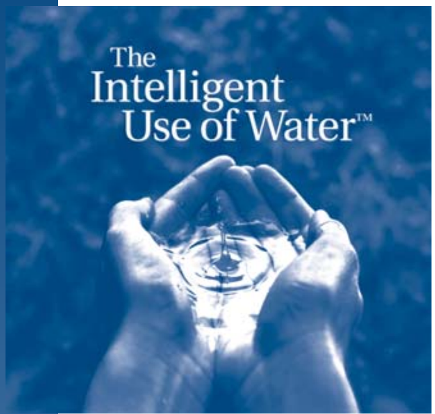

Irrigation for a Growing World

RAIN BIRD®

Water is one of Earth's most precious resources. However, in most cases it is being consumed as if a limitless supply existed.

At Rain Bird, we feel it is our responsibility to increase awareness of the growing threats posed by global water scarcity. Our white papers, entitled *Irrigation for a Growing World*, are just that, an effort to educate readers on the importance of using water efficiently and ways to incorporate these practices into their daily lives.

Since 1933, our research, marketing and manufacturing resources have been committed to developing products and technologies that use water efficiently – we call it *The Intelligent Use of Water*™. It is a commitment that extends to education, training and services for our industry and our communities.

The need to conserve water has never been greater. We want to do even more, and with your help, we can.

Anthony LaFetra
President

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Chapter One **The World's Water Crisis**

Most of the world's water problems arise from a basic conflict: the global water supply is fixed, while the world population and its water consumption is growing. Despite many earlier alarms, this issue is finally gaining the attention of the general public.

There are many options available to address water scarcity. This paper will focus on conservation through the use of water-efficient irrigation as one of the most practical options. From watering in the earlier morning hours to the use of advanced computerized controls, sensors and climate adjustment technologies, water-efficient irrigation methods have the potential to significantly decrease the amount of water used in agriculture and landscape applications while maintaining healthy landscapes and abundant crops.

In *Irrigation for a Growing World*, we will cover:

- The world's water crisis
- Options to address water scarcity
- A detailed discussion on conservation through efficient irrigation, and
- Encouraging water conservation through government incentives, education and public awareness programs

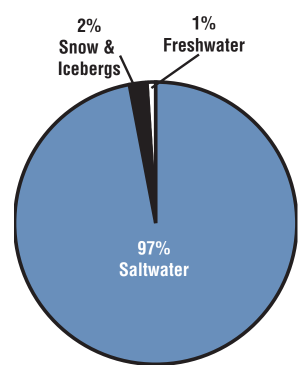
THE BASIC PROBLEMS

Water Availability

To the casual observer, water seems to be the most abundant resource available on Earth. The reality is that 97% of all water is saltwater, 2% is held in snow and icebergs and only 1% is freshwater (the only portion currently useable for human consumption).[1] (Chart 1A)

Earth's freshwater is continually being recycled as it evaporates and returns to the Earth in the form of rain, snow and ice. Most of this "fallen" water evaporates immediately, pours into inaccessible areas, or flows into the oceans before it can be retrieved. Only about 10% of total rainfall on earth is retrievable for use by humans. And of that percentage, only 40% (or 4% of total rainfall) is ultimately used.

Chart 1A – The World's Water



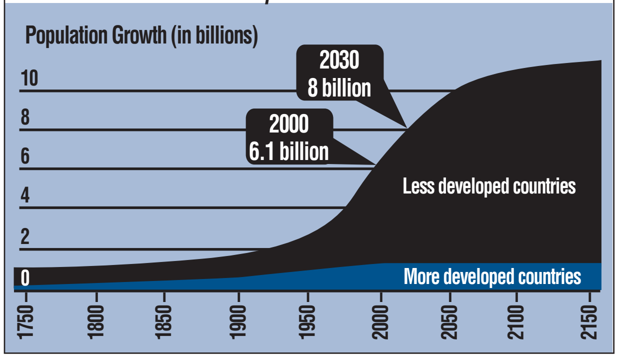
> The amount of water that is retrievable (7.3 billion to 11.3 billion acre-feet) would cover the surface of the earth with one inch of water.[2]

Population Growth

An exponentially growing number of people are tapping into the Earth's finite water supply. Earth's pre-historic population, some 5,500 years ago, is estimated to have been less than 10 million.[3] By 2000, it grew to 6.1 billion[4], and by 2030, the world's population is estimated to reach 8 billion.[5] (Chart 1B)

Presently, half a billion people (8% of the world's population) are experiencing moderate to severe water shortages. The uneven distribution of rainfall to the planet coupled with higher population growth rates in some of the drier areas such as China, India, Nigeria and Pakistan further accentuate the issue. For example, China's 1.3 billion inhabitants (22% of the world's population) receive a meager 7% of the world's freshwater supply.[7]

Chart 1B – The World's Population [6]



Increased Usage

Global water scarcity is not limited to developing countries. Urbanization and manufacturing also have a large impact on water usage. In the United States, 40% of available water is used in industrial applications. Historically, technology and lifestyle improvements have led to the doubling of water consumption every 20 years.[8] The chart (Chart 1C) demonstrates the increased amount of water needed to produce a ton of manufactured product versus the amount needed to grow a ton of agricultural product such as cane sugar.

During the past century the increase in per capita water usage has outpaced the growth of the population. Since 1900 the U.S. population has doubled, but per capita water use has increased eightfold.[10] Most urban users far exceed the estimated 20.5 gallons per day minimum that each person needs to maintain life, hygiene and food production. On average, residents in the U.S. use 101 gallons per day. (Chart 1D)

Chart 1C – Water Used to Produce Food & Materials [9]

Product (1 ton)	*Water (gallons/liters)*
Cement	1,360 g/5,148 l
Cane Sugar	28,100/106,370
Beet sugar	33,100/125,297
Plastic	48,000/181,700
Paper	60,000/227,125
Steel	62,200/235,453
Synthetic Rubber	110,000/416,395
Wool/Cotton	202,000/764,653

The Draining of Our Water Sources

Increases in water consumption are draining underground aquifers throughout the world faster than they can be replenished. Many industrialized countries, such as the United States, have applied innovation and technology to retrieve more usable water. Prime examples of measures taken are the dam and water channeling projects during the 1950s. Through these massive undertakings, a great deal of usable water was captured before flowing out to sea. Worldwide, the number of dams is now at 45,000. In the United States 98% of all major rivers are currently dammed.[11]

As a result, many freshwater lakes and seas have been turned into toxic salt flats. Some of the earth's mightiest and most well known rivers – Egypt's Nile, India's Ganges, China's Yellow and the Colorado in the United States – nearly run dry before their waters reach the ocean. The following chart outlines the depletion of some of the world's largest water bodies. (Chart 1E)

Chart 1D – Per Capita Water Usage/Day [12]

