WATER CONSERVATION PLAN

LAKE HAVASU CITY, ARIZONA

First Draft - August 27, 2010
Revised November 30, 2010

EXECUTIVE SUMMARY

As a Colorado River diversion contract holder, Lake Havasu City is required every five years to submit a water conservation plan to the Bureau of Reclamation. This document is not only an exhibit that demonstrates the city's present and past water use and infrastructure status, but is also a plan guide for the City to implement water conservation measures in the most efficient and beneficially way that helps the city both reach a consumption goal and minimizes the effects of water shortages. The first six chapters of this plan describe the geographical setting, water supply characteristics, the past and projected water demands within the contract water service area, the dynamics for declaring a Colorado River water supply Shortage, the City's present effluent reuse practices and water conservation ordinances and resolutions currently in place. Chapters seven and nine describe water conservation measures that the City is either currently practicing or will be in the future as conditions allow. Chapter eight focuses on response strategies that the City may implement to changing water supply availability. Chapter ten presents expected water saving results as these water conservation measures are executed. The last two chapters briefly indicate how these measures would affect the environment and summarize the five year implementation schedules of these measures.

Lake Havasu City, with an estimated population of 55,000 and a 4^{th} priority Colorado River water contract entitlement of 28,319 ac-ft, has been engaged in water conservation activities for a number of years. These activities such as water reuse, progressive water rate structuring, promotion of water saving devices and home water audits by the City's Water Conservation Officer have helped to level off water use even as the population of the city has grown. Further growth of the city will primarily be through subdivision development on converted Arizona State Trust Lands on the city's north side, which will provide new opportunities and challenges for water use. Lake Havasu City's primary water source is the 26 million gallon per day horizontal collector well, which purveys water to the city's water treatment plant that removes manganese, iron and arsenic and disinfects the water prior to delivery to customers. The City tracks types of water use with residential consumption leading the way at roughly 73% of the total. Water demand projections indicate that with improved conservation, the city's current entitlement may be sufficient for the build-out population of approximately 96,000 under normal water supply conditions. The City's 2007 Water Master Plan has determined the needed infrastructure upgrades and schedule to efficiently deliver water to these future customers. Water supply uncertainty also looms in Lake Havasu City's future as the Department of the Interior may be forced to declare a water Shortage in the Lower Colorado River Basin, which will primarily affect 4^{th} priority contracts in Arizona. The City has developed a Shortage response plan that gives the City Manager and Council the flexibility and agility to implement strategies appropriate for the water reduction magnitude that the City experiences. These include voluntary and mandatory water conservation measures, access to the City's 113,000 plus ac-ft supply of banked water held by the Arizona Water Banking Authority, activate a potential land-fallowing agreement through the Mohave County Water Authority, authorize special water pricing and rationing water.

Voluntary water conservation measures taken under normal supply conditions both by customers and the city itself has been the preferred approach to slow water consumption, yet the city has had established water conservation regulations in place since 1990 for plumbing and landscaping in new construction. Water waste is addressed within the City's Irrigation and Drainage District along with a new ordinance that encompasses the entire water service contract area. Water conservation practices in place also include instituting rebates to customers for purchasing selected water saving devices, expanding the educational component by establishing a citizen volunteer program, redrafting a plan to have more effluent replace potable water for turf and landscape irrigation, resuming a leak detection program for the water distribution system, increase monitoring of unmetered water use and upgrading landscape irrigation systems to be more water efficient. Near term added measures will include multimedia water conservation presentations on a variety of topics to all age groups, the establishment of an effluent reuse and recovery operational plan, researching alternative technologies to conventional water softeners and reverse osmosis systems and continue local government improvements such as installing waterless urinals in its facilities, removing non-recreational turf, developing a plan for swimming pool water draining into the sewer system and diversifying the rebate program. Future considerations beyond the five year plan period include the construction of a more extensive effluent delivery system through the city that could serve all schools and some city parks, the installation of a city-wide radio signal water meter system to better account for diversion/consumption differences and the development of water conservation plans for non-residential customers. If funding becomes available within the five year period, then these efforts will be initiated much sooner.

Existing water conservation measures have helped to bring the City's water per capita consumption from over 450 gpcd in the 1980's down to 206 gpcd in 2009. The new measures proposed over the next five years are expected to lower the consumption rate to at least 200 gpcd. Improved education and public outreach through the citizen volunteer group should ensure a more conscience effort by the community to conserve its annual allocations.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

1.0 DESCRIPTION OF DISTRICT

1.1 Location

Lake Havasu City, located in Mohave County, is situated along the eastern bank of the Colorado River in the west central area of the State of Arizona. The City lies at the western foothills of the Mohave Mountains. The general location of the City is shown on Figure 1.1.

1.2 History

Lake Havasu City was conceived as a master planned community in 1963 by Mr. Robert McCulloch, who emphasized a recreational and retirement residential-type development. This theme was augmented by attention to creating a strong employment base. At that time the City encompassed approximately 26 square miles. Initial growth of the City was spurred by manufacturing industry; however, the recreational, construction and retirement industries eventually became the primary economic base with growth. The City was incorporated in October 1978 and now encompasses approximately 42 square miles. Land to the north, east, and south of the City remains as unincorporated land of Mohave County.

1.3 Size of Population

Population estimates between decadal censuses for the City of Lake Havasu, obtained from the State of Arizona Department of Commerce, are generated based on housing permits and modeling the process of migration, births, and deaths in the population by single-age and sex, and by modeling the aging of the population by single-age and sex[1]. The agency releases population estimates for July of each year the following December. The July 2009 population estimate for Lake Havasu City was 55,502. Population estimates form the basis of one type of calculation projecting water consumption into the future. As of this writing, the 2010 census results have not been published.

[1] web site: http://www.azcommerce.com/EconInfo/Demographics/

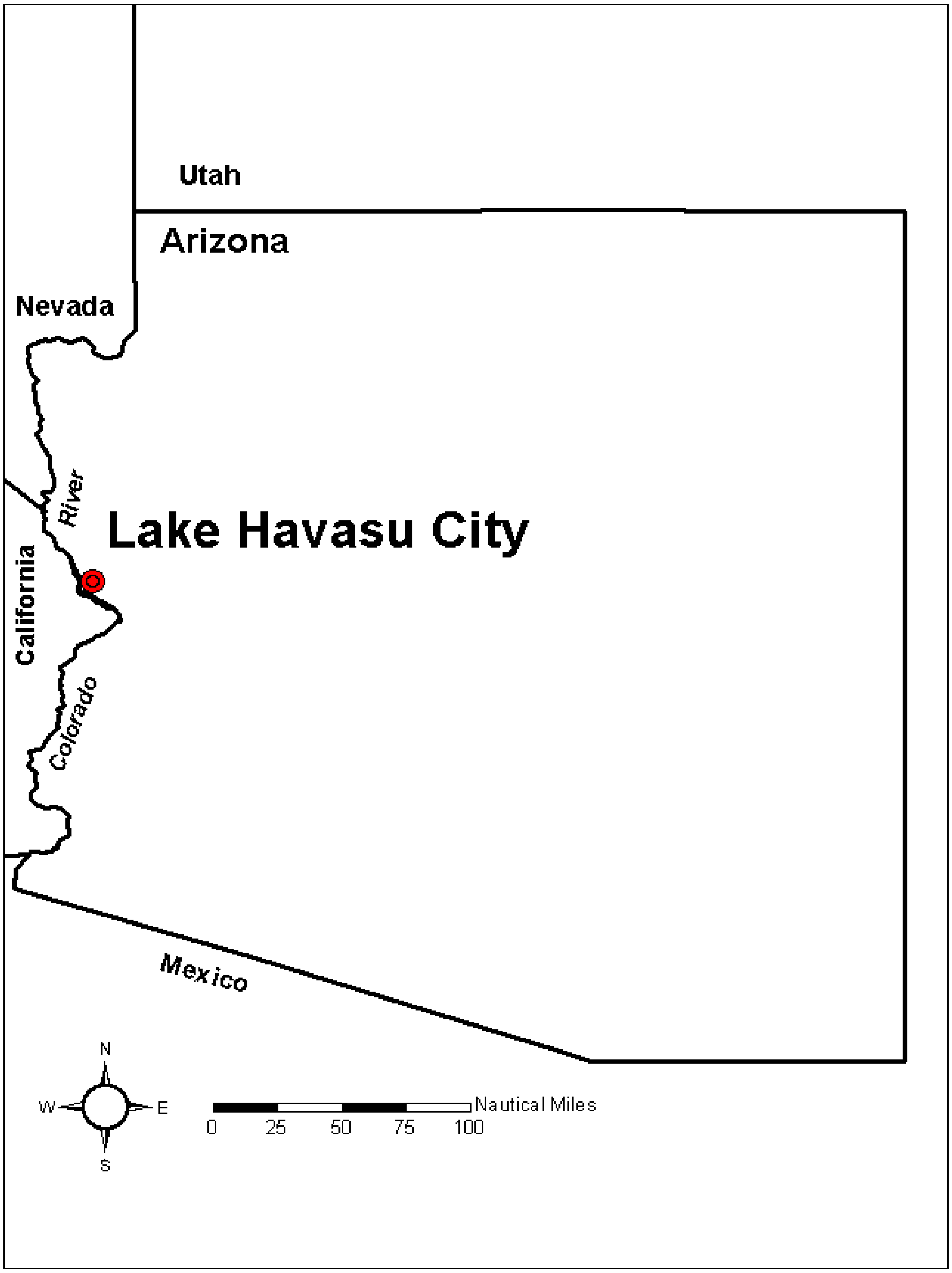

Figure 1.1: Location map of Lake Havasu City.

Estimates of Lake Havasu City's population lack accurate accounts for seasonal variations. Winter visitors spend between 4 to 6 months in the warmer climate only to leave for the summer. Some have second homes and others use recreational vehicles, but still draw on the water supply. Many other homes in Lake Havasu City are vacation homes of residents from Southern California and elsewhere. These factors account for an estimated 70%-75% full-time residency during particular times of the year. The implication is that the population estimates from the state may differ from reality by a significant margin. From 1985 to 1995, population growth almost doubled in Lake Havasu City, increasing from a population of less than 20,000 to more than 35,000 people. From 1995 to 2007, the average yearly population growth rate remained relatively constant, at 5 percent per year, until the recession of 2008 when growth came to a virtual stand still (Table 1-1). Slow economic recovery is expected over the next several years along with a modest growth rate. As the platted part of the city is approximately 85% in-filled, most future growth will be in the form of subdivision development on converted Arizona State Trust Land on the city's north side.

1.3.1 Population Projections

The references used in the development of the population projections are as follows:

- Arizona Department of Commerce (2006)
- Lake Havasu City Phase I (1996) and Phase II (1998) Comprehensive Wastewater Plan
- Lake Havasu City General Plan (2002)
- Lake Havasu City Comprehensive Water Master Plan Update (2007)
- Lake Havasu City Water Conservation Plan (2005)

As discussed in the previous section, slow growth rate is expected to continue for several years, but should increase with improving economic conditions. Based on the 1998 Phase II Comprehensive Wastewater Master Plan, the build out population is approximately 96,000 people. Build out is a timeless description for the ultimate population projected. According to the statistical analysis of the logistic growth of Lake Havasu City provided in the 1998 Wastewater Master Plan, the year 2060 best describes the period for build out with the available data. That estimate will need to be revisited once economic conditions return to normal, as will the state's population projections. Build out planning and population projections are based on the existing Water Service Area (Figure 1.2), which is significantly larger than the City limits, approximately 56 square miles. Updated population projections for Lake Havasu City are shown in Table 1-2.

1.4 Natural Setting

1.4.1 Climate/Weather

Lake Havasu City is located in the Lower Colorado River topographic trough and within the transition zone between the Sonoran and Mojave deserts. The region experiences over 300 days of sunshine with low humidity most of the year, except during the Arizona monsoonal season from July through September. Although normal temperatures range from 78^{o} to 120^{o} Fahrenheit (^{o}F) in the summer and from 37^{o}F to 68^{o}F in the winter, this area is known for its temperature extremes.

Lake Havasu City holds the record for the hottest day for a city in the Western Hemisphere at 128^{o}F and the 30-year overall average temperature of 75^{o}F is almost equal that of Death Valley National Park. In any single year, the City has experienced as many as 145 days over 100^{o}F and 86 days over 110^{o}F along with up to 32 days with overnight lows above 90^{o}F.

Coupled with the high temperatures, the region experiences low precipitation volumes, all as rainfall. Rainfall data for the last 40 years indicate an average annual precipitation of 4.15 inches, including years in which less than 2 inches of rain were recorded. Precipitation usually occurs during the winter months (January to March) from cold fronts and during the summer monsoon season (late July to early September) from scattered convective thunderstorms. The evapotranspiration rates are very high during the summers and annual calculated volume losses exceed 7 feet, perpetuating a deficit in plant water requirements. Since the area lacks significant precipitation rates, native vegetation is sparse, consisting of creosote, bursage, paloverde, brittlebush, acacia, mesquite, ocotillo, cacti of many types and annual flowering weeds and grasses.

1.4.2 Topography/Soils

Lake Havasu City is surrounded by three metamorphic core mountain ranges, the Chemehuevi and Whipple Mountains to the west on the California side of Lake Havasu/Colorado River and the Mohave Mountains east of the city, which top 5000 feet amsl. Foothills to all mountains consist of volcanic lava and ash deposits that have been extensively eroded. The city is built on top of coalesced alluvial fan deposits dissected by many braided, ephemeral stream beds and the local topography consists of a series of northeast-southwest trending ridges between the dry washes. The alluvial fan deposits, including those exposed in the washes contain sand and larger clasts whose composition reflects the adjacent metamorphic and volcanic sources. Elevations in the City range from approximately 450 feet above sea level at Lake Havasu to 1,700 feet near the mountain foothills. The ground surface uniformly slopes downward at a 4 percent grade from the easterly limits of the City to Lake Havasu. Surface runoff is interrupted by streets and directed to a system of improved arroyos, washes and drains. The Mohave Mountains located 6 miles east of the City limits are the boundary of the drainage area.

As described in the Soil Conservation Manual for Mohave County, the predominant soil classification in Lake Havasu City is the Laveen-Carrizo-Antho association. This association consists of nearly level to moderately sloping soils on dissected high terraces and alluvial fans. Soil development is minimal in almost all locations and organic debris accumulations are very low due to the widely spaced plant growth.

Slopes are dominantly 0 to 8 percent but include short slopes up to 50 percent. The soils are formed in both old and recent mixed alluvium and this association comprises about 4 percent of the county. Laveen soils make up about 40 percent of this association; Carrizo soils, 25 percent; and Antho soils, 25 percent. Cavelt, Rillito, Gilman, Vint and Brios soils and Riverwash make up the remaining 10 percent.

Laveen soils have pale brown loam surface layers 10 to 15 inches thick over brown loam substrata that contains many soft to hard masses of lime down to 60 inches or more. Local areas are alkali (sodic) or saline-alkali. These soils are on ridges of dissected terraces with dominant slopes of 0 to

5 percent but having some short side slopes that range up to 50 percent. Carrizo soils have very pale brown loamy fine sand surface layers up to 6 inches thick over stratified very gravelly coarse sand substrata that extends to a depth of 60 inches or more. These soils have slopes of 0 to 8 percent. Local areas are gravelly to very gravelly on the surface. The Antho soils have brown or light yellowish brown sandy loam or gravelly sandy loam surface layers and stratified sandy loam, fine sandy loam, or gravelly sandy loam substrata with thin layers of silt loam, loamy sand, or gravelly loamy sand to a depth of 60 inches or more. These soils have slopes of 0 to 5 percent. Carrizo and Antho soils are subject to brief flooding in local areas.

Within Lake Havasu City, the soils support home sites, commercial and industrial buildings, and recreational usage along the Colorado River outside the city limits. The soils in this association are also used for rangeland with limited seasonal grazing and wildlife habitat.

1.5 Cultural Resources

A survey of cultural resources was conducted for Lake Havasu City in 1991 as part of an environmental assessment of the area. The original report was a Class I Archaeological Document prepared by a subcontract of Willdan Associates and the results of this survey were summarized in a later report, "Colorado River Water Allocation, Lake Havasu City, Arizona, Final Environmental Assessment, June 1992". For cultural resources, the Willdan report noted that the desert environment of the area today is different than the paleo-environment before human habitation, approximately 10,000 to 12,000 years ago. The earlier environment was wetter and warmer with different vegetation, pine trees and some grassland to support big game animals. Mohave Indians were considered the primary inhabitants of the area. The general chronological time periods are: (1) Big Game Hunting, (2) Post Big Game Hunting/the San Dieguito Traditions, (3) The Amargosa Tradition, and (4) Post Amargosa Tradition. Historic land occupations include Spanish exploration in the 16th Century, the mission culture, Mexican outpost establishment and Americans, early in the 19th Century after the Mexican-American War.

The Willdan report stated that the City is located in the lower Sonoran Life Zone, described as Sonoran Desert Scrub, Lower Colorado River Subdivision biome. The Mohave Mountains east of the City contain a growing herd of desert bighorn sheep and some mule deer, and although conditions exist for support, there do not appear to be any of the threatened desert tortoises in the area. Other endangered species in the area include the peregrine falcon, bald eagle, southwest willow flycatcher, Yuma clapper rail, razorback sucker, and bony-tail chub.

The Willdan report also stated that twenty-two cultural resource surveys have been conducted within or near Lake Havasu City, although no studies have been conducted within the boundaries of the Lake Havasu Irrigation and Drainage District (I.D.D.). Sixteen (16) archaeological sites have been reported in the service area with little variation in the type of site found. The majority of features are described as rock rings, rock circles, or sleeping circles, with some intaglios, cairns, and lithic scatters. In some cases trails are noted.

