepage loss: Water loss by capillary action and slow percolation.

Siphon tube: Relatively short, lightweight, curved tube used to convey water over ditch banks to irrigate furrows or borders.

Soil classification: Systematic arrangement of soils into classes of one or more categories or levels to meet a specific objective. Broad groupings are made on the basis of general characteristics, and subdivisions are made on the basis of more detailed differences in specific properties.

Soil conservation: Protection of soil against physical loss by erosion and chemical deterioration by the application of management and land-use methods that safeguard the soil against all natural and human-induced factors.

Soil moisture: Water stored in soils.

Sprinkler irrigation: A method of irrigation in which the water is sprayed, or sprinkled, through the air to the ground surface.

Sprinkler systems:

1. **Boom type:** An elevated, cantilevered sprinkler(s) mounted on a central stand. The sprinkler boom rotates about a central pivot.
2. **Farm system:** System which will properly distribute the required amount of water to an entire farm.
3. **Field system:** That part of a farm system which covers one field or area for which it is designed.
4. **Hand move:** Method of moving the sprinkler system by uncoupling and picking up the pipes manually, requiring no special tools. This includes systems in which lateral pipes are loaded and unloaded manually from racks or trailers used to move the pipes from one lateral setting to another.
5. **Mechanized:** System which is moved either by engine power, tractor power, water power, or hand power on wheels or skids. Generally considered as any type of system that can be moved without carrying manually.
6. **Permanent:** System consisting of permanent underground piping with either permanent risers for sprinklers, or quick coupling valves, in such a manner that sprinklers may be attached.
7. **Self-propelled system:** Portable system which moves continuously when in operation. May rotate about a pivot in the center of field, or move laterally across the field in a predetermined direction.
8. **Semi-portable:** Systems designed with permanent pumping units and mains, but with portable sprinkler laterals.

9. Side-roll system: System, mounted on wheels, usually employing the lateral pipe line as an axle, where the lateral is moved at right angles to the mainline by rotating the pipeline either by hand or by engine power.
10. Solid set: System, either permanent or portable, which covers the complete field with pipes and sprinklers in such a manner that all the field can be irrigated without moving any of the system.
11. Towed system: System where lateral lines are mounted on wheels, casters, sleds, or skids, and are pulled or towed in the field to be irrigated in a direction approximately parallel to the lateral.

Subirrigation: Applying irrigation water below the ground surface either by raising the water table within or near the root zone, or by use of a buried perforated or porous pipe system which discharge directly into the root zone.

Surface soil: Upper part of the soil ordinarily moved in tillage, or its equivalent in uncultivated soils, about 10 to 20 cm in thickness.

Surface water: An open body of water such as a river, stream, or lake.

Surge irrigation: A surface irrigation technique wherein flow is applied to furrows (or less commonly, borders) intermittently during a single irrigation set.

Tailwater: Applied irrigation water that runs off the lower end of a field. Tailwater is measured as the average depth of runoff water, expressed in inches or feet.

Tensiometer: Instrument, consisting of a porous cup filled with water and connected to a manometer or vacuum gauge, used for measuring the soil-water matric potential.

Varied amount - fixed frequency scheduling: Method of irrigation scheduling that involves water deliveries that vary in flow rate or amount over time, but that are made at constant intervals. An example is the rotation method when a minimum flow is delivered almost continuously. Considered a rigid term of scheduling.

Water budget: An analytical tool whereby the sum of the system inflows equals the sum of the system outflows.

Water conveyance efficiency: Ratio of the volume of irrigation water delivered by a distribution system to the water introduced into the system.

Water delivery system: Reservoirs, canals, ditches, pumps, and other facilities to move water.

Water demand: Water requirements for a particular purpose, as for irrigation, power, municipal supply, plant transpiration or storage.

Water holding capacity: Amount of soil water available to plants. See available soil water.

Water transfers: Selling or exchanging water or water rights among individuals or agencies.

West-wide: The 17 Western states in which Reclamation projects are located; namely, Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

Wetlands: Lands including swamps, marshes, bogs, and similar areas such as wet meadows, river overflows, mud flats, and natural ponds. An area characterized by periodic inundation or saturation, hydric soils, and vegetation adapted for life in saturated soil conditions.