Location	*Water (gallons/liters)*
Las Vegas, NV, USA	307 g/1162 l
United States - Average	101/382
Bangkok, Thailand	55/208
United Kingdom – All Urban Users	40/151
Cairo, Egypt	35/132
Estimated Minimum Needed	20.5/77

OUTLOOK FOR THE FUTURE

It is estimated that 69% of all water withdrawn on a global basis is used for agriculture, 21% for industry and 10% for municipal use. If water is used more efficiently, specifically in agricultural applications, it can have a significant impact on the available supply.[13] According to Sandra Postel, director of the Global Water Policy Project in Amherst, Massachusetts, the

Chart 1E – Depletion of Our World's Water Bodies [14]

Body	*Location*	*Problems*
Owens Lake	California, U.S.	Drained to serve Los Angeles 150 miles south, this lake is now a dry salt bed of toxic particulate matter that pollutes regional air.
Colorado River	Seven U.S. States & Mexico	Flow reduced to a trickle at the end, with near disappearance of the Colorado River delta in northern Mexico.
Ogallala Aquifer	South Dakota to Texas Panhandle - U.S.	Original 4 trillion tons of water is 50% depleted. Water levels have dropped 3 feet yearly since 1991, to 100 feet in some places.
Gaza Aquifer	Middle East	Up to 60-foot drop in water tables in Saudi Arabia, Kuwait, Qatar, Bahrain and the United Arab Emirates.
Aral Sea	Uzbekistan	Drop of more than 60% in lake volume, tripling of lake salinity, disappearance of 24 native fish species, surrounding agricultural lands abandoned due to soil salinity, up to 40 million tons of toxic metals and salts pollute the air.

use of water-efficient irrigation technologies could improve water delivery efficiency up to 95%, increase agricultural productivity, reduce water needs by 10% worldwide and double the amount of water available for household use.[15] In the upcoming chapters water conservation through the use of efficient irrigation will be covered in greater detail as a very practical option to address water scarcity.

Global and Industry Focus

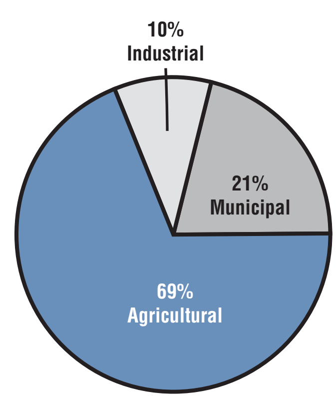
An increasing number of international and regional summits on the issue of the decreasing water supply are emerging. Examples include:

- Earth Summit, Rio de Janeiro (1999)
- Second World Water Forum, The Hague, Netherlands (2000)
- International Freshwater Conference, Germany
- Third World Water Forum, Japan (2003)

Water providers attending the American Water Works Association's (AWWA) Water Sources Conference in Las Vegas (2002) initiated a dialog with the irrigation industry to address water conservation efforts. These discussions are continuing to take place.

In the summer of 2003 U.S. Secretary of the Interior Gale Norton initiated Water 2025, an effort to address water supply challenges in the future and provide a public forum to discuss the topic. The program was initiated with nine regional conferences held throughout the Western United States. As Secretary Norton said in announcing the U.S. conferences, "Crisis management is not an effective solution. We need to work together now [before a crisis erupts]."[17]

Chart 1F – Global Water Use [16]



These international and regional conferences have resulted in additional efforts by water distribution agencies, nonprofit organizations and industry constituents to work together in addressing and researching water-scarcity issues. While approaches and solutions may differ, the problem can only be solved by a united effort.

The common goal of all these partnerships is to make more efficient use of our water through developments in engineering, technology and water management. Preventive measures should be emphasized well before extended drought or other pressures push communities toward division and conflict.

Chapter Two **The Options**

As discussed in the previous chapter, the threat of global water scarcity is growing and requires immediate attention. Some of the options available to address this issue include:

1) Water Re-pricing
2) Water Re-use
3) Desalination
4) Water Transfers and Improvements to Water Delivery Systems
5) Alternative Plant Selection
6) Conservation through Efficient Irrigation

In the pages that follow, we will briefly explore the options mentioned above and will then focus on conservation, specifically through water-efficient irrigation.

Option 1 – WATER RE-PRICING

In many cases, water prices are government-subsidized and are set artificially low to promote development. Many farmers pay an annual flat fee for water per acre – with unlimited consumption. In addition, manufacturers, large commercial developments and golf courses frequently receive volume discounts. Critics of subsidized water pricing point out that low water prices often have a negative effect on conservation because they encourage wastefulness.[18] Below are examples that highlight the huge discrepancies between the price charged for water in comparison to its cost.

Chart 2A – Water-Price Subsidies – Examples [19]

Region	*Price*	*Actual Cost*
U.S.- Central Arizona	$2 per acre foot	$209 per acre foot
Tunisia	$62 per acre foot	$434 per acre foot
Taiwan	$9 - $87 per acre foot	$298 per acre foot

When water prices are adjusted to more accurately reflect production, distribution, collection and treatment costs, consumption typically declines. In Chile consumption declined 26% after water prices were raised.[20] In Bogor, Indonesia, household water consumption dropped 30% in one year after prices were increased to four times the rate of the prior decade.[21]

In general, price increases seem to have the most impact when the raises are significant. Water is still priced so low in many areas that slight increases tend not to capture the attention of users.

CASE STUDY

When the Broadview Water District in California's San Joaquin Valley replaced a flat fee ($16 per acre-foot) with tiered prices based on use (up to $40 per acre foot), farmers cut back. Growers reduced water consumption of cotton by 25%, tomatoes by 9%, cantaloupes by 10%, wheat by 29% and alfalfa seed by 31%. A follow-up study in 2001 indicated these water reductions have been maintained, while farmers' yields per acre remained close to – or increased slightly above – the yield per acre of farmers in surrounding Fresno County.[22]

Option 2 – WATER RE-USE

It is estimated that water recycling can reduce consumption of fresh water by up to 80%.[23] Lightly-treated, or even untreated recycled water, can be used instead of fresh water for power-plant cooling, sand and gravel processing, construction, watering of food crops not meant for raw consumption and irrigation of golf courses, landscaping and pastures.