The Willdan report noted that all sites identified in the cultural resource surveys were found in areas below 1,000 feet in elevation, with the majority of the surveys conducted near the river along or

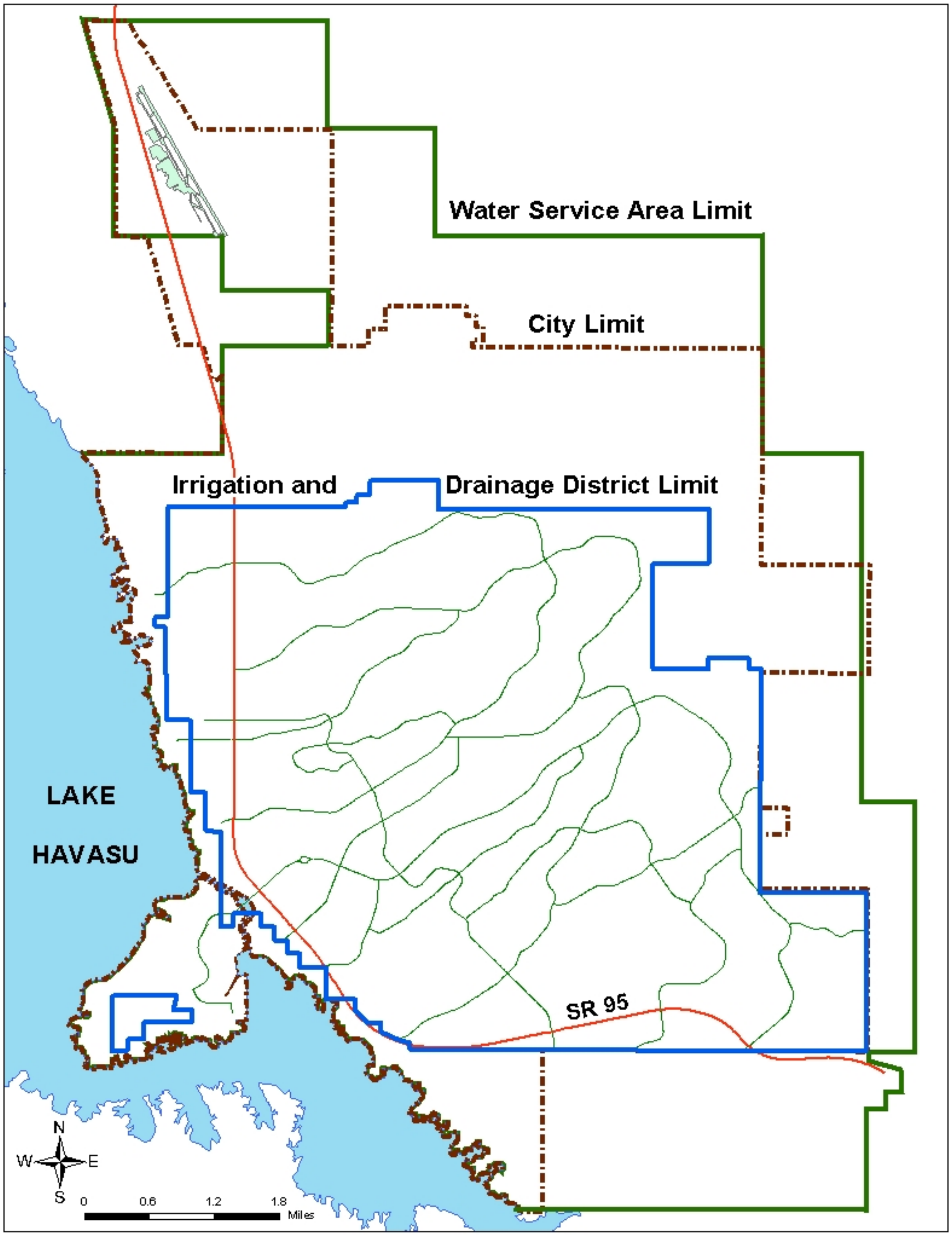

Figure 1-2: Boundaries for Lake Havasu City's irrigation and drainage district, city limit and expanded water service area.

Table 1-1: Lake Havasu City growth rates – 1970 to 2010.

5-YEAR PERIOD	5-YEAR POPULATION INCREASE	5-YEAR POPULATION GROWTH (percent)	AVERAGE YEARLY POPULATION GROWTH RATE (percent)
1970-1975	4,800	84	17
1975-1980	5,500	52	10
1980-1985	3,274	20	4
1985-1990	11,388	59	12
1990-1995	9,715	32	6
1995-2000	9,189	27	5
2000-2005	11,000	26	5
2005-2010	2067	4	1
Source: Arizona Department of Commerce			

Table 1-2: Projected Population estimates for Lake Havasu City 2010 to 2060.

YEAR	PROJECTED POPULATION ESTIMATE*
2010	55,600
2015	63,800
2020	68,900
2025	73,900
2030	78,600
2035	82,700
2040	86,400
2045	90,200
2050	94,500
2055	95,500
2060	96,000

*Information modified from 2006 Arizona Department of Economic Security projections (to 2060).

near the shore line. The Willdan report recommended that the areas below an elevation of 1,000 feet be considered sensitive for cultural remains including historic materials, that the areas above

1,000 feet be considered sensitive until proven otherwise, and that intensive archaeological surveys to identify and, if necessary, evaluate cultural materials precede any proposed activity in areas above 1,000 feet.

The Willdan report also suggested, based on their current data, that the areas below elevations of 1,000 feet above sea level are probably more sensitive for archaeological sites, while the more rugged areas are less likely to yield such remains. The inland areas are likely to yield more trails, isolated finds, and possible repetition of rock feature sites, although densities could not be predicted.

1.6 Zoning

1.6.1 Classifications

Lake Havasu City has established a Zoning Ordinance and an Official Zoning Map. The zoning classifications used by Lake Havasu City are summarized below:

- Single-Family Dwelling Zone (R-l)
- Two-Family Dwelling Zone (R-2)
- Multi-Family Residence Zone (R-3 & R-4)
- Condominium Area (R-5)
- Residential Agricultural Area (R-A)
- Residential Estates (R-E)
- Residential Mobile Home Area (R-MH)
- Light-Agricultural Area (A-1)
- Commercial Area (C-1)
- General Commercial Area (C-2)
- Commercial – Residential (C-R)
- Commercial – Commercial Health District (CHD)
- Mixed Use – Channel Riverwalk (CRW)
- Mixed Use – Uptown McCulloch Mainstreet (UMS)
- Mixed Use – Mixed Use (MU)
- Professional Office Area (C-O)
- Land Use Regulations Industrial Park (M-1P)
- Heavy Manufacturing Area (M-2)
- Golf Course Area (G-C)
- Public Facilities (P-1)

These zoning classifications define permitted uses, conditional uses, and property development standards for the entire area contained within the City limits.

1.6.2 Existing Land Uses

Existing management plans for Lake Havasu City establish land use categories within the City's Water Service Area. The major land uses within the City are residential, commercial/industrial, recreation/resort, and undeveloped. The residential element is dispersed throughout the entire City. The commercial and industrial element is concentrated in narrow strips that parallel the

main traffic routes: Highway 95, Lake Havasu Avenue, North Kiowa Boulevard, and McCulloch Boulevard. The recreation and resort element encompasses the Lake shoreline and the Island, and includes the golf course facilities in the southwestern portion of the City. Undeveloped is the final element, which is located in the northern and eastern parts of the City.
Existing land uses and respective acreages as of March 2010 are summarized in Table 1-3. Developed and undeveloped acreage is shown for each category. Acreage of developed land is based on visual inspections of aerial photography in 2005 coupled with electronic tracking of development conducted from 2005 to the present.

1.6.3 Future Land Uses

The anticipated changes in the existing land uses are outlined in the Lake Havasu City General Plan Update prepared in 2002, and the 2007 City's Water Master Plan Update. The City's land use plan was predetermined in the 1960s. As indicated in the City's planning documents, substantial land absorption will be accounted for by completing development of areas already planned for commerce, industry and residences. In addition, four specific plans were developed to address the variations in growth patterns for sub-areas within the City:

- North Havasu Specific Plan
- Island Specific Plan
- Shoreline Specific Plan
- Havasu Foothills Specific Area Plan

A master plan has been developed for SARA Park, which will consider effluent use for irrigation. Based on the general goals and strategies outlined in the above-listed management plans, projected build out acreage, development units, and density have been estimated for the expanded water service area (Table 1-4), assuming 100 percent development. These land use estimates are based on a build out population of approximately 96,000 people, discussed in Section 1.3.1

In addition to the above land use categories, a Mountain Preserve Protection Area has been designated to keep the foothills of the Mohave Mountains as open space. These areas are mostly designated low density rural residential.

Table 1-3: May 2009 existing land use - percent developed.

ZONING CLASSIFICATION	NET NUMBER OF LOTS	LOTS DEVELOPED	TOTAL ACRES	ACRES DEVELOPED	PERCENT LOTS DEVELOPED
RESIDENTIAL					
R-1	25,912	22,126	8,269	7,016	85
R-2	2,027	1,660	587	484	82
R-E	1,749	1,280	747	633	73
R-A	135	104	203	42	77
RMH	525	506	96	43	96
TOTAL	30,348	25,679	9,902	8,218	85
MULTI-FAMILY					
R-3	1,468	1,090	489	164	74
R-4	1,884	1,518	316	42	81
R-5	918	884	50	484	96
TOTAL	4,270	3,492	855	690	82
COMMERCIAL					
C-1	767	450	291	187	59
C-2	1,228	1,046	560	407	85
C-O	91	68	73	63	75
CHD	130	126	83	81	97
C-R	196	183	65	57	93
TOTAL	2,412	1,873	1,072	795	78
MIXED USE					
MU	2	1	396	1	50
UMS	124	108	28	25	87
CRW	1	0	5	0	0
TOTAL	127	109	429	26	86
INDUSTRIAL					
M-1P	1,860	1,816	689	32	98
M-2	8	2	76	8	25
TOTAL	1,868	1,818	765	40	97
GOLF COURSE					
C-G	2	2	N/A	ALL	100
PUBLIC					
P-1			4,250	N/A	
GROSS TOTALS	39,027	32,973	17,273	9,769 +	84

Refer to Section 1.6.1 for zoning classification explanations. – A-1 not included due to insufficient data.
Source: Development Services Department of Lake Havasu City.

Table 1-4: Projected land use – build-out for the expanded water service area.

LAND USE CATEGORY	TOTAL AREA (acres)	POTENTIAL DWELLING UNITS	DENSITY
Commercial-COM1	1,745	3,219	N/A
Commercial- Nodal	563		
Rural Residential	6198	5,424	1.25
Low Density Residential	15,581	32,721	3.0
Medium Density Residential	95	469	7.0
Industrial-IND1	1,800	1,800	N/A
High Density Residential	957	11,490	15.0
Park/Open Space	7,317	6,455	N/A
Resort	926	926	N/A
Schools-SCH1	278	278	N/A

Expanded Water Service Area (without Desert Hills)
1 Development units in acres.
2 Development units in dwelling units.
3Density in dwelling units per acre.

2.0 WATER SUPPLY

2.1 Water Source

The principal water source for Lake Havasu City is contracted, 4th priority Colorado River water entitlements that will total 28,319 acre-feet/year (ac-ft/yr) by the end of 2010. This amount is a combination of 19,180 ac-ft/yr through an amended Bureau of Reclamation (Reclamation) contract (#14-06-W-203) and 6,000 ac-ft/yr subcontracted (#95-101) with the Mohave County Water Authority (MCWA). The MCWA subcontract was a result of a split in the federal entitlement provided to Kingman, Arizona, who could not economically utilize the water. The City is currently in the process of adding an additional 1,000 ac-ft from the part of the Kingman entitlement not involved in the 1995 subcontract. Additionally, 2,139 ac-ft of 4th priority Colorado River water was secured in 2009 by the City through another MCWA subcontract. This water was part of a much larger, complex acquisition of agricultural water by the MCWA from farmers in the Cibola area of La Paz County, Arizona. The portion of this transaction contracted to the MCWA was re-designated from agricultural to municipal and industrial use. Approximately 1,600 ac-ft of the water kept its original designation and was assigned to La Paz County and to the Bureau of Reclamation's Multispecies Conservation Program. As subcontracted to the City, the water may only be used during a declared Colorado River water shortage or when the City's annual water demand has exceeded its entitlement. Total accessible Colorado River water will be 28,319 ac-ft once the 1995 Kingman grant subcontract has been amended.

The City's practice of reusing treated wastewater for landscape and turf irrigation has lessened the pressure to use treated Colorado River water, thus lowering the City's annual allocation requests. Over 2260 ac-ft of effluent was sold in 2009 to irrigation customers. Effluent will play a larger water management role in the future as the City completes its conversion from residential septic systems to centralize sewer (see Section 5).

Reserved water supplies beyond the Cibola water acquisition include a 2005 firmed water account agreement with the Arizona Water Banking Authority (AWBA) through a subcontract with the Mohave County Water Authority for 119,782 acre-feet of stored water to be accessed when the Secretary of the Interior has declared a water shortage on the Colorado River. Only 113,072 ac-ft has actually been stored in the Lake Havasu City AWBA account to date; however, another 11,992 ac-ft, is expected to be added to the firmed water account in 2010 or 2011 to cover the extra entitlement additions mentioned above. This account will be available to the City until 2096. An additional 950 ac-ft of long-term storage credits were secured in 2003 by the City from the Central Arizona Water Conservation District through the MCWA.

Given the existing land use planning adopted by the City for the existing water service area, the current per capita consumptive use (206 gpcd for 2009 based on billed consumption) and the population and water demand projections, the allocation of 28,319 ac-ft/yr should be sufficient to meet the City's water demands through to build-out population under normal Colorado River supply conditions (see section 3.1).

2.1.1 Colorado River Water Diversion Points

Lake Havasu City primarily diverts water from a 25 MGD capacity, sixteen foot inside diameter, horizontal collector well (HCW) located at London Bridge Beach on Pittsburg Island. This well has the capability of producing up to 32 MGD over short, high demand periods. Nine conventional production wells located in two well fields on the northwest side of the City (7 wells) and on Pittsburg Island (2 wells) are kept in reserve for emergency use (Table 2-1). They are run about once a week to keep them lubricated and fully developed. Four production wells in the South Well Field and one irrigation well in Rotary Park were decommissioned and pumps removed in 2007.

Table 2-1: Lake Havasu City municipal water wells coordinates, depths, and Arizona Department of Water Resources registration numbers.

Well	Longitude	Latitude	Depth	Arizona Dept. of Water Resources 55-registration #
Horizontal Collector Well	114° 20' 54"	34° 27' 54"	103	55-571246
LHC Well#2	114° 21' 5"	34° 28' 6"	163	55-606030
LHC Well#9	114° 20' 57"	34° 28' 6"	175	55-527469
LHC Well#18	114° 21' 36"	34° 30' 27"	450	55-513061
LHC Well#15	114° 21' 36"	34° 30' 24"	550	55-606040
LHC Well#14	114° 21' 36"	34° 30' 19"	509	55-606039
LHC Well#13	114° 21' 36"	34° 30' 12"	429	55-606038
LHC Well#10	114° 21' 36"	34° 30' 5"	550	55-606035
LHC Well#11	114° 21' 36"	34° 30' 4"	439	55-606036
LHC Well#12	114° 21' 36"	34° 30' 1"	553	55-606037
Queens Bay Well	114° 20' 37"	34° 28' 99"	80	55-511667
Memorial Gardens Cemetery Well	114° 21' 40"	34° 30' 50"	N/A	55-807341
South Intake	114° 20' 11"	34° 27' 31"	N/A	N/A

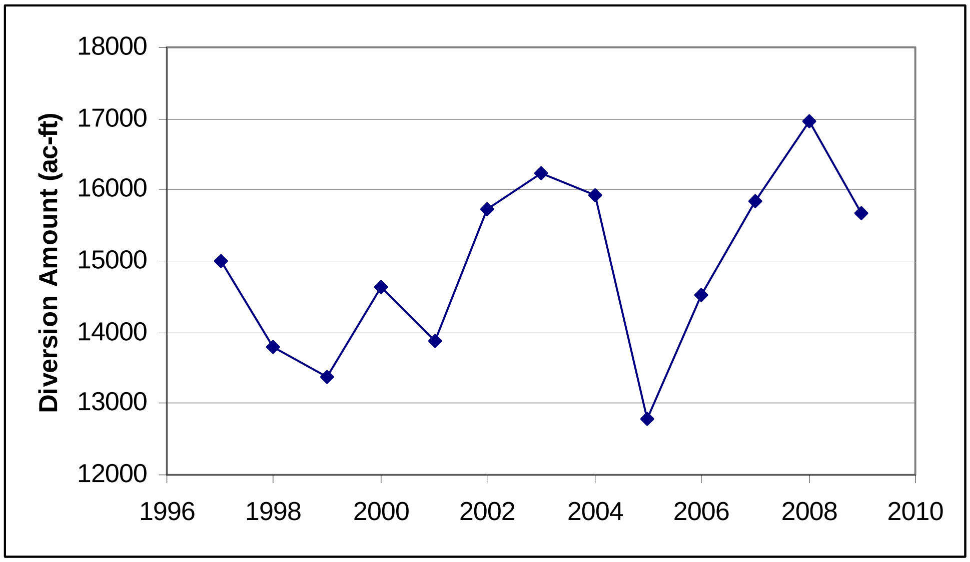

Figure 2-1: Lake Havasu City's Colorado River annual diversions from 1997 to 2009. The 2005 diversion reflects an unusually wet winter/spring period and the 2008/2009 diversions are probably higher than what was really pumped due to meter inaccuracy issues at the entrance to the City's water treatment plant. Those issues have been addressed for 2010.

All wells penetrate the Colorado River Aquifer, which is hydrologically connected to the Colorado River/Lake Havasu. Two private water wells for landscape irrigation are included in the City's accounting of its annual allocation. These wells were established early in the City's history and provide untreated water to a golf course and to a cemetery lawn. Raw lake water is seasonally withdrawn through a surface water intake (called the South Intake), approximately 300 feet from shore and 15 feet below the water surface, to supplement effluent from the City's Mulberry Wastewater Treatment Plant (WWTP). The mix of effluent and lake water is then pumped to the 36-hole London Bridge Golf Course for irrigation. The South Intake typically provides from 1.0 to 1.5 million gallons per day (mgd) of raw water during the summer months for golf course irrigation.

2.1.2 Effluent

Lake Havasu City is currently being served by three wastewater treatment plants. The Island WWTP, located on Pittsburgh Island, has an ultimate design capacity of 2.5 mgd. Approximately 50 percent of the treated effluent from the Island Plant is reused; the balance is disposed in percolation/evaporation ponds. The Mulberry WWTP, located just east of the intersection of Arizona State Route 95 and Mulberry Avenue, has an ultimate design capacity of 2.2 mgd and virtually 100 percent of the treated effluent from the Mulberry WWTP is reused for golf course irrigation. The third and newest wastewater treatment plant, known as the North Regional WWTP, currently has a 3.5 MGD capacity, but can be expanded to an ultimate capacity of 14.0 mgd. This plant contains advanced ultra-filtration membrane technology to filter out particulates, bacteria and viruses down to 0.04 microns. Some of this effluent is injected into the subsurface through vadose zone wells for storage and the rest to either a golf course or to the Island WWTP percolation ponds (see Section 5 – Effluent Reuse)

2.2 Water Utility

Lake Havasu City owns and operates a functional water distribution system including wells, treatment plant, booster stations, transmission and distribution lines and storage facilities, most of which were constructed in the 1960s and the 2000s. The service area includes most of the area within the City limits plus an expanded water service area that is approximately one section wider than the City limits to the north, east and south. The Service Area comprises approximately 56 square miles. However, not all of the residents of Lake Havasu City are within its water service area. Approximately 555 acres of the northwest part of the City and approximately 3000 acres outside the city limit in Mohave County are included in the Arizona-American Water Works Company water service area, a private water provider. Arizona-American has a separate 4th priority Colorado River diversion contract with Reclamation.