Wetted perimeter: Length of the wetted contact between a conveyed liquid and the open channel or closed conduit conveying it, measured in a plane at right angles to the direction of flow.

Wilting point: The soil water content below which plants growing in that soil will remain wilted even when transpiration is nearly eliminated.

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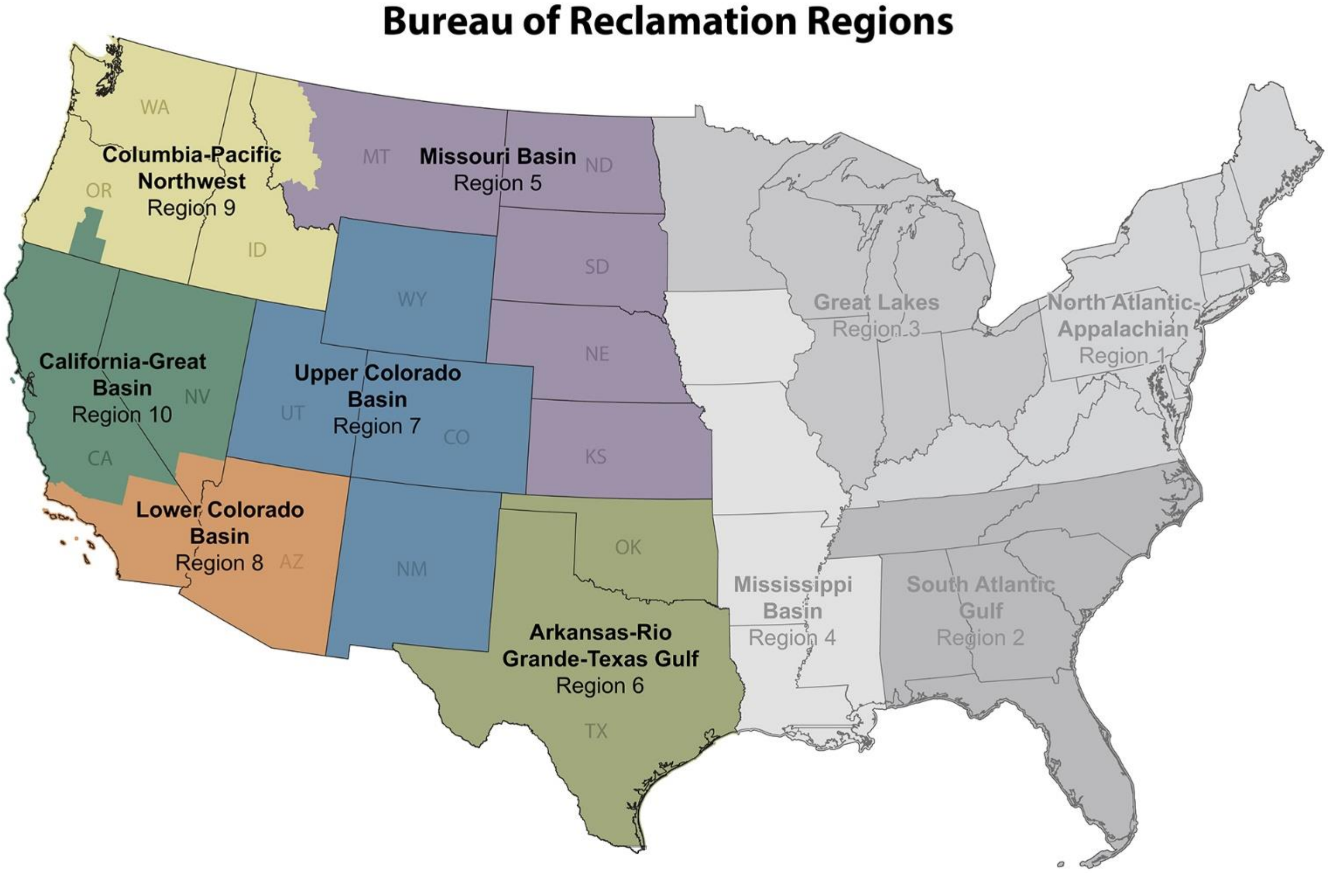
Bureau of Reclamation Regions



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