The water savings reaped by those using recycled water can be tremendous, but capital costs have thus far prevented widespread implementation of such systems. It is estimated that water districts require at least $500,000 to build an effective water reclamation system.[24]

In the U.S., the Metropolitan Water District of Southern California has invested $95 million in water recycling projects from 1982 to 2002 and, by doing so, has recovered an estimated 201,000 acre-feet of water.[25]

In Phoenix, AZ, some water recycling programs and facilities have been able to recover and re-use 80% of wastewater. Likewise, investments in recycling facilities in Israel & Saudi Arabia have resulted in a reclamation of 40% of the region's total wastewater.[26]

Water recycling extends beyond the complex facilities mentioned above. Although costly, water recycling is also being adopted at the household level. Three commonly used methods within urban households are 1) the installation of a stand-alone water recycling system (also referred to as re-plumbing), 2) connection to an existing water-district reclamation systems and 3) water harvesting, the practice of intercepting storm water from a surface such as a roof, parking area or land surface and putting it to beneficial use. The initial costs for options #1 and #2 on a household level start at around $3,000 depending on the size of the project.[27]

CASE STUDY

The Kino Sports Complex in Tucson, AZ irrigated the 110-acre Spring Training Facility entirely with water harvested from a 20 square mile area. This enabled the sports complex to maintain its professional-level playing conditions for two baseball teams, the Arizona Diamondbacks and the Chicago White Sox. This was maintained even during a year in when rainfall was only 6", 4 inches below normal.[28]

Option 3 – DESALINATION

Since 97% of the Earth's water is contained in the oceans, it would seem that desalination technology would be the most logical solution to the world's impending water crisis. Improved desalination technology has reduced the per-gallon costs of desalinated water to become more comparable to the costs of fresh water.

One of the arguments against desalination is that the process itself could be very harmful to the environment. A by-product of the desalination process is a salty brine discharge that could be harmful to marine life in the area. Another downside is the cost. Start-up construction costs of more than $1 million per desalination plant have inhibited wider adoption of this method on a global basis.

Chart 2B – Water Prices – Desalinated vs. Freshwater [30]

	Freshwater (per acre ft)	Desalinated (per acre ft)
U.S. - Carlsbad, CA	$531	$794*
U.S. - Tampa, FL	$488 - $570	$811
Cyprus	$234 - $530	$900
Saudi Arabia	$321 - $1,974	$592 - $2,714
Canary Islands	$1,172**	$1,998
Malta	$1,172**	$1,630

*Estimate for proposed plant **Price for consumption exceeding 80,000 gallons.

Currently, 13,600 desalination plants worldwide produce a total of 6.8 billion gallons of water daily, less than 1% of all the world's water needs.[29]

Harvesting rainwater is one of the key water efficiency recommendations for The U.S. Green Building Council's LEED (Leadership in Energy & Environmental Design) program. Under the LEED program a building is evaluated on six categories including: sustainable site, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality and innovation and design process. Many federal, military, state & private buildings are using rainwater harvesting to satisfy or supplement potable water for irrigation.[31]

Option 4 – WATER TRANSFERS AND IMPROVEMENTS TO WATER DELIVERY SYSTEMS

Water and irrigation districts are both major players in two large-scaled water-saving options: 1) wholesale transfers of water from one area to another and 2) improvements in the water-delivery infrastructure.

Water Transfers

In the case of decreasing water supplies, water transfers and water banks typically shift water from agricultural applications to meet urban and ecological needs, frequently sparking anger and concern from various parties over the long-term consequences.

Chinese rice farmers near Beijing have been losing irrigation water since the 1980s to households and factories. Tirupur, a city in Southern India, buys water for urban and industrial uses from farmers within 20 to 25 miles around the city; as a result these farmers have since abandoned farming. Textile factories in the Indonesian Island of Java pull water directly out of agricultural irrigation canals or buy or rent rice fields from farmers to use the water for manufacturing.[32] Similarly, in California, a recent decision was made to transfer agricultural water from the farmers in the Imperial Valley, located in the southeast corner of California, to urban and residential users in Southern California metropolitan areas.

Thousands of such transfers are conducted yearly. Farmers often agree to transfers for financial benefit. This is especially true if the price received for water exceeds the profits from the crop sold, or if the water sold is excess supply that they do not need. As expected, farmers are generally not supportive of this practice when it affects their ability to continue farming.

Improving Water Delivery Systems

Poorly maintained water-delivery systems waste millions of gallons through leaks, ruptures, blockages, poor connections and theft. Water losses from poorly maintained water-delivery systems comprise approximately 24% of the available water used by municipalities in the United States, to approximately 60% in Jordan.[33] Therefore, many water districts are now focused on improving aging water delivery systems.

In California, two $200-million canal lining projects for the All-American and Coachella Canals will help preserve nearly 100,000 acre-feet of Colorado River water that is normally lost through leakage annually.[34]

In Idaho's Payette Valley, nine irrigation districts and canal companies within the Payette River Water District use 29 control structures and more than 30 remote water monitoring and measurement devices to combat leaks. These projects have dramatically improved the efficiency of their water distribution.[35]

In Florida, the Orlando water district has plugged 1,700 unused and deteriorating wells since 1983, saving 500 million gallons of water daily.[36]

In Central Oregon, water measurement equipment identified leaks in the Ochoco Irrigation District and reduced water losses by 75%.[37]

Option 5 – ALTERNATIVE PLANT SELECTION

Xeriscape™ landscaping, the practice of replacing water-intensive turfgrass and other exotic and non-native plants with low-water use grasses, wildflowers and plants that are native to the local environment is gaining popularity with many water districts in the United States. In some areas, the practice of Xeriscaping has resulted in a decrease in outdoor water usage of up to 60%.[38]

Better matching plants or crops to climates and regions has also been successful in agricultural applications. In Cape Verde, Western Africa, farmers who switched from high-water use sugar cane to crops more suitable to the climate (such as low water-consuming potatoes, onions, peppers and tomatoes) have saved water and increased yields.[39] The golf industry has also embraced this practice, particularly in the areas surrounding the course. By utilizing Xeriscape principles, golf courses have significantly reduced (and in some cases virtually eliminated) the water used for irrigation in those areas.

While Xeriscaping has benefits, it also has some downsides. End-users are restricted in their plant selection – a true commitment to Xeriscaping can require a complete and costly redo of the existing landscaping – the actual water savings on a typical residence can be minimal; and the proper practice of Xeriscaping is often misinterpreted. In many cases, homeowners think they have a native, drought tolerant landscape when they actually have native plants right next to non-native plants. In this situation the water conserving intentions of the homeowner cannot be realized since the watering schedule of the area will be dictated by the needs of the non-native or non-drought tolerant plants. Homeowners often do not know how much water is needed for their landscape and continue to irrigate as they have done before. Proper education of the end-user is critical for this option to provide full benefit.