2.2.1 Water Production and Treatment

Water pumped from all municipal wells is transported via a 48 inch diameter pipeline to the City's water treatment plant. Incoming water is metered and aerated before treatment with ferric chloride to precipitate arsenic. Water is then fed through sand filter beds containing bacteria that utilize and remove manganese, iron and other elements from the water. Water then enters an ultraviolet radiant system and into a chlorine basin for final disinfection before sent into the distribution system. Water used in the treatment process is separated from the solid contents and re-circulated through the plant again. Water is sent out of the facility through a high-service pump station into one of two major distribution lines, one serving the south and central part of the city and the other serving the north part of the city. The current capacity of the treatment plant is 26 MGD with the potential to expand to 32 MGD. Lake Havasu City's 2007 Water Master Plan Update suggests the city begin plans to expand within the next fives years; however, this recommendation was submitted before the economic recession. Even so, the City is embarking on an exploratory program to find a second horizontal collector well location, which will allow for more flexible water source management, and either the water treatment plant will be expanded or a second water treatment plant will be constructed.

2.2.2 Distribution

The two main distribution lines from the water treatment plant connect with four major transmission systems, the north airport, north, south, and the central transmission systems, each of which convey water through a series of pump stations out to the distribution system in the various pressure zones. The sizes of the transmission mains are 30 inches to the north part of the City and 36 inches to the central and southern parts of the City.

Lake Havasu City owns, operates and maintains 15 booster pumping stations (including the south intake, which pumps water from the lake up to the commingling pond and then up to the golf courses) serving seven pressure zones throughout the City (Figure 2-2). Each booster station is controlled by radio signals communicated from the controlling reservoir for that booster station.

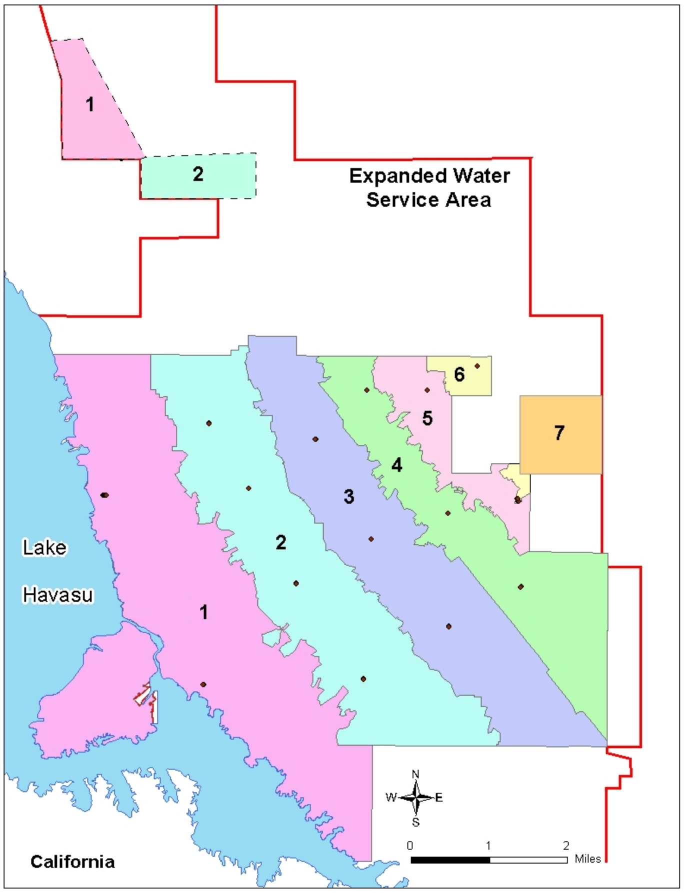

Figure 2-2: Water Pressure zones (1-7) and pump stations (dots) in Lake Havasu City for water distribution reflecting the City's 2-4^{o} southwest sloping topography. Water from one series of pump stations is forced to the next pressure zone and gravity fed to customers. As a result the tops of each pressure zone have much lower pressure (24-50 psi) than the bottoms of each pressure zone (up to 170 psi).

The controlling reservoir is the reservoir receiving water from the booster station. The high service pump station at the water treatment plant takes suction directly from the treated water clear-well located on-site, and pumps to Zone 1. All other booster stations utilize the storage reservoir adjacent to it as the suction supply and pump to the next pressure zone. Water is gravity fed from the storage tanks creating highly varied pressure conditions in the rest of the distribution system. Top of zone pressure ranges from 24 - 50 psi and bottom of zone pressures are up to 170 psi, requiring customers to have pressure regulators installed.

2.2.3 Storage

Water storage facilities in Lake Havasu City are used to equalize pumping rates into the distribution system and to provide a reserve of water for fire fighting and emergency purposes. As the volume of water in a storage reservoir fluctuates during the day, the minimum amount of water stored in the reservoir is considered to be the effective quantity available for fire fighting and emergency use. The City's continuing goal is to have reservoir storage capacity capable of meeting the following three storage requirements:

- ***Operational Storage*** - Operational storage is provided to balance out the daily demand fluctuations so that extreme demand variations will not be imposed on the sources of supply. A volume of water should be stored during periods of less than average water use sufficient to allow water to be returned to the system to meet the increased demands during periods of high water use. This volume of water is also referred to as equalizing storage and allows the sizing of water production facilities to be based on the maximum day demand rather than the peak hour demand. No specific criteria are established to determine the exact amount of operational storage required for a water supply system, although a conservative value used is 20 to 25 percent of one maximum day's water usage. In the 2007 Water Master Plan Update prepared for Lake Havasu City, the volume requirement for operational storage was set at 25 percent of one maximum day's water use.

- ***Fire Flow Storage*** - Fire storage provides a readily available source of water for fire fighting. In the event of a major fire on a day of maximum water use, water production facilities may not be able to meet the fire demand and domestic demand concurrently. The amount of water to be stored for this purpose is determined by the land use in the area served by that system. Lake Havasu City Fire Department follows the flow guidelines issued in the 2003 International Fire Code Commentary by the International Code Council. Recommended flow rates are based on building type and size and are presented in Table 2-2. Total fire reserve storage has been assessed at 14.63 MG in the 2007 Water Master Plan Update.

- ***Emergency Storage*** - Emergency storage provides a source of water to allow for a continued supply during power outages, mechanical failures, transmission line failures, and scheduled maintenance of facilities. Emergency storage for the Lake Havasu system was estimated at 2.23 MG in the 2007 Water Master Plan Update based on providing adequate storage to meet maximum day demand for a 4-hour period. The amount of emergency storage is an owner option based on an assessment of risk and the desired degree of system dependability.

Lake Havasu City typically stores 18.8 MG in 27 storage tanks, including the 2.5 million gallon clear-well at the new water treatment plant. This is not full capacity, which is 23.155 MG, but an operational storage to allow for fluctuations in supply/demand. Two tanks are hydropneumatic tanks that are used for providing pressure in Zones 6 and 6A; these tanks are 5,000 gallons each and are considered negligible in terms of storage capacity. The existing reservoir capacity by pressure zone is summarized in Table 2-3. All existing storage tanks, except the 0.15 MG-bolted steel tanks, are of welded steel construction. The 2007 Water Master Plan Update has recommended that the City have 34.5 MG in storage capacity at build-out population of 97,000.

2.2.4 Water Measurement/Accounting

Municipal water provided to all water service area customers is metered upon entry onto the customer's property. Meter readers visually inspect meter condition and record water usage monthly at each meter. The readings are forwarded to the City's Finance Department, which issues invoices to the users. Lake Havasu City's 2009 annual consumption by user class and the number of water accounts as of January 2010 are shown in Table 2-4 (also Figure 3-2), which also indicates that approximately 93 percent of all of Lake Havasu City's water accounts are of the residential type. Residential accounts consume 73% of the City's total water usage compared with approximately 8 percent of the total for commercial accounts. Unmetered water listed in Table 2-4 is water used for hydrant flushing, fire control, and other city related activities.

2.2.5 Water Pricing/Billing

Current water pricing structure is established by City Code and outlined in Lake Havasu City Operating Policy and Procedure 5.100.99 of the Rules and Regulations of the Lake Havasu Irrigation and Drainage District. These rates have been in effect since August 1, 2009. In addition to the actual usage billed to each customer every month, a fee is charged for administrative costs associated with the account, and is based on the size of the service meter. The monthly meter charges for all types or classes of service are given in Table 2-5 and the quantitative charges for the amount of water used on a monthly basis are given in Table 2-6. The 2009 residential rate change and structure modified previous rate structures in that the lowest tier ceiling volume is 1300 cu. ft. instead of 1500 cu. ft., and the first tier rate has been lowered from $1.48 per 100 cu. ft. to $1.35 per 100 cu. ft. The upper tiers experienced rate increases with lowered tiered ceiling volumes. The structure is to help encourage citizens to use less water and reward those who do.

2.2.6 Operation and Maintenance Program

The City currently has documented an extensive maintenance plan for the water system. A rigorous well and booster station maintenance schedule has been established, as well as monitoring and maintenance of reservoirs, flushing of distribution system lines originating from citizen complaints, chlorination facilities, hydropneumatic systems and visual inspections of transmission line routes. Also, water meter installation and service/main line repairs have been documented in the City's Operation and Maintenance Records.

Table 2-2: Minimum required fire flow and flow duration for buildings[a].

FIRE-FLOW CALCULATION AREA (square feet)					**Fire Flow (gallons per minute)[c]**	**FLOW DURATION (hours)**
Type IA and IB[b]	**Type IIA and IIIA[b]**	**Type IV and V-A[b]**	**Type IIB and IIIB[b]**	**Type V-B[b]**		
0-22,700	0-12,700	0-8,200	0-5,900	0-3,600	1,500	2
22,701-30,200	12,701-17,000	8,201-10,900	5,901-7,900	3,601-4,800	1,750	
30,201-38,700	17,001-21,800	10,901-12,901	7,901-9,800	4,801-6,200	2,000	
38,701-48,300	21,801-24,200	12,901-17,400	9,801-12,600	62,01-7,700	2,250	
48,301-59,000	24,201-33,200	17,401-21,300	12,601-15,400	7,701-9,400	2,500	
59,001-70,900	33,201-39,700	21,301-25,500	15,401-18,400	9,401-11,300	2,750	
70,901-83,700	39,701-47,100	25-501-30,100	18,401-21,800	11,301-13,400	3,000	3
83,701-97,700	47,101-54,900	30,101-35,200	21,801-25,900	13,401-15,600	3,250	
97,701-112,700	54,901-63,400	35,201-40,600	25,901-29,300	15,601-18,000	3,500	
112,701-128,700	63,401-72,400	40,601-46,400	29,301-33,500	18,001-20,600	3,750	
128,701-145,900	72,401-82,100	46,401-52,500	33,501-37,900	12,601-23,300	4,000	4
145,901-164,200	82,101-92,400	52,501-59,100	37,901-42,700	23,301-26,300	4,250	
164,201-183,400	92,401-103,100	59,101-66,000	42,701-47,700	26,301-29,300	4,500	
183,401-203,700	103,101-114,600	66,001-73,300	47,701-53,300	29,301-32,600	4,750	
203,701-225,200	114,601-126,700	73,301-81,100	53,301-58,600	32,601-36,000	5,000	
225,201-247,700	126,701-139,400	81,101-89,200	58,601-65,400	36,001-39,600	5,250	
247,701-271,200	139,401-152,600	89,201-97,700	65,401-70,600	39,601-43,400	5,500	
271,201-295,900	152,601-166-500	97,701-106,500	70,601-77,000	43,401-47,400	5,750	
295,901-Greater	166-501-Greater	106,501-115,800	77,001-83,700	47,401-51,500	6,000	
-	-	115,801-125,500	83,701-90,600	51,501-55,700	6,250	
-	-	125,501-135,500	90,601-97,900	55,701-60,200	6,500	
-	-	135,501-145,800	97,901-106,800	60,201-64,800	6,750	
-	-	145,801-156,700	106,801-113,200	64,801-69,600	7,000	
-	-	156,701-167,900	113,201-121,300	69,601-74,600	7,250	
-	-	167,901-179,400	121,301-129,600	74,601-79,800	7,500	
-	-	179,401-191,400	129,601-138,300	79,801-85,100	7,750	
-	-	191,401- Greater	138,301-Greater	85,101-Greater	8,000	

For SI: 1 square foot = 0.0929 m^2, 1 gallon per minute = 3.785 L/m, 1 pound per square inch = 6.895 kPa.

a. The minimum required fire flow shall be permitted to be reduced by 25 percent for Group R.

b. Types of construction are based on the I*nternational Building Code.*

c. Measured at 20 psi.

Table 2-3. Existing storage capacity.

PRESSURE ZONE	LOCATION	TANK SIZES	CAPACITY (million gallons)
North System	Station 1A	1 @ 1.00 MG	1.00 MG
	Station 1B	2 @ 1.00 MG	2.00 MG
	Station 2A	2 @ 1.00 MG	2.00 MG
	Station 3A	1 @ 1.00 MG, 1 @ 0.25 MG	1.25 MG
	Station 4A	1 @ 1.00 MG, 1 @ 0.25 MG	1.25 MG
	Station 5A	1 @ 0.005 MG	0.005 MG
	Pneumatic Tank	1 @ 0.005 MG	0.005MG
	North Airport	1 @ 2.00 MG	2.00MG
Total Storage for North System			**9.51 MG**
Central System	Station 1	1 @ 1.00 MG, 1 @ 0.25 MG	1.25 MG
	Station 2	1 @ 1.00 MG, 1 @ 0.25 MG	1.25 MG
	Station 3	1 @ 0.50 MG, 1 @ 0.25 MG	0.75 MG
	Station 4	1 @ 1.00 MG, 1 @ 0.25 MG	1.25 MG
	Pneumatic Tank	1 @ 0.005MG	0.005 MG
Total Storage for Central System			**4.505 MG**
South System	Station 1C	2 @ 1.00 MG	2.00 MG
	Station 2C	2 @ 1.00 MG	2.00 MG
	Station 3C	2 @ 1.00 MG	2.00 MG
Total Storage for South System			**6.00 MG**
Water Treatment Plant			2.5 MG
Lake Havasu City Airport Fire Pump System			0.15 MG
Total Water Full Storage			**23.155 MG**

Table 2-4. 2009 Water consumption and number of accounts by user class in January 2010.

USER TYPE	NUMBER ACCOUNTS JANUARY, 2010	2009 ANNUAL WATER CONSUMPTION BY USER CLASS (CUBIC FEET)	PER ACCOUNT (CUBIC FEET)	PERCENT OF TOTAL
Residential	25,041	328,561,840	13,121	59.03%
Residential – Multi Family	1,332	43,596,860	32,730	7.83%
Commercial	901	42,713,384	47,407	7.67%
Restaurants and Hotels	137	11,873,466	86,668	2.13%
Schools	37	6,981,254	188,683	1.25%
Industrial	7	634,551	90,650	0.11%
Construction	56	5,652,584	100,939	1.02%
Golf Course – South Intake	1	20,845,201	20,845,201	3.74%
Irrigation	1,622	77,145,521	47,562	13.86%
Well Water	2	17,321,200	8,660,600	3.11%
Unmetered Water Use		1,308,529		0.24%
Total	29,136	**556,634,390**		100.0
Residential – including irrigation	26,036	365,068,325		65.58
All Others	1,947	191,566,065		34.41
Total Acre Feet Pumped		15,683		100.00
Total Acre Feet Metered		12,779		81.48
Total Acre Feet Unaccounted		2,904 (Discrepancy Includes Metering Inaccuracies at the Water Treatment Plant – corrected for 2010)		18.51 (See Water Consumption Column for Explanation)

Table 2-5. Water rates based on diameter of service line.

<u>Size of Service</u>	<u>In-District</u> <u>Monthly Base Charge</u>	<u>Out of District</u> <u>Monthly Base Charge</u>
Up to ¾ inch	$5.16	$6.45
1 inch	$8.17	$10.21
1 ½ inch	$16.69	$20.86
2 inch	$28.17	$35.21
3 inch	$52.66	$65.83
4 inch	$97.09	$121.36
6 inch	$198.95	$248.69
8 inch	$283.91	$354.89

Table 2-6: 2009 Water rate structure based on quantity consumed.

WATER RATES

SINGLE FAMILY RESIDENTIAL

Quantity Used	In District Charge Per 100 Cubic Feet	Out of District Charge Per 100 Cubic Feet
0 – 1,300 cubic feet	$1.35	$1.69
1,301 – 2,500 cubic feet	$1.76	$2.20
2,501 – 5,000 cubic feet	$2.16	$2.70
Over 5,001 cubic feet	$2.70	$3.38

MULTI-FAMILY RESIDENTIAL

Quantity Used	In District Charge Per 100 Cubic Feet	Out of District Charge Per 100 Cubic Feet
0 – 2,600 cubic feet	$1.35	$1.69
2,601 – 5,000 cubic feet	$1.76	$2.20
5,001 – 200,000 cubic feet	$2.16	$2.70
Over 200,000 cubic feet	$2.70	$3.38

COMMERCIAL / INDUSTRIAL

Quantity Used	In District Charge Per 100 Cubic Feet	Out of District Charge Per 100 Cubic Feet
0 – 31,500 cubic feet	$1.76	$2.20
31,501– 340,000 cubic feet	$2.16	$2.70
Over 340,000 cubic feet	$2.70	$3.38

Table 2-6 Continued: 2009 Water rate structure based on quantity consumed

IRRIGATION RATES

SINGLE FAMILY RESIDENTIAL

Quantity Used	In District Charge Per 100 Cubic Feet	Out of District Charge Per 100 Cubic Feet
0 – 1,200 cubic feet	$1.76	$2.20
1,201 – 3,700 cubic feet	$2.16	$2.70
Over 3,700 cubic feet	$2.70	$3.38

OTHER

Quantity Used	In District Charge Per 100 Cubic Feet	Out of District Charge Per 100 Cubic Feet
0 – 16,000 cubic feet	$1.76	$2.20
16,001 – 89,000 cubic feet	$2.16	$2.70
Over 200,000 cubic feet	$2.70	$3.38

RV PARKS

Quantity Used	In District Charge Per 100 Cubic Feet	Out of District Charge Per 100 Cubic Feet
0 – 39,000 cubic feet	$1.35	$1.69
39,001– 86,000 cubic feet	$1.76	$2.20
86,001 – 150,000 cubic feet	$2.16	$2.70
Over 150,000 cubic feet	$2.70	$3.38

HYDRANTS

Quantity Used	In District Charge Per 100 Cubic Feet	Out of District Charge Per 100 Cubic Feet
All	$2.70	$3.38

2.3 Quality of Water Supply

As mentioned in section 1.8.1, Lake Havasu City's sole raw water source is from the Colorado River and its hydraulically connected Colorado River Aquifer through a series of groundwater wells and one direct lake intake. All drinking water is diverted from the wells, primarily from the City's horizontal collector well, and pumped through a water treatment facility capable of removing arsenic, manganese and iron. The water is also subjected to ultraviolet radiation and chlorine disinfection to destroy microorganisms at the water treatment facility. A compliance schedule monitoring specific elements, compounds and biologic components is in place through Arizona Department of Environmental Quality regulations (Table 2-7).

Table 2-7: Constituents monitored with frequency schedules for compliance with safe drinking water standards regulated by the Arizona Department of Environmental Quality.

Constituent	Sampling Frequency	Maximum Concentration Load	Next Scheduled Sample Event
pH, DO, Alkalinity., TDS, NH3, Hardness, Calcium	Twice per week	2nd; TDS-500mg/l & pH – 6.5-8.5	Every week
Lead and Copper	3 years		01/01/11
Volatile Organic Compounds	Quarterly	6 years	01/01/14
Maximum Residual	Monthly	various	Every month
Trihalomethane	Quarterly	0.08 mg/l	Each yearly quarter
Halocetic Acid	Quarterly	0.60 mg/l	Each yearly quarter
IOC's 141.23	3 years		01/01/11
SOC-PCB-Aroclor	3 years		01/01/11
Asbestos	9 years		01/02/14
Total coliform	Monthly	None	Every month
Nitrate	Annual	10 mg/l	01/01/11
Nitrite	9 years		01/01/14
Sulfate	No Schedule	2nd; 250 mg/l	n/a
Fluoride	No Schedule	4.0 mg/l	n/a
Chloride	No Schedule	2nd ; 250 mg/l	n/a
Arsenic	Weekly	0.01 mg/l	Weekly
Iron	Weekly	2nd ; 0.3 mg/l	Weekly
Manganese	Weekly	2nd ; 0.05 mg/l	Weekly
Radionuclide; Ra 226&228	6 years	5 pCi/L	01/01/14; 01/01/11

2nd – Secondary MCL goals

2.3.1 Groundwater

Colorado River Aquifer water quality is determined by sampling municipal wells and monitoring wells within the Lake Havasu Basin at varying intervals depending whether the constituent is under compliance through the Safe Drinking Water Act, through Aquifer Protection Permits issued by the ADEQ for wastewater disposal, or for non-compliance water quality studies. The water is generally classified as sodium chloride type with a significant sulfate component (Table 2-8). Groundwater from wells located approximately two miles from Lake Havasu tends to be more chloride rich and groundwater close to the lake contains more sulfate, calcium and magnesium.

Chloride, pH, manganese, sulfate, and total dissolved solid (TDS) values in groundwater within the basin can occur above the respective secondary MCLs. Chloride and sulfate concentrations 0have been detected as high as 1,258 mg/l and 972 mg/l, respectively, but the typical ranges are exemplified in Table 2-8. Multiple field recordings of groundwater pH, when collecting water samples, average from 7.5 to 9.7. TDS was detected at concentrations ranging from 204 to 1,770 mg/L, with higher TDS values from wells less than one mile from the lake. Manganese was detected at concentrations ranging from <0.01 to 1.44 mg/l in the Lake Havasu City municipal

Table 2-8: Average concentrations of major constituents in groundwater from the Lake Havasu basin. The City's main drinking water source, the horizontal collector well (HCW) and one reserve municipal well, well #12, are compared with two monitoring wells located about 1.5 to 2.5 miles from the lake, one near the center of the city (MW-3) and the other outside the developed area (NP-2).

Well	**TDS**	**Hardness**	**Ca^{+2}**	**Na^{+}**	**Mg^{+2}**	**SO_4^{-2}**	**Cl^{-}**	**HCO_3^{-}**	**NO_3^{-}**	**F^{-}**
HCW	780	340	85	140	32	280	140	170	0.8	0.72
Well #12	760	360	82	150	38	270	180	150	0.6	0.74
NP-2	770	n/a	35	237	3.1	144	262	97	2.0	5.65
MW-3	610	96	30	170	5.2	80	85	169	4.6	8.29

wells, but is consistently below 0.3 mg/l from the horizontal collector well. Lake Havasu City's new water treatment plant, which biologically removes essentially all the manganese from the influent water pumped from the horizontal collector well has removed the impetus of periodic flushing of "black" water at street hydrants around the city.

Fluoride and nitrate concentrations at several sample locations within the basin occur at concentrations above their respective maximum contaminant levels (MCL). The MCL for fluoride is 4.0 mg/l and concentrations of this analyte range up to 8.4 mg/l. Most of the high concentrations are in groundwater traveling through felsic volcanic rocks of the Mohave Mountains foothills that leach this constituent. The groundwater emanates from confined aquifer conditions to mix with groundwater of the Colorado River Aquifer such that the concentrations decrease westward, away from the foothills and towards Lake Havasu. Fluoride in municipal water wells is below 2.0 mg/l, the secondary MCL for fluoride.

The MCL for nitrate is 10.0 mg/l and concentrations of this analyte occur up to 26 mg/l in monitoring wells within the developed areas of the city, particularly in a zone between 1000 feet from the Lake Havasu eastern shoreline and approximately one mile from the shoreline. However, within 1000 feet of the shoreline, where all municipal water wells occur, nitrate concentrations are generally below 3 mg/l. A groundwater model indicates that oscillations in Lake Havasu's level, which occur on several scales (i.e. diurnal, monthly, seasonal), cause an intermixing transition zone between groundwater unaffected by these oscillations and the lake body. This transition dilutes nitrate concentrations in westward flowing groundwater that comingles with infiltrating lake water. Nitrates are presumably sourced from thousands of septic tanks that once occupied almost all of the residential parcels in the city. Nitrate concentrations in the Colorado River Aquifer outside of the developed portion of the city are less than 2 mg/l.

Lake Havasu City is entering its final year of a nine year wastewater expansion program to decommission over 22,000 septic tanks, eliminating much of the nitrate sources. However, a very flat groundwater gradient coupled with the paucity of precipitation for recharging the aquifer keep the residual nitrate in the aquifer from quickly flushing through the system. A nitrate monitoring program has been in place since 2005 and will continue to track nitrate concentrations well after the wastewater expansion program has ended.

2.3.2 Surface Water

Surface water and groundwater quality data from federal, state, regional, commercial and academic sources for the Lower Colorado River, including Lake Havasu, will soon be available from the Southern Nevada Water Authority's water quality database. This compilation will be the result of a seven year agreement (beginning in 2009) between the Colorado River Regional Sewer Coalition, a group of local and regional sewer and water providers using Colorado River water (Lake Havasu City is a member), and the Lower Colorado River Region of the Bureau of Reclamation. Data will be mapped according to GPS location and displayed in a number of ways, including using a GIS interface map.

Most water quality information for Lake Havasu has been collected by the Metropolitan Water Company of Southern California and by the Arizona Department of Environmental Quality. Whereas none of the available information indicates that the surface water contains any regulated constituents greater than their designated maximum concentration load as set by the U.S. Environmental Protection Agency, water quality may be impacted from several sources. Nutrient loading through near river/reservoir septic tank effluent and agricultural fertilized fields provides nitrate-nitrogen for uptake in aquatic photosynthetic organisms. Nutrient loading has helped with significant increases in aquatic plant populations, particularly spiny naiad and various types of algae, which have nuisance and maintenance issues. Increased phytoplankton has helped quagga mussel populations expand. Added sediment loading from side ephemeral washes may also bring in nutrient supplies for bacterial growth, particularly *E. coli* during the warm summer months. Other potential concerns on the lower Colorado River include hexavalent chromium plumes migrating to the system, uranium tailings from active and inactive mines on the Colorado Plateau, hydrocarbons from recreational water vehicles, and pharmaceutical and other endocrine disruptive compounds.

2.3.2.1 Inorganic Constituents

Because the Colorado River Aquifer (CRA) is in direct hydraulic connection with the surface water of the Colorado River, the inorganic constituents in surface water should be similar to the groundwater where the municipal wells are located. However, groundwater is also percolating from the Mohave Mountains, mixing with the CRA and the sand and gravel sediments also contain leaching constituents, which together, increases the manganese, arsenic, iron, and fluoride content of the groundwater (see Section 2.1.1).

2.3.2.2 Organic Constituents

Certain organic compounds capable of producing adverse health effects can be found in some surface waters, usually in small quantities. Chlorinated organic compounds, specifically chlorinated hydrocarbons, may be the most significant organic compounds in drinking water in terms of potential health risk. Reactions between naturally occurring organic materials such as humic and fulvic acids (precursors), and chlorine used for disinfection are likely sources of chlorinated organics, particularly trihalomethanes (THMs). The formation of trihalomethanes is dependent on time and the concentrations of organics, chlorine, and bromine. With chlorine added as a disinfectant as the water is pumped into the system, THM formation occurs primarily after the water has entered the distribution system.

Two tests which serve as indicators for THM formation are trihalomethane formation potential (THMFP) and total organic carbon (TOC). Based on the data obtained on these parameters from sampling in the HCW, it appears that THM formation in the distribution system, after treatment, would be well below the current MCL of 100 parts per billion (ppb).

Pharmaceutical and other endocrine disruptive compounds were sampled by Lake Havasu City between 2007 and 2008 in two locations, in Thompson Bay of Lake Havasu, which is well within urban development, and in the Colorado River north of all urban development in the Lake Havasu Basin. They were also analyzed from HCW and water treatment plant samples. Constituents analyzed consist of those thought to be very persistent in the environment or of interest to researchers for their potential influence on bacteria. Of the 30 plus constituents analyzed, up to seventeen compounds were detected in the surface water and six from the HCW (Table 2-9).

2.3.2.3 Microbiological Parameters

Microbiological organisms that are commonly found in surface water supplies include bacteria, viruses, and protozoa. To achieve 4-log (99.99 percent) removal of viruses and 3-log (99.9 percent) removal of giardia cysts, disinfection, filtration, and adequate disinfectant contact time must be provided as part of the surface water treatment process. Microscopic particulate analysis results did not indicate the presence of giardia, coccidian, or total coliform in water samples collected from the HCW.

Table 2-9: Pharmaceuticals and other organic endocrine disruptive compounds analyzed and detected in Lake Havasu's Thompson Bay, in the Colorado River just north of Lake Havasu, from the city's horizontal collector well (HCW) and from the city's water treatment plant (WTP) between 2007 and 2008. All values are in ng/l (parts per trillion).

Compound	Compound Use	**Colorado River**	**Thompson Bay**	**HCW Average**	**WTP Average**
Atenolol	Heart regulator	**2.2**	**1.7**	ND	ND
Caffeine	Stimulant	**7.4**	**12.4**	ND	ND
Carbamazepine	Anticonvulsant	**4.0**	**3.1**	**18.4**	**14.6**
Dilantin	Antiepileptic	**4.0**	**3.9**	**4.52**	**4.3**
Gemfibrozil	Lowers lipid levels	**0.5**	**0.4**	ND	ND
Ibuprofen	Anti-inflammatory	ND	**1.6**	ND	ND
Meprobamate	Tranquilizer	**10.9**	**10.7**	**1.78**	**1.1**
Primidone	Anticonvulsant	**3.1**	**3.0**	**14.4**	**15.2**
Sulfamethoxazole	Antibiotic	**12.5**	**9.5**	**21.2**	ND
Triclosan	Chlorinated aromatic	**2.1**	ND	ND	ND
Trimethoprim	Antibiotic	**0.4**	**0.4**	ND	ND
Methamphetamine	Illicit psychotic	**14.0**		ND	ND
MDMA (ecstasy)	illicit psychotic	**30.0**	**2.0**	ND	ND
Atrazine	Herbicide	**1.3**	**1.2**	**0.608**	**0.6**
DEET	Insecticide	**7.0**	**8.4**	ND	ND
TCEP	Reducing agent	**11.9**	**8.1**	ND	ND
TCPP	Flame retardant	**116.0**	**120.0**	ND	ND

3.0 HISTORIC AND PROJECTED WATER DEMANDS AND WATER SYSTEM DEFICIENCIES

3.1 Water Demand

Well water measured through a meter at the City's water treatment plant and lake water measured through the City's South Intake lake diversion, are both reported in acre-feet per month (ac-ft/mo) (Table 3-1). Highest water consumption occurs from May through October, which correlates with a combination of recreational impacts and the higher water demands of the summer season. The average amount of water pumped during this period ranges from 1,500 to 1,900 acre-feet per month; November through April, consumption is between approximately 900 to 1,400 ac-ft/mo (Table 3-2). Metered diversions reported at the end of each month do not necessarily equate with volume of water consumed. Billed consumption is determined through individual customer meters read and reported at different times of a given month, so within certain months, the volume used can actually be slightly larger than the volume diverted. However, over a year's time, the billed consumption should be close to the diversion volume minus unaccounted water losses, which can compose from 7% to 12% of the total water diverted. Over the past two years (2008-2009); however, the difference between Lake Havasu City's diversion and billed consumption has been up to 20% due to metering inaccuracies at the City's water treatment plant. This issue has been resolved for the 2010 reporting year.

Water usage is also typically reported by combining billed consumption with population estimates from the Arizona Department of Commerce to calculate a per capita consumption given in gallons per person per day (gpcd). This unit is an easy way to compare a water provider's total demand through time and a way to compare with other water providers, yet a per capita approach is most valid when considering individual use. Lake Havasu City's total water demand and residential water use has leveled off over the past eight years (Figure 3-1) due to a combination of water conservation measures and the association of monthly sewer charges with winter water consumption. The billed per capita consumption of Lake Havasu City has decreased from 250 gpcd since 1998 and to near 206 gpcd in 2009. Residential per capita use, which includes water volumes from single and multi-family residential irrigation meters since 2006, has also fallen to just above 150 gpcd. These accounts composed 73% of Lake Havasu City's total water use in 2009 Figure 3-2). The other 27% consumption came from businesses, schools, park irrigation and industry, which would not accurately reflect a per capita consumption based on population.

Projecting the City's water needs into the future given population projections is not straightforward. Population projections from the Arizona Department of Commerce have not been revised since 2006, yet yearly estimates indicate that these projections are very much obsolete due to the economic recession that began in 2008. Results from the 2010 census will help correct future population estimates. However, many people have lost their homes due to foreclosure and many more people living permanently outside of Arizona have bought vacation homes in the city. City staff estimate that between 25% and 30% of the homes in the water service area are vacant at any given time, which of course precludes accurate population counts at any given time regardless of the census results. The frequency of occupation of these homes ranges from periodic weekend visits by people who live within 6-7 hours drive of the city to six plus month stays from visitors escaping northern latitude winter weather. Many of these homes have active water accounts, which are sparsely utilized most of the calendar year, with the possible exception of landscape irrigation. If demographics change in the future to where people begin to occupy these homes permanently, then the per capita consumption could be affected without the city necessarily experiencing significant growth or new construction.

The decreasing water consumption trends for the City are also influenced by the way the City is financing its $350 million wastewater expansion program, which averages winter water consumption for residences and compares the mean volume to a corresponding monthly fee, established on a sewer rate table, that is fixed the rest of the year. Residents are encouraged to conserve on water to get the lowest sewer charge possible. This fee structure has been in place since the inception of the sewer expansion program in 2002 and could continue until loans used to pay for sewer construction costs have been paid (up to 30 years from 2010). If a different funding mechanism replaces the current one that does not depend on water usage, then the incentive to conserve during the winter may disappear. With both vacancy and sewer fee concerns in mind, which cannot be reliably quantified to be included in water demand projections, two water demand projections have been produced instead of one. One is based on a modified population projection trend modeled from the recent population estimates published by the Arizona Department of Commerce (Figure 3-3a) and the other takes population considerations out of the equation. The second set is based on water consumption trends and either forecasted using a linear algorithm or an exponential growth expression (Figure 3-3b). In each case, the projections indicate that the City may have enough water for increasing demand to the build-out population of 97,000 or at least to 2060 under normal water supply conditions and keeping per capita consumption at respectable levels. Since these projections do not consider the above issues, new projections will have to be constantly generated to reflect changes in the community that would affect the water consumption rate.

The dashed "Shortages" lines in both figures indicate expected declines in the City's entitlement due to federally declared Colorado River water Shortages. These estimates are based on modeling results from the Arizona Department of Water Resources. Lake Havasu City's 4th priority status thrusts the city to the forefront of future water supply uncertainty as the City's entitlement will be among the first to be affected (see Section 4).

Table 3-1:. Monthly water diversions from 2000 to 2009.

Acre-Feet Pumped	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
JANUARY	866.75	871.78	953.52	978.68	1009.95	980.85	954.22	1148.82	1105.00	1068.19
FEBRUARY	803.15	770.17	942.98	862.97	957.00	925.42	889.44	1025.12	1029.67	906.77
MARCH	850.49	968.37	1143.12	1026.07	1155.00	1,096.99	963.39	1106.75	1211.14	1190.72
APRIL	1078.15	1154.12	1269.57	1191.73	1322.61	1,121.72	1230.00	1137.75	1348.48	1204.88
MAY	1384.16	1505.63	1479.53	1499.52	1533.87	1,220.00	1457.59	1141.00	1500.09	1528.02
JUNE	1343.60	1607.93	1702.27	1832.35	1634.95	1,292.87	1472.91	1499.83	1642.70	1477.26
JULY	1926.80	1476.78	1677.62	1869.42	1734.03	1342.04	1399.45	1632.00	1926.45	1731.27
AUGUST	1571.95	1588.91	1475.35	1702.45	1658.69	1148.10	1212.92	1794.00	1815.05	1604.70
SEPTEMBER	1641.97	1558.22	1715.20	1505.97	1294.69	947.0	1284.41	1522.86	1604.71	1450.93
OCTOBER	1281.22	1376.64	1393.29	1510.99	1563.62	813.0	1204.18	1458.70	1563.47	1437.02
NOVEMBER	977.14	1202.70	1088.86	1179.47	893.99	930	1236.07	1269.96	1175.00	1116.81
DECEMBER	904.75	980.61	899.43	1061.22	1082.24	969	1229.88	1112.57	1051.63	966.25
ACRE FEET	14,630	15,062	15,741	16,221	15,841	12,786	14,534	15,849	16,973	15,683
% Change	9.49	2.95	4.51	3.05	-2.34	-19.2	12.0	8.2	6.6	-8.2
WATER ACCOUNTS	n/a	n/a	23,518	25,082	26,465	27,706	28,541	28,828	28,841	28,870
% Change	n/a	n/a	n/a	6.24	5.25	4.48	2.93	1.00	0.05	0.10
ACRE FEET PER ACCOUNT	n/a	n/a	0.67	0.65	0.60	0.46	0.51	0.55	0.59	0.54
ALLOCATION	25,180	25,180	25,180	25,180	25,180	25,180	25,180	25,180	25,180	27,319
REMAINING ALLOCATION	10,550	10,118	9,439	8,959	9,339	12,394	10,646	9,331	8,207	9,497
PERCENT RESIDENTIAL USE	0.70	0.67	0.66	0.68	0.67	0.69	0.74	0.73	0.74	0.73
	Note: % Residential Use beyond 2005 includes irrigation meter use.									
POPULATION ESTIMATES	41,938	44,200	46,400	48,730	51,700	53,435	54,610	55,263	55,429	55,502
BILLED CONSUMPTION	13,127	13,789	14,549	14,119	14,337	14,229	14,895	14,942	13,427	12,779
CITY WIDE PER CAPITA WATER **CONSUMPTION** IN GALLONS	279	279	280	258	245	235	244	234	216	206

Table 3-2. Average monthly water consumption (ac-ft) in Lake Havasu City from 2005 to 2009.