CASE STUDY

Prairie Crossing, a housing subdivision outside Chicago, IL, grouped homes closer together on 200 acres, and created more open spaces for native grasses and wildflowers on 450 acres. The prairie-like landscaping proved to be more water-efficient, reducing runoff by 50% and filtering the water before it drained to a near-by lake, which is home to many frogs and other wildlife.[40]

CASE STUDY

The Southern Nevada Water Authority provided up to $900 in incentives for homeowners to replace water-intensive turfgrass with desert-adapted shrubs, trees, ornamental grasses and mulch. In cases where "Xeriscapes" were properly designed with the appropriate irrigation installed, homeowners saw their water consumption decrease and water costs fall to $1.64 per 100 square feet, versus $11.16 for predominantly turf-filled landscapes.[41]

Option 6 – CONSERVATION THROUGH WATER-EFFICIENT IRRIGATION

Many of the options detailed above require efforts by large governing bodies, are expensive and in many cases are still not fully developed for effective use today. Conservation through water-efficient irrigation is one option that can be implemented immediately and in varying stages. Agriculture draws approximately 69% of all usable, available water, yet only 11% to 16% of crops worldwide are grown using more efficient irrigation methods, such as sprinklers, micro or drip systems.

In the U.S., 25% to 33% of the estimated 101 gallons of water per capita consumed daily in residences is used to water plants, lawns and gardens.[42] In arid regions like the southwestern United States, that percentage can be as high as 70%.[43] As a result, water districts have begun to focus more intensely on outdoor water-conservation efforts. Many governments and worldwide water governing bodies have implemented conservation programs targeting residential, industrial and agricultural users. These programs combined with water-efficient irrigation can result in tremendous potential savings.

Some examples include:

- Albuquerque, N.M., U.S. – Free water audits and water-efficient landscaping classes were offered to homeowners in addition to rebates for the installation of low-flush toilets. Results: water consumption was reduced by 6 billion gallons annually.[44]
- Kamloops, B.C., Canada – The city's water conservation program offered workshops and demonstration gardens to highlight water-efficient landscaping and irrigation. Results: water consumption was reduced by 23%; enabling the city to save $500,000 by not having to expand the water delivery system.[45]
- Melbourne, Australia – An extensive program was initiated consisting of water-efficient landscaping incentives, water-use restrictions and water recycling. Results: an average annual savings of $800 per household was achieved.[46]

Cost can be a concern when considering a new irrigation method. However, there are many ways to incorporate the practice of water-efficient irrigation without significant cost. For example, an end-user could reschedule his or her irrigation system to run in the early morning instead of midday, and divide the run time into two or more shorter cycles. This simple change would decrease the amount of water lost to evaporation and runoff. Also, the installation and proper adjustment of a rain shut-off device would ensure that the irrigation system would not turn on during or immediately after rainfall. The 15-20% water savings realized from adding a rain shut-off device would quickly cover the small cost of adding it to the system.[47] On a larger agricultural site, it could cost hundreds of thousands of dollars to convert an entire agricultural crop from a flood system to drip. However, significantly lower operating costs in areas of water, labor and fertilizer would offset the installation cost. In return, healthier vegetation, increased agricultural production and improved landscaping are often the final result.

Summary

While there are a variety of water saving options available, water conservation through efficient irrigation is one of the most feasible options that can be implemented immediately and can result in significant water savings. A summary of the options is provided below. In the next chapter, the topic of water-efficient irrigation and the importance of proper system design, installation and maintenance will be discussed in detail.

Chart 2C – Options to Address Water Scarcity [48]			
	Description of Option	*Advantages*	*Disadvantages*
1	Water Re-Pricing	• Once pricing adjusted, impact could be immediate.	• Lengthy process as this option requires the buy-in of government and/or policy groups. • Limited savings potential. Once prices are adjusted and savings realized additional savings are limited.
2	Water Re-Use	• Creates a "new" sources of water. • Can be beneficial to plants in some cases.	• Expensive – costs to set up a household starts at $3000. • Option may not be available in all areas.
3	Desalination	• Creates "new" sources of water. • Supply is virtually unlimited.	• Expensive - the minimum start up costs are $1 million per plant. • Potential byproduct of desalination process could be harmful to the environment.
4	Water Transfers & Improvements to Water Infrastructure	• Satisfy an immediate need for water. • Improve efficiency of current water delivery systems.	• Lengthy process that involves many government and policy groups (i.e. Imperial Valley Water Transfer). • Water transfers ultimately reallocates water; does not save or find new sources. • Improvements to infrastructure can be costly.
5	Alternative Plant Selection	• Implementation can be inexpensive and achievable on a household level. • Need minimal amounts of water to sustain vitality. • Require less use of pesticides.	• Usually requires a complete landscape overhaul. • Restricted to native plants. • Susceptible to being over run by "invasive" non-native plants.
6	Conservation through Efficient Irrigation	• Can implement in various stages - from very simple to more complex methods. • Savings can be significant in the Ag area. • Benefits can be reaped immediately.	• Efficient irrigation requires the combination of four critical components: design, water-efficient products, installation and usage/maintenance - without all four, savings may not be achieved.

Chapter Three **Water Conservation through Efficient Irrigation**

After reviewing a number of potential options to address water scarcity in Chapter 2, it is clear that water-efficient irrigation provides significant benefits. Since over 70% of all water used worldwide is used to irrigate agricultural crops and landscapes, the savings potential from installing more water-efficient systems can have a great impact on the future of our water supply.

Across the globe a wide variety of irrigation systems are available. Products and systems range from pressurized sprinklers to sophisticated computer controls using satellite data – all designed to achieve maximum watering efficiency. Although the majority of irrigators do not use these advanced irrigation methods today, they are rapidly being adopted.

TYPES OF IRRIGATION

The earliest forms of irrigation, such as those used for centuries in Egypt's Nile River Basin, simply followed river cycles. Farmers planted crops and waited for river flooding. They dug channels and used gravity to transport river water to where it was needed most. Soil was saturated, allowed to dry out until plants nearly wilted, and then soaked again. Flood-furrow surface irrigation is still the most common method of agricultural irrigation used worldwide. Though significant advancements in irrigation techniques and technology have been made, many farmers and growers throughout the world still rely on flood-furrow irrigation largely due to the lack of understanding of advanced systems and the cost to convert their systems to more efficient methods.

> On December 18, 1933, Orton Englehart filed a patent for his novel watering device, described as a "spring-activated horizontal impact arm driven sprinkler." Patent number 1,997,901 was granted on April 16, 1935. The impact sprinkler was durable and distributed water farther, more evenly and more efficiently than existing sprinklers of that time. Clem and Mary LaFetra, neighbors of the inventor, recognized the potential impact of Englehart's device and began marketing it. Subsequently, the LaFetras set up a manufacturing facility in the family barn, which evolved into today's Rain Bird Corporation.[49]

Today, sprinklers dominate agricultural and landscaping use worldwide. They range from small pop-up spray head sprinklers used in a typical backyard to larger rotating sprinklers for commercial or agricultural applications.[50] Low volume irrigation is also gaining popularity in both the agricultural and landscape markets because it can provide water efficiency of up to 98% for the appropriate applications. Low volume irrigation uses bubblers, drip emitters and micro sprays to deliver precise amounts of water slowly and evenly, at or near the plants roots, eliminating waste. These components in combination with advanced controls that adjust watering schedules according to weather conditions and plant needs make up some of the most efficient systems available today.