Month	Billed Consumption (ac-ft)
January	945
February	818
March	801
April	920
May	1079
June	1165
July	1477
August	1547
September	1534
October	1445
November	1181
December	1051

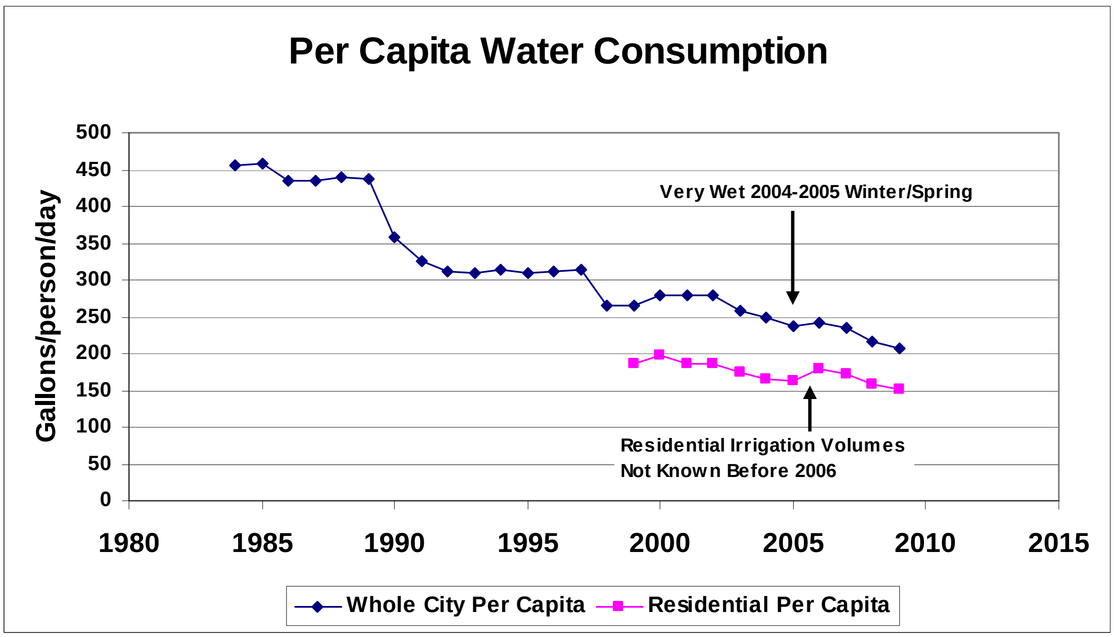

Figure 3-1: City wide and residential water consumption per capita from 1984 to 2009.

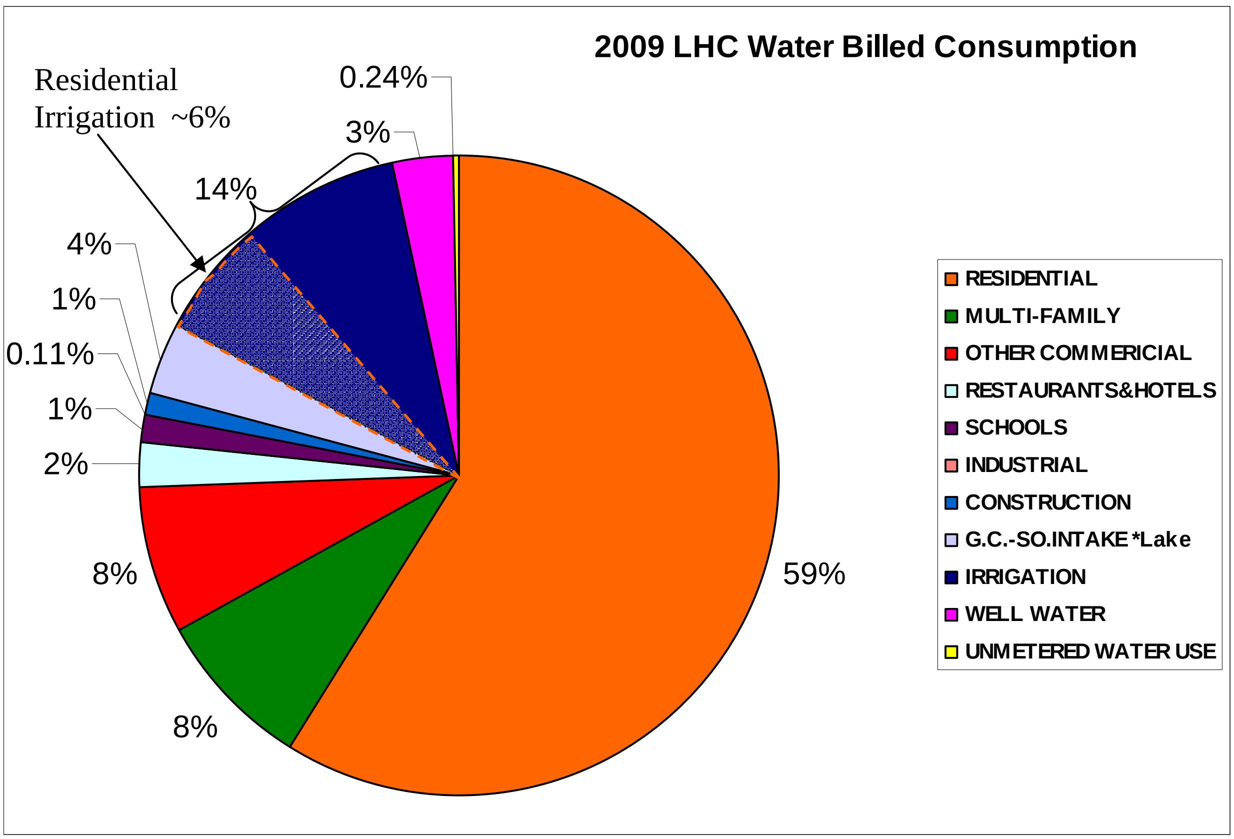

Figure 3-2: Distribution of Total Water Consumption in Lake Havasu City for 2009.

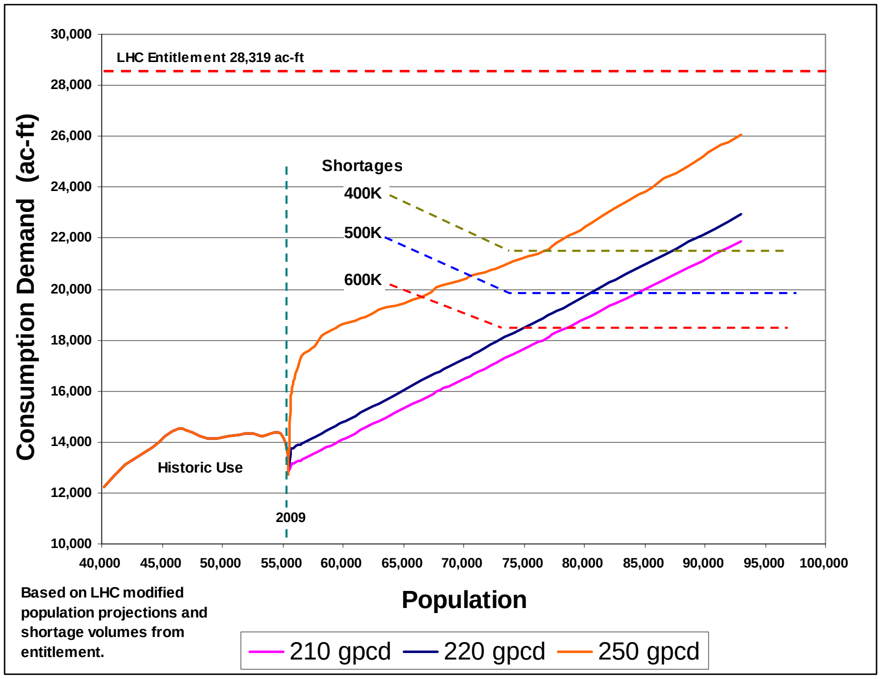

Figure 3-3a: Lake Havasu City projected water demands based on population trends modified from 2006 Arizona Department of Commerce projections and various consumption rates. Shortage estimates are based on percent reductions from the City's entitlement and increasing allocations for all Colorado River contract holders.

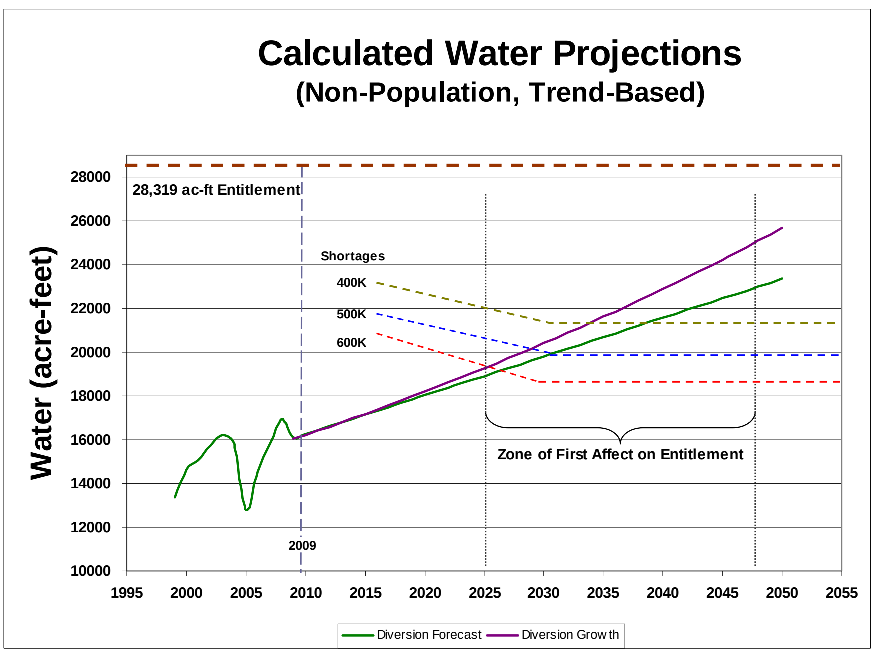

Figure 3-3b: Non-population based water diversion projections for Lake Havasu City based on increasing linear and exponential demand from 2010 to 2060.

3.1.1 Overall 2009 water budget summary

SUPPLY

Colorado River water entitlement (2009)	27,319 ac ft/yr	
Effluent (2009 total generated)	3,479 ac ft/yr	(3.10 MGD)
TOTAL	**31,798** ac ft/yr	

The total effluent generated increases monthly as the Lake Havasu City's wastewater expansion program proceeds through its ninth year. Expected total wastewater treatment volumes by the end of the program in mid-2011 will be between 4.5 and 5.5 MGD or up to 6161 ac-ft/yr.

DEMAND

Well Water †	12,300 ac ft/yr	
Raw Lake Water*	479 ac ft/yr	(0.67 mgd)
Effluent (Reused in 2009)	2,264 ac ft/yr	(2.02 mgd)
TOTAL DEMAND	**15,043** ac ft/yr (47% of total water supply)	

† Demand well number does not include distribution system unmetered losses.
* Water is pumped from the South Intake in the lake to supply the London Bridge Golf Course.

3.1.2. Water Use Classifications

Water consumption in Lake Havasu City is categorized into eleven classes through the City's accounting and billing process (Figure 3-2 and Table 2-4). Although the chart shows two residential classes (single and multi-family), there is another residential component hidden within the irrigation class (highlighted in the figure). Irrigation is a combination of non-residential use and those residential customers with irrigation meters separate from their domestic water meter. The number of residential irrigation meters has been rising as the City progresses with the wastewater expansion program. Those with irrigation meters can water their landscape during the winter months without worrying about how that would affect their monthly sewer charges since the water does not drain into the sewer system. About 40-45% of the irrigation volume is residential use. All consumption categories will be addressed concerning water conservation in the next five years, yet reducing residential consumption will be a primary focus.

3.2 Deficiencies

Whereas recent water acquisitions (2,319 ac-ft from Cibola water transfer to the MCWA in 2008 and 1,000 ac-ft from the Kingman entitlement in 2010) may sustain water supply needs to the City's build out population under normal water supply conditions, the Lake Havasu City 2007 Water Master Plan Update indicates there are infrastructure augmentation and upgrades that will be necessary to deliver the City's entire entitlement to customers. These modifications range from source water volume increases through to distribution and storage expansion and alteration. As an example, the City is currently exploring for a second horizontal collector well diversion site to help with increased withdrawal volumes and to build some redundancy into the water source system in case of system failures at the first collector well site. The bulk of the recommended infrastructure changes; however, will occur in water pressure zones two through five, coinciding with projections of where the largest population increases will occur.

3.2.1 Supply and Treatment

The City's current maximum daily water supply is 45.2 mgd, 24.9 mgd from the horizontal collector well and 20.3 mgd from the reserve municipal wells (if needed). On the other hand, the maximum daily water treatment capacity at the City's water treatment plant is 26 mgd. While the City's 2009 average daily treatment production was 11.4 mgd, the City's 2007 Water Master Plan Update projects a maximum daily water demand of 44.8 mgd at build-out population. The City will have to expand the water treatment capacity to at least 56 mgd and add new points of diversion (up to 9 mgd) to satisfy the projected demand.

3.2.2 Storage

The 2007 Water Master Plan Update also indicates that the City will need to have 34.5 MG of water storage capacity, including 2.25 MG emergency reserve and 24.69 MG fire reserve, to adequately serve the community at build-out population. The City has a current storage capacity of 23.2 MG, with multiple storage tanks sites in each of the seven water pressure zone serving the adjacent topographically lower pressure zone (Table 2-3). Additional storage tanks will be needed within each pressure zone, except Pressure Zone 1 as the residential development in this area is at capacity.

Water pump stations at storage tank sites to get water upslope to the above water pressure zone storage tank sites are in need of major upgrades as many are at least 35 years old. Specific recommendations in the 2007 Water Master Plan Update are laid out in project form for upgrade implementation. The City started the process in 2008 to modify and expand the stations in most critical need.

3.2.3 Distribution and Metering

The 2007 Water Master Plan Update study identified that beyond the obvious need for future water mainlines with population growth, there are various deficiencies within the distribution system, including undersized transmission and water mainlines, insufficient fire flow to certain areas and water pressure issues, both low and high. Suggestions to correct these deficiencies are site specific, which may include modifying pressure boundaries and adding new water mains to supplement low pressure areas.

All city water distribution lines are metered at the point of use, and no deficiencies were identified on the 2007 Water Master Plan, yet thousands of the residential meters and many commercial meters are over 15-20 years old. As meters wear out over time and read lower than the passed volume, the City has established a meter replacement program. The City is also considering automating all of its residential meter accounting by installing radio transmitters on each meter so that real time consumption can better coincide with diversion recording.

Customers may also be able to track their consumption via an on-line account and be more cognoscente of their water use practices. This practice would be especially useful during winter water use averaging when monthly sewer charges are determined for each customer.

4.0 COLORADO RIVER SHORTAGES

With the continuation of drought in the southwest United States, the Colorado River and Lakes Mead and Powell in particular, are losing storage capacity. A Record of Decision was issued through the Bureau of Reclamation by the Department of Interior in 2007, which established the Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lakes Powell and Mead management program. This 20-year program was developed to balance the water storage in both reservoirs and to establish criteria from which the Secretary of the Interior could declare a reduction in water deliveries (Shortage) downstream from Lake Mead. Any Shortage to the lower basin will primarily affect 4^{th} priority contracts in Arizona. Lake Mead's water elevation is used as the benchmark for knowing when to declare a Shortage. When the lake's elevation reaches 1075 feet above mean sea level (amsl), a 400,000 ac-ft Shortage is automatically declared. This declaration will actually be made several months (by August of the previous year) prior to the calendar year that it is implemented, based on projections of lake elevation made by Reclamation. If the lake elevation should reach 1050 feet amsl, 500,000 ac-ft would be held back and if the lake elevation reaches 1025 feet amsl, a 600,000 ac-ft shortage will be declared. Further drops in lake elevation will prompt a conference between Reclamation and the affected states for negotiation of options, which could include implementing a second tier of Shortages that effectively bars all water deliveries to 4^{th} priority users in Arizona such as Lake Havasu City. As of December, 2010, Lake Mead's elevation was just below 1082 feet amsl, 7 feet above the first trigger elevation and 30 feet below the January, 2009 elevation. Reclamation's 2011 Draft Annual Operating Plan (AOP), issued in September 2010, includes Lake Mead elevation projections for most probable occurrence, minimum probable occurrence and maximum probable occurrence (Table 4.1). Although the most probable estimates favor increasing lake levels in early 2011, minimum probable estimates for July through September 2011 are projected to be below the 1075 feet first trigger elevation to initiate a declared Shortage. Since the release of the draft AOP, realized elevations have been below the projected minimum probable elevations.

Entities directly affected by the reduced water supply during a Shortage outside of Arizona include Nevada, which will take 3.3% of the Shortage volume, and possibly Mexico, which may take a percentage (up to ~16.7%) of the Shortage volume. The degree of Mexico's involvement is currently being negotiated. These reductions are supposed to be implemented before Arizona 4^{th} priority contract entitlements are impacted. California's Colorado River entitlement and Arizona's priority one through three contracts will not be affected by the Shortages described above. Once higher priority Arizona allocations are satisfied, Reclamation will calculate the percent reductions to the 4^{th} priority entitlements. These calculations will be based on the percent water volume attached to each entity's entitlement compared to Arizona's total 4^{th} priority apportionment and to the total apportionment of 4^{th} priority mainstream contracts (those entities actually adjacent to the river system versus the Central Arizona Project). For example, Lake Havasu City's 2010 entitlement of 28,319 ac-ft (including the Cibola subcontract) is 1.82% of the total 2010 fourth priority water available to Arizona and is 17.2% of the total 4^{th} priority water entitled to the mainstream users. Reclamation and the Arizona Department of Water Resources (ADWR) have produced models predicting the probability of when Shortages might occur and in 2006 ADWR drafted preliminary "what if" Shortage calculation scenarios showing plausible reduction volumes to 4^{th} priority contracts.

Table 4-1: Bureau of Reclamation draft probabilistic Lake Mead elevation projections for the operating year from October 2010 to September 2011*. Numbers in bold are below the first trigger elevation initiating a declared shortage.

Month	Most Probable Inflow Scenario Projected Elevation (feet)	Minimum Probable Inflow Scenario Projected Elevation (feet)	Maximum Probable Inflow Scenario Projected Elevation (feet)
October 2010	1,082.89	1,082.25	1,083.00
November 2010	1,084.98	1,084.03	1,085.11
December 2010	1,088.17	1,086.89	1,088.44
January 2011	1,091.80	1,089.81	1,093.91
February 2011	1,095.56	1,091.55	1,103.56
March 2011	1,095.11	1,087.37	1,108.58
April 2011	1,094.46	1,081.56	1,112.12
May 2011	1,094.73	1,077.41	1,117.28
June 2011	1,096.32	1,076.08	1,123.95
July 2011	1,099.07	**1,074.72**	1,130.24
August 2011	1,101.74	**1,074.40**	1,136.95
September 2011	1,101.97	**1,071.65**	1,142.57

*Taken from the BOR Draft Annual Operating Plan for Colorado River Reservoirs 2011.

Table 4-2: Estimated entitlement reductions to Lake Havasu City in acre-feet and percent with progressive Colorado River Shortage volumes. Range of reductions is based on when the Shortage is declared and total 4th Priority mainstream demand.

Declared Shortage Volume	Estimated Reduction Range to Lake Havasu City	
	2016	**2031**
400,000 ac-ft	4130 to 5165 ac-ft	4883 to 5928 ac-ft
	14.6 - 18.2% reduction	17.2 – 20.9% reduction
500,000 ac-ft	5370 to 6687 ac-ft	6135 to 7464 ac-ft
	19 – 23.6% reduction	21.7 – 26.4% reduction
600,000 ac-ft	6610 to 8163 ac-ft	7387 to 8954 ac-ft
	23.3 – 28.8% reduction	26.1 – 31.6% reduction

(Calculated based on 2006 Arizona Department of Water Resources model estimates)

What percent water allocation reduction Lake Havasu City will truly receive will depend on the depth and timing of the Shortage and on the amount of the reductions to other entities mentioned above. Reductions to the City's entitlement from Shortages occurring in the near term will not be as deep as those further into the future because the calculations are partly based on actual total 4th priority mainstream demand (Table 2). Few Colorado River contract holders are currently using 100% of their entitlement. As population grows along the river, demand will increase and more water providers will reach their entitlement limit, forcing slightly higher reductions. Rough calculations based on currently understood conditions (they will probably change) indicate the Lake Havasu City will experience reductions from 4130 to 5928 ac-ft for the 400,000 ac-ft declared shortage, depending when the declaration is made and on the agreed percent reduction to Mexico. These numbers include augmentation by the Cibola entitlement. Successively deeper reductions will occur with the 500,000 ac-ft and 600,000 ac-ft shortages, up to a maximum of almost 9000 ac-ft. (~31.6% of the City's total CR entitlement) when all 4th Priority mainstream contractors are using their total entitlements.

As the federal interim management plan was finalized, the State of Arizona through ADWR held a series of meetings to establish an intrastate Shortage sharing agreement. The agreement, formalized in letters from ADWR's Director to Arizona's governor and to Reclamation's Lower Colorado Regional Director and in a joint letter from MCWA and the Central Arizona Water Conservation District, indicates that water reductions from mainstream contracts will be made from their respective entitlements, not from their previous year's annual allocation. Further, reduction volumes will be calculated based on the criteria mentioned above. Lake Havasu City's 2009 diversion is on track to be approximately 15,800 ac-ft by year's end. Since this is 60% of the City's current 26,180 ac-ft entitlement (the Cibola subcontract volume is not included because it cannot be accessed until the 26,180 ac-ft is wholly used or if needed during a Shortage), only a Shortage volume of more than 9380 ac-ft would have directly impact water use in the city. This agreement should be honored throughout the Colorado River Interim Guidelines period, which ends in 2026. There is no guarantee; however, that the Arizona agreement will not be legally challenged or will be extended, even if the federal management program is continued beyond 2026. The City may eventually have to take reductions from previous year's consumption resulting in real water losses. In any case as time progresses, water demands will increase with population growth and eventually close the gap between the annual allocation and the City's total entitlement, resulting in direct water losses during Shortages.

The Lake Havasu City Council passed a resolution in 2010 to include a strategic plan within this water conservation plan to mitigate water shortages whether declared by the Federal government or from emergency situations. The plan is discussed in Section 8.

5.0 EFFLUENT REUSE

5.1 Effluent Reuse

A majority of the effluent generated from the three existing wastewater treatment plants is currently being used for irrigation with the balance of the effluent going to either percolation ponds located on the Island or to vadose injection wells for temporary storage. Effluent produced at the 2.5 MGD Island wastewater treatment plant (IWWTP) is currently pumped through a reuse system to four users on Pittsburgh Island. These users include the Nautical Inn Golf Course, the Nautical Estates Condominiums, the Lake Havasu Marina and the Islander R.V. Park. In each case, the effluent is used for landscape or turf irrigation. The treatment process includes standard aeration and denitrification processes, but also includes tertiary ultraviolet treatment to obtain A+ classified effluent (highest effluent quality level set by the Arizona Department of Environmental Quality). Any excess effluent is disposed in percolation ponds on site.

Effluent from the 2.2 MGD Mulberry wastewater treatment plant (MWWTP) also obtains Class A+ quality through the same technology as the IWWTP. The effluent is seasonally mixed with water from Lake Havasu and pumped to two 18-hole golf courses for turf irrigation. The lake water is pumped through an 18-inch line to the MWWTP's commingling pond and blended with the plant's effluent. Water is then pumped to the London Bridge West Golf Course where approximately half of the water is used for irrigation. The remainder of the water is pumped through an 8-inch line to the London Bridge East Golf Course where it is also used for irrigation. Effluent generated by the MWWTP not disposed into the commingling pond is sent to the IWWTP percolation ponds.

Effluent generated at the 3.5 MGD North Regional wastewater treatment plant (NRWWTP) is either sent to the Refuge Golf Course, which lies outside the city limit and outside the City's water service area, or is injected into the subsurface via vadose injection wells. The NRWWTP uses ultra-filtration membrane technology on top of the standard processes previously mentioned, which not only improves the Class A+ quality water, but also minimizes particulate clogging of perforated screens in each vadose well. The NRWWTP is planned for expansion up to 15 MGD, in 3.5MGD phases, as demand warrants.

Long-term wastewater management and reclaimed water reuse issues and goals addressed in the 1998 Phase II Comprehensive Wastewater Plan are undergoing revision with the development of an updated wastewater master plan and effluent reuse plan. The City has constructed an interconnecting infrastructure system to flexibly convey wastewater and effluent given particular situations. Any of the three wastewater plants may receive influent from any part of the city and effluent may be separately delivered from one wastewater plant to another to supplement customer deliveries. Several effluent pipelines were installed, but not activated in the early 2000's to potential customers. These lines will be utilized first to pump effluent to these new customers when there is enough to pressurize the lines all year.

The main goal of effluent reuse is to maximize the replacement of Colorado River raw and potable water irrigation with a maximum number of customers feasible. Treated effluent represents an opportunity to reduce water demand on a gallon for gallon basis. Converting turf and landscape irrigation areas now using potable water to effluent is a high priority for the City.

The expected maximum effluent generation volumes when the City finishes its sewer expansion program in mid-2011 will be between 3.5 and 4.5 MGD. The 2008 demand of several parks, a cemetery, city hall/police station and a middle school close to effluent conveyance lines indicate that the projected effluent flows should be enough to convert most of these areas to effluent (Table 5-1). Candidates such as Rotary Municipal Park, Lake Havasu Memorial Gardens Cemetery, Arizona State Route 95 landscaping, some of the schools in the community, and a future municipal golf course will be evaluated through the next five years as to the feasibility for effluent application. The City will also require sewer connections for future development outside the current sewer expansion program area, which will further increase available year-round effluent.

Lake Havasu City has utilized its Lake Havasu intake pump (South Intake) to supplement effluent in the city's Mulberry Wastewater Treatment Plant commingling pond (see sections 2.1.1. and 3.1.1) that then is pumped to a local golf course. As more effluent has become available through increased residential sewer connections, less raw water has been needed to be pumped through the South Intake (Figure 5-1). The goal is to eventually discontinue use of the South Intake when enough effluent becomes available and when all feasible potable water irrigators have been converted to effluent. Closing the South Intake will also eliminate a pathway for quagga mussel transport into the Mulberry comingling pond and to the golf course irrigation system.

Educating irrigators on effluent watering practices to most efficiently utilize the water is key to the above goal. Two issues associated with effluent reuse are the uneven seasonal supply/demand phenomenon and the high dissolved solid content of the effluent. Lake Havasu City, like most other municipal water providers in the desert southwest, experiences seasonal demand for irrigation water. Effluent is more or less evenly generated throughout the year, yet during the winter when irrigation demand is low, much of the effluent must be disposed by percolation below the accounting surface and is permanently lost. Summer demand consumes almost all available effluent, but with more effluent available in recent years due to the sewer expansion program, the opportunity to add customers would be feasible if the winter effluent were able to be stored and retrieved. To that end, Lake Havasu City initiated a subsurface recharge program with an eventual recovery component (see next section).

Generated effluent typically contains TDS levels three times higher (up to 1700 mg/l) than newly treated potable water (500-600 mg/l). Turf application of this water over time produces unwanted salt buildup in soils and on grass roots creating a variety of pernicious conditions. The main strategy to rid the soil of salt is to use large quantities of effluent to flush the system, which is a waste of water. One golf course is able to utilize lake water from the South Intake to blend with the effluent and effectively dilute the TDS concentrations, yet this water is counted against the City's allocation.

5.2 – Effluent Recharge and Recovery Program

After receiving an aquifer protection permit from the Arizona Department of Environmental Quality to dispose effluent from the NRWTTP, Lake Havasu City completed and outfitted four, four-foot

Table 5-1: Estimated irrigation demands of several land uses in Lake Havasu City, based on 2008 billed consumption.

User	Ave. Demand (MGD)	Maximum Demand (MGD)
Rotary Municipal Park	0.12	0.22
Daytona Middle School/ Cypress Municipal Park	0.024	0.142
City Hall/Police/ Jack Hardy Municipal Park	0.018	0.035
Memorial Gardens Cemetery	0.11	0.163
SR-95 Landscape	~1.21	~2.0

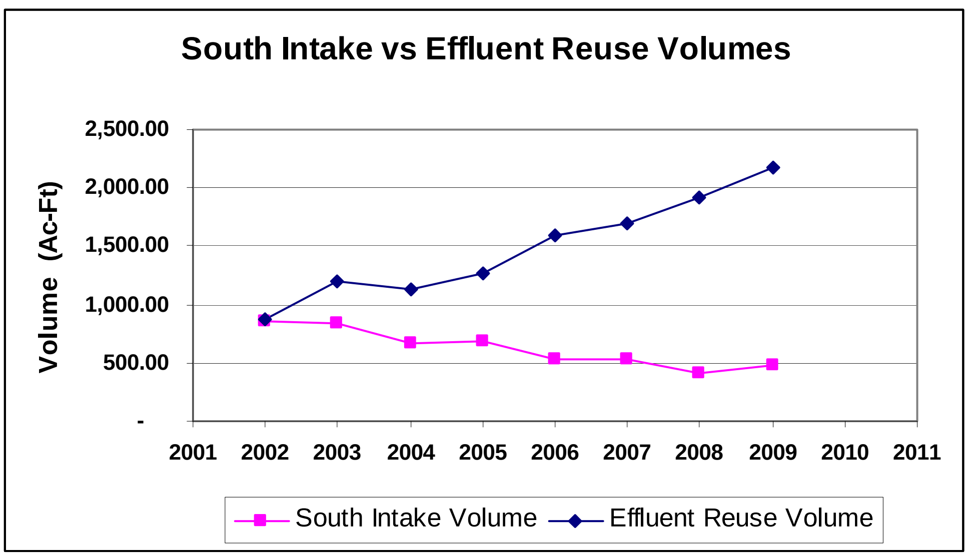

Figure 5-1: Eight year trend of declining Colorado River water use from the South Intake versus an increasing effluent reuse rate. Almost half of the former South Intake volume (2002) has been replaced with effluent (2009). The South Intake will eventually be discontinued.

diameter vadose injection wells, each 180 feet deep adjacent to the treatment plant in the summer of 2008. A 250,000 gallon reuse tank at the treatment plant temporarily stores effluent, which is connected to a distribution pipeline that pumps effluent either away from the NRWWTP to customers or to a pipeline network leading to the vadose injection wells. This site was chosen for this disposal method due to favorable hydrologic conditions. The Colorado River Aquifer surface lies approximately 400 feet below ground level in a sand and gravel alluvium and is a few feet above the regional accounting surface of 449.7 feet amsl established by Reclamation. Any water extracted at or below this surface would be charged against Lake Havasu City's annual Colorado River allocation, but any water diverted above this surface is considered groundwater not under the influence of the Colorado River. Placing water in the vadose zone overlying the aquifer will create a "mound of water" that could later be extracted independent of the City's federal allocation. Vadose well depths assure that mounding water would be above the accounting surface. The wells were placed in service as a pilot project beginning mid-December 2008, injecting between 0.5 and 1 million gallons of effluent per day. Injection continued throughout 2009, with the exception of May, at volume rates between 0.27 and 0.63 MGD to study the subsurface hydrodynamics of the effluent. The pilot study has continued through 2010 to also determine the rate of water migration away from the injection field by ceasing injection for several months.

Lake Havasu City is in the process of expanding the vadose well field to increase injection capacity. A test recovery well is also scheduled for installation by 2011 to determine the effluent recovery efficiencies, which will determine a recharge/recovery water budget and indicate how much irrigation water will be available year round above and beyond the volume used by current effluent customers. This critical number will then help determine how many new customers are converted from potable water irrigation.

Water quality is also a concern in this process and the City began monitoring for regulated compounds in 2005 as part of the aquifer protection process. This work was expanded in 2007 to include unregulated pharmaceutical and related endocrine disrupting compounds found in the effluent. This work will become more important as the injection field is enlarged.

6.0 EXISTING LAKE HAVASU CITY WATER CONSERVATION ORDINANCES AND RESOLUTIONS

6.1 General

Lake Havasu City, since the 1980's, has implemented several water conservation and water budget regulatory elements and added resolutions promoting water conservation. Water conservation ordinances and water accounting ordinances pertaining to water consumption limits that have been adopted by the city are included in Titles 7, 11, 12 and 14 of Lake Havasu City Code (http://www.amlegal.com/nxt/gateway.dll/Arizona/lakehavasu_az/lakehavasucityarizonacodeofordinances?f=templates$fn=default.htm$3.0$vid=amlegal:lakehavasu_az). These conservation ordinances and regulations and their success in improving water use efficiency are discussed in the following section.

6.2 Water Conservation Ordinances

Title 7 - Water Allocation and Management

The purpose of this title is to coordinate how water allocations will be assessed and accounted with growth of the City (Chapter 7.08), regulate private water well drilling within the City's water service area, establish through reference water conservation ordinances (Chapter 7.12) and develop water waste measures during water shortages. The City's entitlement is split and budgeted into two geographic areas based on whether the location is within or outside the original Lake Havasu Irrigation and Drainage District (the platted parcels in the city) and individual water service allocations are issued based on zoning type and amounts referenced by the Arizona Department of Water Resources (250 gallons per day (gpd) for single family residences, 200 gpd for multi-family zoning, and 1.59 ac-ft per acre for commercial/industrial use. Revisions to this title are being considered to budget water recently acquired by the City and to address how water is accounted.

Lake Havasu City has established water well regulations (§ 7.08.060) to prevent private interests in accessing water from the Colorado River Aquifer, which is hydrologically connected to Lake Havasu. This water is federally controlled and needs an entitlement contract with the Secretary of the Interior to access. In Lake Havasu City's case, unauthorized access to this water would be counted against the City's entitlement. Waste of water restrictions (Chapter 7.20) were recently adopted by the City Council (April 2010) to regulate excessive water waste only during direct water shortage conditions such as declared Colorado River Shortages or emergency situations. Such measures regulated include over-watering during outside irrigation, failure to fix leaks, hosing/washing buildings or impervious surfaces, use of outside water features and re-filling swimming pools. Other water conservation ordinances are discussed below.

Title 11 – Lake Havasu Irrigation and Drainage District

Chapter 11.04 Public Improvements, Article X – Irrigation and Drainage District Rules and Regulations refers to Ordinance 09-970, which adopts the document, Regulations Governing Domestic Water Service within the Lake Havasu Irrigation and Drainage District (IDD). Water conserving measures outlined in this document include unauthorized use of water such as causing water to waste because of plumbing leaks, washing sidewalks and driveways in a manner that prevents usual and customary use of public streets and sidewalks and over irrigation such that water runs onto public right of ways and promotes safety hazards. These rules only apply to the IDD, which is the current platted portion of the City where 95% of the growth has taken place. However, future growth is expected north of the IDD boundary. The waste of water ordinance developed in Title 7 was developed to cover all of the City's expanded water service area.

Title 12 – Buildings and Construction

Chapter 12.08.100 of the City Building Code specifies criteria for installing low-flow plumbing devices in new construction and additions in the City starting in October 1, 1990 as well as for replacement of certain water fixtures or devices. This code specifies that all faucets and showerheads will not allow a water flow rate in excess of 2.75 gallons per minute and that public restroom faucets must also be self-closing. Toilets and urinals must have a flow rate of 1.6 gallons/flush or less. Chapter 12.08.105 mandates that water cooled refrigeration systems must be equipped with a water tower, an evaporative condenser, or an acceptable recirculation system.

Title 14 - Water Conservation Landscape Requirements

Chapter 14.32 of the Lake Havasu City Code sets regulations for Landscape Standards. The code stipulates that low water use plants be used in landscaping on lots with a zoning district classification R3 or higher (see Section 1.6.1). Also instituted is a "no-turf" policy for commercial, multi-family, and industrial uses. The "no-turf" policy is not applicable to single-family residential. The Lake Havasu City Zoning Department enforces the code as part of the design review process. Although there are no codes governing the type or intensity of landscaping for single-family residential zoning classifications R1 and R2, a landscape plant list is advertised to citizens. There is a minimum landscape requirement of 10 percent for commercial and industrial, and 20 percent for multi-family residential. Provisions in the same chapter prohibit outdoor bodies of water such as fountains or lakes in any multi-family, commercial or industrial development. Also included in this code is the addition of non-vegetative landscaping to supplement previous vegetative landscaping requirements. Non-vegetative landscaping includes architectural features such as sculptures, benches, masonry and stone walls or decorative paving.

6.3 Water Conservation Resolutions

Recommended Landscape Plant List Resolution

Resolution 10-2450, "Revised Lake Havasu City Water Conserving Plant List For Landscaping", revising resolution 90-625, was developed in 2010 to recommend the use of low water consuming plant species, many of which are native to Arizona and the lower Colorado River region. The list, containing trees, shrubs, cacti, succulents, groundcover and wildflowers is posted on the City's water conservation web site and is actively promoted to the community. This plant list will also be used through Chapter 14.32 of the City Code for applicant landscape design review.

Water Shortage Response Strategy

Resolution 10-2415, "Water Supply Stages and Recommended Shortage Response Plan", was adopted in 2010 to formalize mitigation options available to Lake Havasu City when its water supply is reduced below demand requirements. The contents of this resolution are discussed in section 8.0, Water Supply Stages And Water Shortage Response Plan.

Increasing Scale Water Rates

Lake Havasu City established through resolution a 4-tiered "increasing scale" water rate structure in 1990 that has since then had several rate changes. Rate and fee adjustments are made after completing a water rate study and approval from City Council through Title 3.2 of the Lake Havasu City Code. The intention of this rate structure was to reduce water consumption while still providing water at a fair price. Most of these rate increases have had the desired effect of helping to reduce water consumption (Figure 6-1). The most recent water rate study was initiated in 2008 and new rates instituted in August 2009. Rates increased in the top three volume tiers while slightly decreasing in the lowest volume category (0 – 1,300 cubic feet) so as not to penalize those customers who voluntarily conserve (Table 2-6). The affect on water consumption is yet undetermined, but any difference due to this particular rate change may be masked by the affects of how the City finances the sewer expansion program. Customer monthly sewer rates are locked in one year intervals based largely on an average of winter water consumption (November through March). Those customers who conserve water during this period will have lower monthly sewer charges.