IRRIGATION APPLICATIONS

Golf Courses

Golf courses (over 17,000 in the United States alone) are part of the largest group of water users, consuming approximately 2.7 billion gallons per day in the United States.[51] The amount of water used to maintain the quality of greens demanded by players often makes golf courses the target of criticism, particularly in drought-prone areas. However, contrary to public perception, there are many cases to show that the golf industry has actually been on the forefront of implementing water-saving measures such as advanced central control systems and the use of reclaimed water. Water conserving irrigation practices pioneered on golf courses have subsequently been used in other applications, allowing for the overall advancement of water-efficient irrigation. Ongoing efforts in efficient water practices as well as building this awareness among golf course management professionals and players are necessary in order to continue these positive trends and rectify any negative perceptions.

In the United States, turfgrass takes up an estimated 50 million acres, an area larger than that dedicated to any single U.S. crop, and larger than the state of Pennsylvania.[52]

CASE STUDY

The two, 18-hole golf courses at Olympia Fields Country Club in Olympia Fields, IL, had previously used an older automatic timer system without controls or sensors. The old-fashioned, finger-in-the-ground method determined moisture and estimated water demands. This often resulted in over-watering to compensate for the older sprinkler system and uneven coverage of water. The upgrade to the ET-based central control system occurred in conjunction with an expansion of the course. This new system enabled Olympia Fields to irrigate a larger course with no increase in water. In addition, they also achieved better water distribution, better control over the system and decreased labor costs.[53]

Agriculture

Farmers and growers, who often have historic and legislative rights to water, sometimes feel they are being unfairly asked to solve the world's water crisis. But as history has demonstrated, policy makers often move water to markets of highest value. As water becomes even scarcer, it will be treated and distributed differently. Thus, many farmers recognize that converting to more water-efficient irrigation can benefit them in multiple ways – healthier crops, higher yields, lower water usage and the additional financial opportunity of selling their water to urban users and taking advantage of the "higher-value" commodity status of water.

Since the majority of farmers still use the flood-furrow method of irrigation, there is a large opportunity for water savings as this segment upgrades to more efficient methods. However, in most cases, a lack of understanding of the benefits of advanced irrigation technology and the cost to install the new systems are significant barriers for most farmers.

Landscape – Commercial & Large Users, Homeowners and Recreation

As mentioned earlier, water used to irrigate landscapes can range from 25 to 70% of total water usage, depending on the location of the site. A major portion of the water used in landscaping is used to irrigate turfgrass. However, while turfgrass tends to require more water that other types of plants, it is very often over-watered – which is a major reason for its high water consumption.

Converting to a more water-efficient landscape irrigation system can involve the use of very advanced technologies and costly equipment. However the practice of water-efficient irrigation can be as simple as adjusting a sprinkler timer to water less during the winter months and doing quarterly checks of a system. Through the use of more water conserving irrigation methods, there are many opportunities for homeowners and property managers to significantly reduce their watering bills and improve the health of their landscapes.

KEY STEPS TO IMPLEMENT WATER-EFFICIENT IRRIGATION

Water-efficient irrigation is proven to reduce water usage and promote healthier plants. However, in order to achieve maximum water savings, advanced irrigation technology and products must be used in combination with proper system design, installation and maintenance. Without each of these steps, optimum water efficiency may not be achieved.

1) Proper Irrigation Design

The first step in achieving water savings through efficient irrigation is a properly designed irrigation plan. Whether the needs are for a large commercial property, golf course, agricultural crops or a front yard, different plants require different amounts of water. It is important that users know exactly what plants they will be irrigating before designing their system.

1a) Divide by Zones

For residential and commercial users, landscape areas should be divided into separate irrigation zones to accommodate for watering needs of different plants. For example, many landscapes include turfgrass, shrubs and trees. Each of these plant types has different irrigation needs and should be treated as a separate hydrozone.* In addition, the variation of exposure to the sun in a landscape (full sun versus shade) will also affect irrigation needs. Generally, turfgrass areas require more water to stay healthy than the shrubs and trees. If everything is on the same irrigation zone, the watering schedule will be dictated by the needs of the grass, and shrubs and trees will be over-watered.

*Hydrozone: Grouping of plants with similar water (and environmental) requirements

1b) Consult with a Licensed Professional

Consulting with a certified landscape, agricultural or golf course irrigation professional when developing a water-efficient irrigation system is highly recommended. The Irrigation Association operates a Certified Irrigation Designer program, which has been specifically set up to raise the level of expertise and competency in the irrigation industry on efficient and cost-effective irrigation designs for landscape (commercial, residential and golf course) and agricultural areas. These individuals are trained in irrigation design and are knowledgeable about water-efficient products, the watering needs of various plants and local environmental conditions.

In addition, resources in the landscape area also include licensed landscape architects, members of the American Society of Landscape Architects and members of the American Society of Irrigation Consultants.

Properly designed irrigation plans are extremely important for golf courses and agricultural crops. Healthy landscapes and crops are essential to the success of these businesses. In addition, since both are large water users, an efficient (or non-efficient) system can significantly impact profitability of the course or crop.

2) Use the Most Water Conserving Products Available

In the last century, there have been significant advances in efficient irrigation systems. And though public perception may be that automated systems use more water, systems can be set to use the minimum amount necessary to maintain the health of the plant or crop. Below are recommendations for irrigation components that contribute to more efficient water use:

2a) Use Automatic Controllers with Water-Conserving Features

Some of the water-conserving features available in automatic controllers and central control systems (large commercial, golf, agriculture) are:

Multiple Start Times and Multiple Independent Programs – allow for shorter and more precise run times based on the individual needs of the plants. This enables the landscape or crops to better absorb water; reducing run-off and water waste. Run-off is a common water waste problem that occurs when water is applied faster than plants and soils can absorb it and the excess runs off unused.

Water Budget – provides an easy way for users to adjust their system based on the needs of the environment. For example, during the rainy season, a user can adjust his/her controller's "water budget" down to 15% of its peak setting to reduce water usage by 85%.

Rain Delay – allows a user to postpone watering when irrigation is not needed (typically during the wet season) and automatically resume schedules when appropriate.

Cycle + Soak™ – applies water at a rate that the soil can more easily absorb, reducing run off, erosion and waste.

ET Programming – enables the controller to calculate daily evapotranspiration (ET) values and automatically adjust station run times to replace only the water needed by the plants. This technology is predominantly used in larger commercial sites, golf courses and agricultural crops (versus homes) mainly due to cost and system complexities.