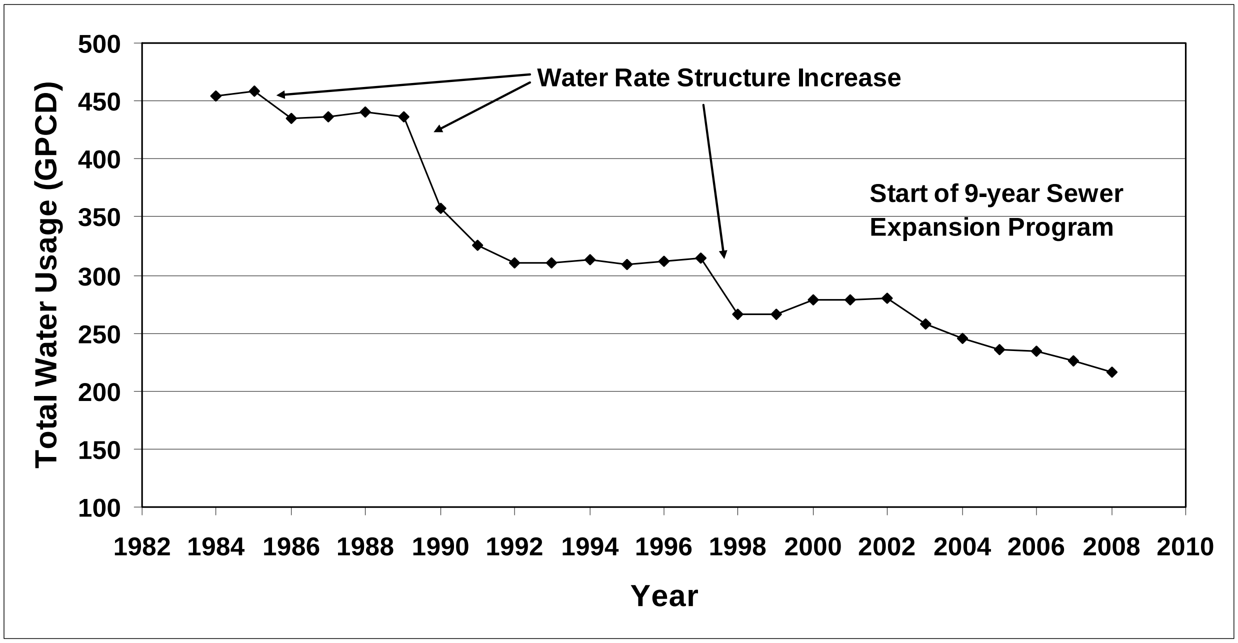

Figure 6-1: Historic Lake Havasu City per capita water consumption trend showing affects of instituted water rate increases and the affects of the City's wastewater collection expansion program, which will be completed in 2011.

Fix a Leak Week Proclamation

Lake Havasu City Mayor Mark Nexsen issued a proclamation on April 17, 2009 that the fourth week of each month is fix a leak week. The proclamation addresses the awareness of possible water leaks in plumbing at home and of course repairing them as soon as possible. Lake Havasu City's Water Conservation Officer developed a large banner to remind citizens to check their water systems and it is displayed in one of the city's high traffic areas during this week.

6.3.1 Modifications to the City Code

Lake Havasu City will be reviewing and modifying the City's water allocation budget in Title 7 over the next two-three years. The current budget was established using per capita consumption levels higher than what the City has experienced in the last five years. A more detailed sense of what proportions of the water will be allocated to customers is needed. There is also some redundancy within the regulations that need to be streamlined. Water conservation measures are spread over four titles in the City Code and city staff will examine ways to consolidate these measures for easier referencing.

7.0 CURRENT WATER CONSERVATION ACTIVITIES INCLUDING IDENTIFIED CRITICAL WATER CONSERVATION MEASURES

Water conservation efforts currently utilized by Lake Havasu City will help to alleviate the water supply issues the City will face during the next few decades. Conservation measures already implemented have helped to reduce consumption to approximately 210 gpcd (2009). These activities include critical conservation measures (*), identified in the Bureau of Reclamation's Conservation Plan Guidelines. Activities beyond the City Code regulations are discussed in this section.

7.1 Water Conservation Officer*

The City designated an official Water Conservation Officer in 2004 to oversee daily conservation efforts. Duties are as follows:

1. Investigate high water usage for businesses and residents.
2. Perform residential and commercial water audits for high water usage residents and businesses.
3. Hold water conservation and irrigation education workshops.
4. Teach water conservation to the 2^{nd} and 4^{th} grade students in our public school system.
5. Enforce new water ordinance codes.

The Water Conservation Officer (WCO) conducts almost 1000 water audits per year, most of which are residential related to elevated water consumption and high sewer charges. Lake Havasu City has instituted a sewer billing program based largely on winter water consumption to help pay for the City's $380 million wastewater expansion program. The billing program examines water usage from December through March, throws out the high consumption month and averages the three other months. The resulting average consumption is paired with a specific monthly sewer fee on a rate table (that is adjusted annually). This fee is fixed over the next year and is included in the customer's monthly water and trash bill. Many customers who had not paid much attention to their water usage in the past and who do not realize that their water bill will drastically change call the WCO for an audit. Still other people will call if their consumption dramatically increases from past usage. A high usage alert is also issued by the City's Customer Service section to the WCO who then sets up an appointment with the customer. Residential and commercial audits consist of an interview with the customer, searching for water leaks or excessive water use practices inside and outside the home, and giving recommendations what to do to correct any problem. The WCO also has low flow water kits with flow reduction devices such as showerheads and faucet aerators, toilet leak detection tablets and toilet flappers to hand out to individuals when needed. Beginning in 2010, irrigation stop valves that can be installed in the irrigation line prior to bubbler heads will also be given away on a case by case basis, particularly to help those residences that are unoccupied for several months at a time. Unattended irrigation systems can generate a large water loss volume if they break.

The non-residential audit program focuses on excessive use and on appropriate water meter sizing. Larger water meters meant for multiple tenants or lessees may not measure very small flow rates, allowing leaks to go undetected and increasing the city's unmetered water loss. The audit program identifies these situations and recommends replacement meters to the City's Water Division staff. Other leaks and plumbing issues are also recognized for correction.

The WCO also initiates multi-media "Slow the Flow" advertising efforts for water conservation practices and performs presentations to educate primary school students (over 1500 in six schools), special interest groups like the Lake Havasu Master Gardener's Club and the general public on water conservation measures they can take to save water and money. The Lake Havasu City Council directed staff in March, 2010 to continue to stress public education as the primary tool to help citizens reduce their water consumption. To this end, water billing messages, bumper stickers on city vehicles, City bus signs, banners and news printed messages have been generated promoting what citizens can do to save water. The WCO also runs the City's water conservation rebate program to help citizens obtain water efficient or saving devices.

7.2 Effluent Irrigation to Supplant Potable Water Irrigation

Lake Havasu City has for many years provided effluent to golf courses and a few other turf and landscape irrigation sites, reducing demand on the City's Colorado River allocation. This topic is more fully discussed in Section 5.1.

7.3 Distribution System Audit, Leak Detection and System Upgrades Program

Lake Havasu City periodically conducts distribution system leak detection surveys to identify and repair system problems. The last survey in 2007, covering the west side of the city, revealed 14 leaks with a cumulative estimated leak rate of 8 gpm or 4.2 million gallons per year. The City has also purchased an acoustical leak detection multi-sensor meter for pinpointing leaks at fire hydrants. A leak detection survey will be renewed in 2012 pending available funding.

The City's Water Division has taken advantage of the City's wastewater expansion program by replacing old PVC water service lines to residential customers with wrapped copper lines as sewer laterals are installed. The PVC lines have proven to be undependable with many leaks and ruptures taking place. The copper lines have drastically reduced the number of repairs and improved the distribution system efficiency.

7.4 Closely Monitor Unmetered Water Use

Not all water use in Lake Havasu City is metered. The City's Fire Department uses water for training and extinguishing fires that is taken from unmetered hydrants. Their use is reported to the Water Resources Coordinator as events occur and these volumes are included in the monthly water account reports to Reclamation. Unmetered uses or accidents have also occurred during the City's wastewater expansion program. The lost water volume is estimated weekly and added to the monthly accounting report.

7.5 Turf Irrigation System Upgrades*

Lake Havasu City Parks and Recreation Department finished upgrading their turf irrigation systems in 2007 and today use approximately 25% less water than before the improvements. Some of this savings stems from flow meters that allow the system to shut down automatically when a break or a high flow occurs. Lake Havasu City is working to partner with the Lake Havasu Unified School District to help upgrade their irrigation systems, which should result between 25-30% water savings after new components are installed.

7.6 Water Conservation Rebate Programs

Lake Havasu City offered its first water conservation rebate program in 2008, which was partially funded by a grant from Reclamation's Water Conservation Field Services Program. The rebate program consisted of offering cash back for the purchase and installation of low flow toilets that replace old high flow toilets and for swimming pool covers to slow evaporation. The program was very successful with the City issuing more money than was originally intended. The City has renewed this program for 2010-2011 again with the assistance of the Field Services Grant Program. This rebate cycle includes the same items as before plus includes instant hot water recirculation pumps. The City will continue this program, subject to available funding, in one form or another to help lower residential consumption.

7.7 Government Role Model

Reducing community water consumption relies greatly on education and public outreach, yet leadership by example is also an effective way to show that the water provider is serious when promoting these reductions. Lake Havasu City has begun this role by upgrading turf irrigation efficiencies on its own facilities and with partnerships of other irrigators, replacing rupture prone water service lines with more reliable ones as the sewer expansion program proceeds throughout the community, actively locating and repairing distribution system leaks, tracking unmetered water use, and actively seeking funding for water conservation efficiency upgrades, education and outreach. The City is also in the process of replacing all its government flush urinals with waterless urinals and replacing selected, irrigated turf areas with xeriscaping. The City is also working to convert several public turf and landscape areas from potable water to effluent. Effluent is becoming more abundant as the City completes its sewer expansion program. The City will continue to develop new measures to lower its water consumption.

7.8 Measurement and Accounting*

The City has water meters on all its conventional wells, at all discharge points (except fire hydrants) and at the reuse facilities. All previously unmetered water accounts in the City's water system have been upgraded to metered service. Also, a computerized accounting system capable of showing historical billing for an account to determine if any variance in usage has occurred has been implemented. The horizontal collector well, the City's primary water diversion point, is not directly metered due to construction restrictions at that site that limit proper metering practices. Instead the water from this well is metered at the entrance of the City's water treatment plant. This meter is continuously calibrated against outflow meters from the treatment plant to make sure the diversion readings are true.

7.9 Water Pricing Structure*

The City implemented an increasing scale rate structure in 1990 for all customers which is a disincentive for excessive use. Since that time, several rate increases have gone into effect, the last occurring on August, 2009. The current pricing structure is given in section 2.2.5 (Table 2-6) and discussed further in section 6.3. Future rate increases are not currently being considered, although if Colorado River shortages are declared by the Bureau of Reclamation and these shortages directly impact Lake Havasu City's water entitlement, then implementation of rate increases will be one possible strategy to curb consumption.

8.0 WATER SUPPLY STAGES AND WATER SHORTAGE RESPONSE PLAN

8.1 Introduction

Lake Havasu City's 2005 Water Conservation Update to the Bureau of Reclamation includes a drought preparedness plan demonstrating how the City would respond to various drought stages. The drought stages and targeted reduction goals in that plan are not very compatible with the expected outcomes of declared Colorado River Shortages. The drought plan is best suited for water suppliers that are directly impacted by local drought conditions where their water supply may gradually dwindle. Some of these entities have alternative water sources to tap when their main supply dries up. Unlike those water providers, Lake Havasu City's water supply is constant under any typical non-emergency situation with the exception of federally declared Shortages on the river, which as of this writing have never happened. All Arizona 4th priority Colorado River mainstream contractors are in this situation. Unlike the Central Arizona Project, which will also share Shortage reductions, fourth priority mainstream users have no other local sources and are not severely impacted by local drought conditions, but by regional climate trends. Instead of steadily declining local groundwater or surface water levels, federal policy dictates when Shortages will take place. This will mean an instant, step-wise reduction in the City's Colorado River water entitlement as shortages deepen.

When Shortages are declared, these water providers will operate either under what could be called "paper" Shortage conditions, when the gap between the water provider's annual allocation demand and its entitlement is sufficiently wide apart to absorb the assigned reduction, or under "wet water" conditions, when Shortage reductions are larger than the aforementioned gap. Paper Shortages in a strict sense do not require the City to initiate any accelerated water conservation action, yet these conditions send a strong signal that future water supply availability is highly uncertain and prudent action may be warranted. Paper Shortages will disappear when either water reductions are subtracted from the City's prior year water consumption (possibly starting in 2026 – see Section 4.0) or when the City's water demand reaches the normal supply entitlement. Under wet water Shortages, a mandatory reduction of the City's annual allocation will be realized, which of course, will have to be addressed in some fashion. Strategies to ameliorate these reductions have been drafted forming an alternative Shortage response plan that was approved by the Lake Havasu City Council in March 2010 for inclusion in this water conservation plan.

8.1.1 Strategies to Ameliorate Water Shortages

There are at least five basic strategies available to water providers that address reductions in water supply; ask citizens to voluntarily conserve water, establish mandatory water use restrictions, utilize alternative water sources, mandate water rationing allocations and modify tiered water rates to suit the situation. All of these strategies need to consider the amount or goal of the city-wide reduction, how effective the strategy will be in accomplishing that goal and the City's financial capability in implementing the strategy. The City Manager, through staff recommendations, will advise City Council on the Shortage implications to the City and submit what strategies should be implemented, noting that adjustments could be made with changing conditions. Those conditions include, but are not limited to the success of meeting the city-wide water consumption reductions, financial burden affects, and the feasibility of accessing alternative water sources. The main points of each strategy are given below.

1) Voluntary Water Conservation (VWC)
   - includes education on water conservation measures.
   - education about the City's short and long term water situation.
   - rebates for water conserving devices.
   - set water rates so that higher users pay a lot more and/or reward conservation activities that lead to a determined % reduction.

Volunteer water conservation has been promoted continuously through the City's Slow the Flow campaign and will be emphasized during all water supply stages. Water providers in other areas have found that this strategy is successful when required water use reductions are less than 15%. Particularly, success depends on the cooperation of the community to collectively participate and the ability of the City to educate the public. Lake Havasu City's water conservation program would have to enhance its community outreach by providing information to all sectors on current and future water supply conditions as well as what measures need to be implemented to successfully reach the reduction goal. Public outreach will be accomplished with enhanced advertising in all types of media, holding public meetings, and offering water conservation programs such as rebates and workshops. A citizen volunteer water conservation program is being developed to help enhance this effort. The City may suggest irrigation schedules for residents and promote changes that City government will make to lead the way in modifying water use habits. Rebates on water bills for those customers who have exceeded the requested percent reduction will be considered. As the gap between demand and available allocation closes, the City will intensify efforts to educate citizens on water conservation practices, to inform the public of the City's water supply situation and to offer various incentives for increased conservation.

2) Mandatory Restrictions (MR)
   - focus on non-essential measures – e.g. irrigation, water waste, etc.
   - may be applied to both residential and non-residential water use.
   - quantify to fit desired reductions that satisfy the shortage situation.
   - mandate government water use conservation program.

Water districts in other areas whose water use reduction goals are greater than 10-15% during water supply shortages have not found voluntary measures sufficient. Higher reduction goals usually entail some mandatory aspect in water management. The most common restrictions imposed are enacting no water waste ordinances and restricting residential and some commercial irrigation use. Irrigation is addressed as this is almost universally the greatest use of municipal water and it is relatively easy to manipulate to fit the water shortage severity. Most water providers begin by restricting use to three times per week based on address, one time per zone per day for some length of time and restrict irrigation times to the period between early evening and early morning. Both the duration and number of days are reduced as conditions worsen.

If Lake Havasu City adopts irrigation scheduling, there is quite a bit of flexibility regarding how the restrictions are imposed. The time of day and the number of watering days of the week for each home can be adjusted throughout the year or adjusted according to the severity of the Shortage, the restrictions could be imposed only a particular time of the year, and the water scheduling could be advanced to the public as a voluntary measure before the need for mandating. Graduated restrictions may also be applied to changing Shortage conditions. For example, light restrictions may be imposed during “Paper Shortages”, but additional magnitudes of restriction may be applied as Shortages creep closer to “Wet Water” Shortages.

Other restrictions may be addressed through Ordinance 10-1004, No Water Waste, whose provisions may be implemented through the City Council as the water supply conditions dictate (see Section 6.2).

3) Alternative Water Sources (AWS)

The two main potential water sources outside Lake Havasu City are firmed Colorado River water banked through the AWBA and water leased through land fallowing agreements. Both will dramatically demand more funding through the City’s budget. Requesting water from the AWBA account will include a recovery charge, which is estimated to be between $80 and $150 per acre-foot, depending when the water is withdrawn. The water will be sold to a customer within the Central Arizona Project system and credits will be assigned to the City’s account. The city can then pump an equal volume of water locally. The City is required to replace the water within a three year period after a Shortage ends OR pay cash at water market value at that time. If the City is not using its entire entitlement after a period of Shortage ends and a normal supply condition resumes, the City cannot use any of its unused entitlement to “pay back” that water. The water market value cannot be precisely predicted because there is no precedent as there has never been a Shortage declared on the Colorado River. Values will probably be based on other lease fallowing agreements or private water sales during a Shortage period. The market value would be expected to be higher than the $1400 per acre-foot that Lake Havasu City paid for the Cibola acquisition in 2008. Of course market value will fluctuate through time, probably increasing into the future. Regardless, compared to the $0.25 per acre-foot cost through the City’s Bureau of Reclamation Colorado River contract, there will be a much larger financial burden on the City. The firmed water account is good until 2096 or until all water has been withdrawn from the account. Because the account is not replenished, the City will have to be prudent in using this source to make it last 86 years.

The City is also developing a land fallowing agreement with Mohave Valley Irrigation and Drainage District (MVIDD) through the Mohave County Water Authority. Negotiations with MVIDD will be on-going through 2010 and the agreement is proposed to be scaled-down version of a land fallowing agreement executed between the Palo Verde IDD in California and the Metropolitan Water District of Southern California. The essence of a fallowing agreement is to compensate farmers for not using a specified amount of water to irrigate, by way of fallowing a field, so that a water provider can lease that same water for a specified period.

Reuse of the City’s water via treated wastewater or effluent is a third alternative water source distinct from the other two mentioned. Increased use of effluent in place of potable water for irrigation on large landscape areas extends the City’s water allocation. The main difference from the two other alternatives is that this water source is currently utilized, is planned to be maximized in the near future, and is a potential revenue stream.

A water resources fund dedicated to paying for the firmed water or for water resulting from fallowed land needs to be established prior to Shortages if the City elects to implement this strategy. Future Shortage conditions may be such that the City may have no other recourse. Water conservation, whether voluntary or mandatory, has its limits with respect to maintaining an achievable standard of comfort. Accessing the firmed water or paying for agricultural water may be the most plausible approaches in this situation. The water resources fund could be established in several ways including incorporating it into the water rate pricing structure noted below, redirecting water resource impact fees on new development, and/or dedicating some of the revenue of effluent sales to the fund. Notwithstanding, the process of acquiring the needed funding should begin long before Shortage conditions dictate the need to acquire these alternative water sources.