The Benefits of Automatic Irrigation Systems: Automatic controllers enable users to save time and irrigate more efficiently, precisely and evenly based on the specific needs of the plants. And, when the controllers are equipped with the water conserving features mentioned in this section, end-users can enjoy significant water, labor and cost savings, and healthier plants and crops. Automated controls make it easier to water large landscape sites consistently and at the ideal time of day – between 5 a.m. and 10 a.m. Early morning watering is most efficient because evaporation due to wind and sun tends to be less than during the mid-day. In addition, automated systems make it easier to design irrigation schedules according the needs of each irrigation zone. A typical golf course has a wide range of microclimates – from fairways, greens, rough and surrounding areas, to the clubhouse and parking lot areas. Golf central control systems make it possible for golf course superintendents to apply the minimum amount of water needed for each zone.[54]

CASE STUDY

The Fort Stockton School District in Texas previously struggled to manually irrigate its seven campuses. Most of the district's schools are at least forty years old and, until the fall of 1996, all of them had manually irrigated grounds. Every day, water cannons on the school district's baseball and football fields blasted water for hours on end while janitors continuously moved portable sprinklers on lawns and playgrounds. Water use on one football field in July 1996, when temperatures regularly simmer above the century mark, was measured at 1,373,000 gallons at a cost of $1,800 for the month. Despite the effort expended and amount of water consumed, it was impossible to irrigate an entire campus in one day and stubborn dry spots marred the fields and lawns. Following the installation of an automatic irrigation system that distributed water in a uniform and efficient manner, water use on the same football field was reduced by just over 1 million gallons, a 75% reduction in water use and a significantly lower water costs of $471 for the month.[55]

CASE STUDY

Heyne's Wholesale Nursery in South Australia operated with an overhead sprinkling system and hand watering that annually wasted approximately 9.5 million gallons at a cost of $22,000. More efficient sprinklers were installed and new ET sensors are planned, both of which will reduce estimated water consumption by 30%, potentially saving $21,000 in water costs annually. Water use efficiency is estimated to increase from 63% to 83%. The total investment will only be $73,000.[56]

CASE STUDY

Quady Winery, Madera, California: The biggest issue for this 10-acre vineyard was the time and precision needed to adjust their irrigation to deal with four very distinct soil types. To address this issue, Quady Winery upgraded their irrigation system with a wireless controller system and new cast iron valves. As a result they are now able to control the amount of water applied to each soil type and the frequency of application. The health of their vines has improved, irrigation run time has been reduced by 44% and pumping costs decreased $1,600 per year. Ultimately, the upgrade of their irrigation system resulted in less plant disease, better quality wines and reduced water and labor costs.[57]

2b) Add an Automatic Shut-Off Device to All Automatic Controllers

Adding an automatic shut-off device such as a rain or moisture sensor to an automatic controller can result in 15-20% or more in water savings.[58] Sensors are available for both residential and commercial applications and automatically shut-off the system when it is raining or when sufficient soil moisture is detected. Several U.S. states and cities are considering or have passed legislation that requires a rain or moisture sensor on all automatic irrigation systems. Among the areas: Texas, Minnesota, Connecticut, New Hampshire, New York and Rhode Island.

CASE STUDY

Denver, CO: In 2003 Denver Water launched a program offering up to $720 in rebates to customers that upgraded their irrigation systems to more water conserving technologies, planted low water use trees and shrubs and made recommended soil amendments. Some of the irrigation technologies included in the program were rain sensors, ET controllers and automatic controllers with features such as water budget, multiple start times, and multiple independent programs.[59]

2c) Use Low Volume Irrigation Whenever Possible

Low volume irrigation systems (bubblers, micro and drip) are generally the most efficient method of irrigating non-turf areas because they deliver precise amounts of water slowly and evenly at the plant's roots, eliminating water waste, run-off and overspray on to roads, sidewalks, streets, waterways or drains. The slow, consistent application of water at or near the plants' roots reduces weeds and plant disease and helps plants and crops thrive. In landscaping, low volume irrigation is often best for trees, shrubs, flowers and other non-turf areas. In agriculture, drip and micro is typically used in higher value row crops such almonds, apples, oranges, plums and peaches.

Despite the high efficiency rates of low volume drip irrigation, installation and maintenance costs and a lack of understanding of the benefits of low volume systems are key obstacles to its wider adoption.

AGRICULTURAL CASE STUDIES

The Texas Agricultural Extension Service converted their cotton fields from furrow irrigation to drip and low-tillage methods. Result: water usage was reduced and yields increased by 27%.[60]

In Maharashtra, India, university researchers converted sugarcane crops from traditional flood to drip irrigation. Result: water use was cut by 30% to 65%.[61]

In Turkey, drip irrigation systems were installed on banana and cotton crops. Result: the banana crops used 50% less water and maintained yields. The cotton crops used less water and yielded 34% more than neighboring cotton growers using furrow irrigation.[62]

In the Texas Rio Grande Valley, pressure compensating drip irrigation systems were installed on grapefruit orchards, allowing growers to keep the root zones small and better control nitrogen applications. Result: growers produced higher-priced, more desirable and larger-sized Fancy #1 grades, while using 35-40% less water than previous flood irrigation.[63]

2d) Use Pressure Regulating Devices in High-Pressure Situations and Pumps in Low-Pressure Environments to Provide Optimum Pressure to the Watering Device

In landscaping and agricultural sites, water is often wasted through evaporation when systems appear to be "misting or fogging." This is generally a result of excessively high water pressure and can be reduced by pressure regulating nozzles, sprayheads, valves and regulators. By utilizing the right products to address high water pressure in landscaping applications, every 5-psi (pounds per square inch) reduction in pressure reduces water usage by 6-8%. The savings in an area can be over 50% if a 70-psi spray zone is reduced to the recommended 30 psi.[64] For low-pressure situations that can result in uneven coverage, use a high efficiency irrigation pump to boost the pressure to peak efficiency combined with pressure regulating system (PRS) sprayheads to ensure efficient and complete coverage.

2e) Use High Efficiency Nozzles for Uniform Coverage

Whether the site is a golf course, a vineyard or a residential backyard, uniform water coverage is important. When coverage is not uniform, irrigation schedules are often run for longer periods of time to compensate for areas of weak coverage. This ultimately results in the over-watering of all other areas. In landscaping, high efficiency nozzles can reduce water usage by up to 30%.[65]

Advanced Irrigation Technology: Controls, Sensors and Climate Adjustment

Historically, farmers, horticulturists and landscapers have depended on their own judgment to determine soil moisture and irrigation schedules. Now sensors provide accurate measurements of soil and air moisture. In addition, automated controls, computer technology and satellites enable complex systems to control multiple sites.

Weather Stations & Data - Meteorological data, such as rain, temperature and wind, are measured via weather stations and up-to-date weather information is transmitted back to growers and irrigators who then adjust irrigation schedules accordingly.

Water districts also post online ET measurements and soil moisture levels via the Internet to provide watering recommendations for residential water-users. For example, many of the recommendations for California are based on the information provided by The California Irrigation Management Information Service (CIMIS). The CIMIS takes hourly data from more than 100 automated and computerized weather stations throughout the state, and makes the information available to the public. In one study, California farmers using the California Irrigation Management Information Service (CIMIS) were able to fine tune their irrigation schedules and reduced water usage by 13% and increased yields by 8%.[66]

Computerized Central Control Systems – Advances in networking & communication technologies have led the way for significant changes in irrigation tools and central control systems. Central control systems allow landscapes and farms to directly and automatically manipulate irrigation valves in the field based on user-defined schedules and ET or sensor data. Independent Water Managers can be hired to operate and manage irrigation systems remotely making this technology affordable to small irrigation systems.

CASE STUDY

Prompted by a decade of drought, the City of Bakersfield, CA, Parks Division upgraded its outdated, manually operated electromechanical controllers and replaced them with a sophisticated central control system, weather station, ET sensors and other technologies to irrigate the parks and street landscapes at the south end of the city. A new development there included a country club, an 18-hole golf course, four neighborhood parks, schools and major landscaping on the medians and streets. When compared against the older system still in use in other parts of the city, the upgraded irrigation system saved more than 10 million gallons in one year.[67]

Unlike other types of consumer appliances such as light bulbs, showerheads or clothes washers, water-efficient irrigation products cannot just be "plugged in" to automatically achieve water savings. Proper installation and maintenance are critical to achieve water savings.

3) Proper Installation

After a system has been properly designed and water-conserving products have been selected, proper installation and maintenance are essential to achieve the most efficient use of water. Hiring a certified irrigation contractor is recommended for the entire process. The Irrigation Association (IA) is an international organization with local chapters in various U.S. states and provides comprehensive certification programs for irrigation specialists in the landscape, golf and agricultural areas. The IA is also very involved in efforts that bring together water distribution agencies, nonprofit organizations and industry constituents to address and research water-scarcity issues.

One of the programs offered by the IA is the Certified Irrigation Contractor program for the landscape and turf arenas. As part of the certification process, qualifying individuals must show an understanding and be able to demonstrate all aspects of layout (design), installation, maintenance and repair of irrigation systems used in turf and landscape applications. There are several U.S. states and counties such as New Jersey, Connecticut and parts of Florida that are now requiring this IA or similar type of certification for any contractor installing irrigation systems.

4) Proper Maintenance

The last and ongoing step in conserving water through efficient irrigation is proper maintenance. Whether it means maintenance visits by irrigation professionals, or teaching end-users how to adjust their controllers when the seasons change, periodic monitoring is just as important as the design, products and installation. Overwatering, uneven pressure, improper run times, broken pipelines and clogged sprinklers, sprayers or drippers can all defeat the best efforts to achieve water savings.

Proper maintenance of a system would include the following practices:

4a) Set Systems to Operate in the Early Morning Hours

Early morning is the best time of day to irrigate. Water lost to evaporation tends to be less in the early hours versus midday.

4b) Do Routine Inspections of the Irrigation System

Since lawns and gardens should be watered in the early morning hours, a problem may not be discovered until it is too late. Regardless if the site is a golf course, a wine vineyard or a theme park, periodic checks are very important. A broken pipeline or spray head can waste significant amounts of water if left undetected.

To insure the system is maintained at high efficiency standards, consult with an IA Certified Landscape Irrigation Auditor.

4c) Adjust Watering Schedules When the Seasons Change

In landscaping, over-watering often occurs because end-users rarely adjust their watering schedules according to seasonal changes. Many of the controller features mentioned earlier and the installation of a rain sensor or moisture sensor make it very simple to reduce water use.

4d) Adjust Watering Schedules When Plants are Changed

Similar to adjusting a system for weather changes, irrigation schedules also need to be adjusted when new plants are installed. If drought-tolerant, native plants are installed, it is likely that watering times would also be reduced.

Summary

It is clear that conservation through efficient irrigation is proven to reduce water usage and promote healthier plants. However, in order to achieve the maximum water savings, advanced irrigation technology and products must be used in combination with proper system design, installation and maintenance. Without each of these steps, water efficiency may not be achieved and waste can still occur. To encourage and further the adoption of water-conserving practices, it is important to combine the effort with government incentives and public education campaigns.

Chapter Four **Encouraging Water Conservation**

In the face of growing global water shortages, action is needed now. However, individuals, businesses and communities only adopt conservation behavior and values if they are motivated to do so. Key motivators include government incentives, education and public awareness. The consistent use of these measures over time can impact long-term change in water consumption patterns. The goal – to encourage water conservation behaviors – is essential to ensure an adequate water supply for future generations.

As indicated previously, the supply of water worldwide is finite, yet, with a growing global population, demand keeps rising. One of the most feasible options to address this issue is the proper management of existing water resources through conservation and water-efficient irrigation.

Why "Shutting Off the Taps" is Not Recommended

The first reaction to drought and water shortages tends to be along the lines of "shutting off the taps." Drastic water restrictions are often hastily imposed, only to be lifted when the rains come again. In many cases, when the restrictions are lifted, water-users return to their previous consumption behavior and the cycle repeats. In comparison to a true change in behavior, as described above, it is not surprising that stopgap water restrictions are often ineffective in the long-term.

Such actions led to confusion by consumers when bans were imposed, removed, then imposed again. "On-again, off-again" restrictions in Virginia, Florida and New Jersey, created such confusion with the local communities that the South Florida Water Management District and the state of New Jersey resolved the confusion issues by introducing comprehensive, year-round water-use restrictions as a permanent conservation measure.

In fact, evidence exists that such "on-again, off-again" measures may actually increase water consumption. For example, in Sydney, Australia during the 2002 drought, residents adhered to water restrictions, meeting the goals for two months. However, when restrictions were lifted, consumption increased to a level 4% higher than pre-restriction levels.[68] Similarly, water officials in Delaware County, PA noted a 10% increase in usage after the temporary summer restrictions were lifted. This result ultimately required a reinstatement of restrictions later in the year.[69] Similarly, restrictions such as watering every other day, or every third day, often encourages users to over compensate and use more water on the days that they are allowed to water.

GOVERNMENT INCENTIVES

"Many countries face a governance crisis, rather than a water crisis," states an online summary statement of the Third World Water Forum, held in Japan in March 2003. "Primary responsibility rests with governments to make water a priority . . ."[70]

Realizing the need to change water-consumption behavior, conservation incentives and disincentives are being explored and implemented by governments, worldwide.

Global Examples (Agriculture):

- Israel – low-interest loans are available for farmers to install more efficient irrigation systems.[71]
- Pakistan – loans and working capital are offered to farmers to install canals, small dams and drip and sprinkler irrigation systems.[72]

- Governments in countries such as Australia, Canada, Brazil, Argentina, France and Spain are pursuing a policy of "conservation agriculture" similar to the policy laid out by the United States Farm Bill of 2002 (described in the section below).[73]

U.S. Examples (Agriculture):

- **U.S. Farm Bill 2002** – A 10-year measure that contains 11 different programs with more than 180 conservation initiatives; measures are funded by an additional $17 billion, to boost total farm bill spending to $37 billion; conservation efforts were increased from 7% to 40% of total farm assistance.

  Programs in this bill include:

  - **Environmental Quality Incentive Program (EQIP)** – Farmers can receive maximum grants of $50,000 yearly for water or topsoil conservation; $450,000 over six years for other conservation projects, plus technical assistance.
  - **Conservation Security Program** – Farmers can receive up to $13,500 to implement and maintain practices that conserve water, prevent soil erosion and encourage the planting of more climate-appropriate crops in this $2 billion program.
  - **Farmland Protection Program** – This program provides funds to help purchase development rights to keep productive farmland in use. Working through existing programs, USDA joins with state, tribal, or local governments to acquire conservation easements or other interests from landowners. The qualifications are numerous but include provisions stating that the farmland must have a conservation plan and must be large enough to sustain agricultural production. In addition, farmland must have surrounding parcels of land that can support long-term agricultural production. In exchange for giving up highly erosion-prone farmland for "conservation easements," farmers retain the right to use the land and receive funding for conservation measures.

Many states offer conservation subsidies such as loans, grants, rebates, and tax incentives. In one case, the Texas Water Development Board provided more than $44 million in low-interest loans to hundreds of farmers for the installation of water-efficient irrigation equipment. Estimates of water savings ranged from 13 million to 26 million gallons of water annually per individual farmer.[74] Similarly, to encourage cities, counties and school districts to install more water-conserving equipment, Texas offers property tax exemptions.

CASE STUDY

In Washington, the Seattle Public Utilities and its wholesale customers have operated a water-efficient Irrigation Program for over four years. The program helps large commercial irrigators identify and fund irrigation improvements. In the first four years, through capital improvements alone, the program achieved water savings of more than 117,817 gallons per day (GPD), at a cost significantly less than the utility's cost for new water supply. Customers often receive additional benefits such as reduced labor costs and improved landscape health. A wide range of customers participated in the program including cemeteries, multifamily complexes, office parks, public parks and schools. Water savings per customer ranged from an average of 2,000 GPD for public parks, to 30,000 GPD for cemeteries. The associated savings in water costs ranged from $800 to $12,000 per year.[75]

EDUCATION AND AWARENESS

Many water users still treat water as an unlimited commodity and are not conscious of waste. The public needs to understand that conservation efforts taken today will significantly impact future generations. Increased social responsibility is crucial to changing long-term behavior. With proper motivations, people will be more inclined to act.

Professional Education Programs

Organizations such as the Irrigation Association and irrigation equipment manufacturers have recognized the importance of education and training of the professional audience in the area of water-efficient irrigation. Changing how society uses water is not a simple task. Proper education and training of the professional installers that service the homeowners and property owners will help to ensure that the proper systems are designed, installed and maintained in conjunction with the most water-efficient products. Through this effort, professional installers can also reinforce the message of conservation with end-users and homeowners.

- Australia – The Water Authority of Western Australia worked in conjunction with the Irrigation Association of Australia to develop a training program for irrigation contractors in the Kalgoorlie/Boulder area. The focus of the course was on conducting water audits and evaluating irrigation systems. For the general public, the message was reinforced via television, radio and newspaper stories and public speaking events with elected officials. In addition, public demonstration gardens featuring water-efficient landscaping and water conservation kits were distributed in the grade schools. This effort was part of an overall $2.7 million water efficiency program that reduced demand by 330 million liters annually.[76]

Public Education and Awareness Programs

Water and irrigation districts, especially those in arid or water-short regions of the U.S. such as the Southwest, Rockies and Florida, have created programs for residential, commercial and institutional users that focus on interior water savings. Many of these programs include the installation of low-flow toilets and shower shut-off valves and rebates for low-water washing machines and dishwashers. Recently, exterior water conservation programs have joined these indoor efforts.

- Seattle, Washington, U.S. – Seattle Public Utilities, one of the key water agencies at the forefront of conservation programs, created a public awareness campaign to encourage a change in outdoor water use. Seattle communicated this campaign via print, radio and TV advertising; direct marketing bill inserts and newsletters; and public workshops and seminars and exhibits at various trade show exhibits. The campaign resulted in water savings of between 14 million gallons per day in winter and 25 million gallons per day in summer.[77]
- California, U.S. – The Metropolitan Water District of Southern California in 2002 launched a $2.3-million public awareness campaign focusing on outdoor conservation. The key messages were the promotion of the efficient use of irrigation and the use of native and drought-tolerant plants. The program also featured professional and residential educational sessions, rebates for the installation of water-saving devices, demonstration gardens featuring water-efficient irrigation systems and an "online sprinkler index" made available online to help homeowners properly adjust their outdoor irrigation controllers.[78]

While many of the public awareness efforts are aimed at the major users of water – the adults – many groups also recognize that these same principles and values must also be instilled in future generations.

- Project WET (Water Education for Teachers) is a 20-year-old nonprofit organization sponsored by a number of U.S. states, the U.S. Environmental Protection Agency's Office of Environmental Education, the U.S. Department of the Interior, Nestlé Waters North America and other corporations. The primary role of Project WET is to train educators on the properties of water and the importance of conserving the resource, in addition to providing water-related curriculum materials for students in grades K-12.[79]

LOOKING AHEAD

Recognition that water is a finite resource is the first step in a process that can ultimately lead to the more efficient use of water – globally, regionally and individually. Once that fact has been grasped, policy makers at all levels need to understand the options that exist to better manage this precious resource.

Many of those in agriculture and landscaping and those engaged in the manufacturing and development of tools and technologies for large-scale water use are already committed to water conservation practices. They are working to be part of the solution by developing and adopting water-smart irrigation solutions, landscaping techniques and manufacturing systems that conserve water.

Desalination, water re-use and other methods all address the issue, but conservation, especially through water-efficient irrigation, is an advantageous option that is relatively easy to implement and can make a significant impact on global water savings. Conservation is a proven method derived from decades of advances in techniques, hardware and technologies that can be applied today. Furthermore, experts in the Green Industry and Agriculture can assist with education and implementation of conservation through efficient irrigation.

Solving the world's water crisis is going to take a collaborative effort by water stakeholders – in effect, all of us. Efficient irrigation is the most viable solution and should be more widely embraced and more rapidly adopted. Policymakers should act now to encourage the adoption of efficient irrigation before the crisis worsens.

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