4) Water Rate Pricing (WRP)

- Establish a special rate system effective for the Shortage term.
- Need to be based on revenue/cost of delivery ratios and on the cost of acquiring alternative water sources (AWS).
- Set excess surcharges to users that go over their allocation (WRA).

Restructuring water rates has historically encouraged water conservation. Water rate pricing may also be used to generate funds for the potential access of firmed water from the ABWA or water leased from a fallowing agreement. The City may explore seasonal water rates to correspond to demand changes, similar to the electric power industry. Revenue decoupling is another strategy electric utilities employ to generate targeted revenue while at the same time not to disincentive energy efficiency. Similarly, water conservation efforts would not need to be impacted if the desired revenue is not impacted by the amount of billable water delivered.

The water rate pricing strategy is present for two main reasons, to provide a financial incentive for high water use consumers to conserve and to establish or augment a rainy day fund to help pay for alternative water source acquisitions. Historically, water consumers decrease their use when rates are increased and if the City decides to access the firmed water from the AWBA, there will increased costs associated with recovering, managing and replacing that water. The rate strategy could be applied a couple of different ways. The normal supply three-tiered rate structure permanently in effect could be modified during “wet water” shortages to reflect increased costs associated with possible water acquisition and/or to offset revenue reductions due to decreased water consumption. More tiers could be added to the rate schedule or different rates could be applied to different user categories. Excess rates may also be applied for the high volume consumer based on the citywide percent reduction goals. Careful rate consideration must be made in order not to penalize the user who is already conserving water.

5) Water Rationing Allocations (WRA)
   - Allocate water to each customer based on desired water % reduction to fit the shortage scenario.
   - Needs to be equitable among users.
   - Fit allocations to needed reduction – May be adjusted annually or sooner if goals are not met.

Drought status has been severe enough in some areas of the country (California, Texas and Georgia) that temporary water rationing went into effect, including making water available only during a specific time of day. A few California water providers have established the allocation rationing model by setting allocation limits to customers based on a percentage reduction of their prior use. The cities of Goleta, Redwood City and Santa Cruz along with the Redwood Valley County Water District have provisions for allocations in advanced drought stages of their water management plans. This strategy has met with mixed success in past drought situations. The California Department of Water Resources has published an urban drought guidebook detailing the allocation rationing concept. The document presents five allocation schemes; 1) percent reduction, based on prior use, 2) financial rationing based on the number of residents in a home, 3) per connection allotment that establishes a customer's water consumption goal on a unit basis calculated from an estimate of essential uses, 4) a per capita allotment per person, and 5) a hybrid of per capita and percent reduction. The type of rationing established depends on 1) the amount of water available for health, safety and sanitary purposes, C&I uses and landscape irrigation; 2) seasonal variation in water consumption; and 3) the degree of homogeneity among customer types. The hybrid model for residential accounts has been noted as providing an equitable way to balance reductions with those customers who already conserve.

8.1.2 About Implementing Water Rationing Allocations

Water rationing allocations are recommended only during "wet water" Shortages when the City's actual allocated supply is reduced by 20% or more. Reductions less than this may be addressed through a combination of the above mentioned strategies. Introducing allocation rationing during reductions greater than 20% will afford the City a good chance of obtaining its goal. The allocations could be assessed in combination with some of the other strategies mentioned to ameliorate the burden on the City's customers and could be flexibly managed in several different ways to fit the particular Shortage conditions. Any apportionment rationing will require a set of criteria to base decisions on the amount of water a particular customer will receive in a year or month. The criteria include account historical usage, family size (per capita consumption), and health and safety needs. City financial and logistical considerations, community impacts, and supply availability also need to be considered when planning this strategy. Reclamation will make its determination in August of the year before the Shortage is implemented, giving local water providers about 4 months to make final preparations.

There are several approaches to meet percent reduction goals for residential accounts under the allocation rationing strategy. One approach is a month by month reduction based on the prior year's use or prior five-year average for each month. This percent reduction could be weighted among customers based on level of consumption (i.e. to what rate tier the average corresponds) so that customers who already conserve will not be penalized. Alternately, the reduction could also be based on the prior year or averaged five-year total consumption regardless of month. This second tactic will heavily rely on the customer to pay attention to their water use throughout the year. A basic health and safety allocation should be assigned per person (68 gpcd was used by Goleta Water District) and customers on higher tiers would have to proportionately cut back on consumption so that those customers who already conserve are not penalized. For example, if the reduction is based on a customer's averaged monthly consumption, then a customer account that is using less than 1000 cubic feet per month, may not have their water reduced. Those customers that use progressively more water could have imposed on their account a sliding scale percentage reduction with more use (Table 8-1).

Table 8-1: An example of residential reductions based on consumption history, keeping a base supply for health and safety considerations. Some residents may have greater needs for health and safety than others, which can be accommodated. The reductions do not consider the size of the property or landscape irrigation requirements.

Average Consumption History	Percent Reduction from Average
Less than 1000 cu. ft.	No reduction
1000 - 1200 cu. ft.	5%
1200 - 1400 cu. ft.	10%
1400 - 1600 cu. ft.	15%
1600 – 1800 cu. ft.	20%
1800 – 2000 cu. ft.	25%
2000 – 4000 cu. ft.	30%
4000 – 6000 cu. ft.	35%
6000 – 8000 cu. ft.	40%
8,000 – 10,000 cu. ft.	45%
Greater than 10,000 cu. ft.	50%

Over 50% of Lake Havasu City's total annual water consumption occurs as residential landscape irrigation, most of which takes place during the warmer months. Since water demand is highly seasonal, a third possible approach to allocation reductions is to shoulder the burden of the required reduction to one part of the year. Each season has benefits and disadvantages on some level. Limiting water consumption during the winter months would help customers financially by keeping their monthly sewer charges lower and more water would be available in the summer months for most usual practices (i.e. fewer restrictions). A winter averaging program is already in place that sets monthly sewer charges for the rest of the year and forcing a reduction on top of that may not yield the desired results. The City would also experience reduced revenue to pay for the sewer program. Focusing on reductions during the summer would not impact incoming sewer revenue and would help in reducing peak flow periods. Saving water at this time of year will also keep citizens focused on water conservation for more of the year (since winter averaging will still be in effect). Limiting water use during the summer may worry citizens about damage to their landscapes, yet an aggressive public education program could ease those concerns.

Straight percent reductions have been favored for non-residential customers during water shortages in other regions of the country, yet some water providers have considered the number of employees that a company has to factor in health, safety and sanitary needs. The amount of reduction mandated will depend on the overall reduction to the City's allocation and the proportion of the non-residential consumption to the residential consumption.

Enforcement of rationing programs is typically in the form of excess surcharges assessed to customers who exceed their allocation limit. Excess surcharges are separate from drought surcharges in which the later is a part of the water rate pricing strategy to compensate for lost revenue during water shortages. Excess surcharges are automatically included as a separate line item in the customer's water bill and the surcharge is usually much steeper than a change in water rates due to revenue losses, on the order of $3.00 to $25.00 per 1000 gallons used above the allocation limit.

8.1.3 Water Rationing Allocation Caveats

Unlike mandatory restrictions, the ideology of water rationing allocations does not by itself, necessarily restrict how the water is used. In a perfect world for a given allocation period, customers are expected to stay within their allocations and the water provider is expected to keep the customer informed regarding their status. However, none of the water providers who have a rationing allocation component in their drought mitigation plan use this strategy alone. Most initially address shortage reductions with voluntary and mandatory restrictions that are kept in place while implementing allocations as conditions worsen and deeper water consumption reductions are required. A highly organized effort is required by the water provider to assess the allocations among its customers, particularly developing a mechanism to keep customers informed of their use. Redwood City, California has perhaps the most well developed system, including using the web for customers to log on and find out their current usage. A component of this approach is to have in place a residential meter recording program, such as a radio transmission/receiver system, that can yield real time water volumes available for both city staff and customer use. Lake Havasu City's lag time, between when the water meters are read, which are done manually, and when the customer knows how much they have consumed (i.e. when they receive their water bill), is approximately 3-4 weeks.

A prime reason why many water providers do not use allocation rationing is the intense labor needed to develop and implement such a program. The required manpower to fully develop and implement this process is greater than the present workforce Lake Havasu City has dedicated to water conservation/supply. At least three more employees need to be dedicated to the program to administer the program's logistics, such as tracking customer usage and communicating that usage to the customer, database development and management, public outreach and field checking water issues (e.g. violations). The public needs to be kept fully informed about their water usage and the circumstances under which they are using the water. The program's projected costs and the City's budget climate will dictate whether this form of water management is implemented.

One seeming advantage of this strategy is the implied flexibility the customer has in using the water, yet when this approach has been implemented in California, mandatory irrigation and no water waste restrictions have also been in place. Quite a few water providers use the term rationing in their drought shortage plans, but the measures within the rationing scheme are really restrictions on irrigation and other water use to obtain the desired reductions. A mandatory restriction with penalties is by far the most common strategy for water providers across the country to reduce water consumption under stressed conditions.

8.2 Shortage Response Strategies Implementation Examples

These strategies can be thought of as a toolbox, from which the City could implement with changing water supply conditions. Each strategy could stand alone, depending on the water reduction goals and how the City would like to approach the problem, but most water providers across the country use some hybrid form to conserve their dwindling resources. This approach maximizes water consumption efficiency, gives the City flexibility to adapt to varying resource and financial circumstances and minimizes the burden on the community. Table 8-2 provides examples of hybrids matched against water supply stages for Lake Havasu City. These possible scenarios are ordered from least restrictive, where citizens have more of a choice in their water use, to a more mandatory guided effort. There are other possible combinations of strategies, yet the five selected give a sense of flexibility to implement strategies that fit the City's water supply and financial situation at the time of Shortage.

Table 8-2: Water supply stages and example drought strategy combinations to mitigate Lake Havasu City Shortage reductions.

STAGE	Example Drought Strategy Combinations				
Normal Supply	VWC	VWC	VWC	VWC	VWC
Paper Shortage	VWC	VWC / WRP	VWC / WRP	MR / WRP	MR / WRP
Wet-Water Shortage	VWC / AWS / WRP	AWS / WRA / WRP	AWS / MR / WRP	WRA / MR / WRP	AWS / WRA MR / WRP

8.2.1 Paper Shortage Conditions

Although a Paper Shortage does not specifically limit the actual amount of water that the City would normally use in a particular year, the gap between the demand and the allocation ceiling will be variable, tending toward a convergence with time. The first Shortage declaration will be 400 KAF when Lake Mead's elevation drops to 1075 feet amsl. Each year after, while the elevation is still below 1075 feet, but above 1050 feet amsl, the Shortage volume may or may not stay the same, depending on the allocation needs of the higher priority users. Under normal economic conditions, the City's population will grow through this same period, pressing for greater water needs and thus narrowing the supply – demand gap. If the lake's elevation drops below the next two trigger elevations, successively larger Shortage volumes come into play (500

KAF and 600 KAF) along with the expected demand increases. Aspects of the proposed strategies presented in Table 8-2 can also be applied within the Paper Shortage stage (Table 8-3). As the supply – demand gap closes; the City will have the opportunity to proactively adjust to the increasingly deleterious conditions, if it wishes, by taking steps to prepare for Wet Water Shortages during Paper Shortages. Action measures in the table are only examples of what could be implemented given the type of strategy employed. Since the Paper Shortage category's length of applicability is uncertain, a long term management approach is recommended.

8.3 Projected Water Savings

Calculated water savings using any of the above strategies depends on available historical consumption rates and a few assumptions where data is not obtainable, such as frequency and duration of irrigation at all residences. Some pre-Shortage (normal supply) voluntary measures such as implementing home water audits can be used to estimate water savings based on a sampling of water consumption histories before and after the audit. The City is actively developing a database to track and calculate the effectiveness of water audits. A small sampling indicates savings of 6-10%, yet there are several factors to consider. Not all accounts achieve reductions right away and repeat visits may be necessary. Also many water accounts belong to part time residents or second home vacationers that may not regulate water use (such as fixed irrigation schedules throughout the year) or be responsive to changing conditions such as developed leaks or appliance failures.

Converting non-residential, potable water irrigators to effluent use is directly quantifiable and at this point a voluntary measure for the user if an effluent pipeline is in close proximity and if enough effluent is available. The percent potable water saved would be account specific. The City saved over 2200 ac-ft of potable water due to effluent irrigation in 2009. Similarly, the amount of water saved by irrigation converting from potable water to well water not tied to the City's Colorado River allocation can be determined. Most likely, these two efforts would be done before Shortages as normal water conservation measures.

Other voluntary water conservation measures will rely heavily on public outreach by the City, particularly when focusing on outside water use. Billing consumption for the last year and a half indicates that residential irrigation composes approximately 63 % of the total City's water consumption. A focused program on landscape irrigation sanctioned by local landscape and nursery companies can help lower irrigation volumes. Depending on how the recommended restrictions are structured and the cooperation of the community, total allocation reductions between 5% and 15% can realistically be obtained as documented from other water providers who experienced recent droughts in California and Texas.

Proposed residential irrigation restrictions should assume an average irrigation volume from irrigation meter accounts to estimate the percentage of residential use actually goes to irrigation. The City is currently determining this ratio by examining all residential accounts with irrigation

Table 8-3: Example of Paper Shortage stage of Table 8-2 expanded to include possible increased water conservation measures as the allocation demand nears the entitlement ceiling.

Paper Shortage 400K-600K ac-ft	**VWC**	**VWC /WRP**	**MR / WRP**
Percent water demand allocation below entitlement ceiling	Stress extent of voluntary measures.	WRP should be scaled for revenue loss and for AWS funding.	Tier mandatory restrictions.
> 20%	Continue public education similar to Normal supply conditions, but add messages about Shortages.	Implement a revised water rate structure to fund firmed water orders.	Impose irrigation restrictions & strictly enforce No Water Waste Ordinance.
20% - 10%	Step up public outreach & suggest irrigation schedules along with other water use limitations.	Review revenue generation for firmed water orders and adjust as needed.	Same as above.
< 10%	Full scale public outreach, rewards program(?), more stringent irrigation requests, & intensify water audit program.	Continue review of revenue generation for firmed water orders and adjust as needed.	Tighten irrigation restrictions by reducing # of days and duration.

meters for each month in 2008. The resultant ratio can be applied generally to all residential accounts with the stipulation that accounts with irrigation meters may actually irrigate more than residents who do not have an irrigation meter. The thought behind this is those with irrigation meters do not have to consider sewer lock-in rates from winter averaging, so higher winter irrigation usage is not penalized. Before the irrigation-domestic ratio is determined, an example of potential water savings through the modification of irrigation application in Lake Havasu City is given (Table 8-4). Assuming the typical application rate is 5 days a week year-round for either all residential accounts (25,200) or just half of them (12,000), and a consistent duration rate (either 30 minutes or 15 minutes), then the percent water use reduced from the 2008 allocation of 13,427 ac-ft will vary depending on the degree of reduced number of applications per week. Even the most conservative estimates indicate 2% – 10% reductions in water use. These changes whether voluntary or mandatory may be sufficient in early Shortage stages where the City’s realized reduction is less than 20% of normal supply.

Mandatory reductions greater than 20% will probably require either tightening restrictions and/or added strategies such as drastic changes in rate structure, accessing water from the AWBA, or rationing the existing water supply. Water savings from each strategy will depend on the severity of the restriction (again willingness of the public to cooperate), allocation ration, and on the amount of water accessed from the ABWA account.

Estimating water savings from other water conservation measures is not easily quantifiable because these measures may not be able to be separated from the account as a whole. For example, rebate efforts (replacing high use toilets and installing pool covers) and installation of efficient restaurant spray rinse heads would require the water use from these items to be isolated to get a really good idea of the percentage reduction. Other uses associated with domestic (especially if there is no irrigation meter) or restaurant consumption may overwhelm a perceived reduction, although intuitively there is a savings. Likewise, advertising and education campaigns most certainly help, but hard to quantify in terms of real water savings.

Table 8-4: Water consumption reduction estimates from Lake Havasu City's 2008 water allocation when irrigation practices are altered.

Percent Reductions from 2008 Allocation of 13,427 ac-ft based on original 5 day/week irrigation all year						
Irrigation Duration	# of Residential Accounts Considered	Seasonal Changes in Irrigation Frequency	4 days/week Irrigation all year	**3 days/week Irrigation all year**	2 days/week Irrigation all year	1 day/week Irrigation all year
30 min.	25200 12000	29.65% 14.12%	9.95% 4.74%	**19.91%** **9.48%**	32.35% 15.40%	42.30% 20.14%
15 min.	25200 12000	14.83% 7.06%	4.98% 2.37%	**9.95%** **4.74%**	16.17% 7.70%	21.15% 10.07%

Seasonal Changes in Irrigation Frequency:

3 days/week for 5 months

2 days/week for 4 months

1 day/week for 3 months

8.4 Non-shortage emergency situations

Lake Havasu City has short term water supply emergency contingency plans in the City's Emergency Response Plan, yet the provisions in the plan do not cover long term catastrophic disruption in water supply. Many of the strategies for Shortage response in this document are applicable, depending on the severity and type of the disruption. Barring out-right disconnection of the distribution system so that water cannot be transferred to the customers, wet water reductions by allocation rationing, restrictions and water rate pricing could be utilized either alone or in combination. Complete incapacitation of the City's water treatment plant would mean by-passing it and pumping only from the existing north and central well fields as in the past, at least until the a new connection and treatment process can be configured to the force main from the Horizontal Collector Well. Adjustments of this magnitude and the associated time involved may require a schedule of varying strategies to accommodate for health and safety water demands as well as responsibly easing stress on the citizens as soon as possible.

9.0 2011 – 2015 WATER CONSERVATION ACTIVITIES

The overall goal of the 2011 - 2015 water conservation plan cycle is to decrease Lake Havasu City's per capita water consumption to at least 200gpcd. This per capita rate goal could increase if the percentage of commercial and industrial development increases relative to residential development and associated active conservation measures, yet with the current poor economic standing of the world today, sluggish short-term commercial growth is anticipated and the gpcd goal stated should be achievable over the next five-year conservation period primarily through education and outreach.

9.1 Measures that will be implemented within the 5 year period

A number of activities ranging from an increased education/outreach component to converting more potable water irrigation customers to effluent are proposed over the next five years to help lower the City's water consumption. Much of the effort will be focused on lowering residential irrigation, since over 50% of the City's water consumption is in this water use category, yet non-residential irrigation with potable water will also be addressed.

9.1.1 Establishment of a Citizen Volunteer Water Conservation Group

Lake Havasu City will establish a citizen volunteer water conservation group in late 2010 to help with public education and outreach. City staff along with volunteers will develop a logistical plan for training and scheduling a variety of activities. The volunteers will then carry out the activities and document changes in water consumption either per customer account or within a water use category.

Initial proposed activities by this group include:

1) Developing open workshops, each covering a range of topics pertinent to residential and commercial customers. (i.e. – tie winter water use with monthly sewer fees, irrigation practices, how to read a water meter and track water use, landscape plantings, evaporative cooler and swimming pool auto-refill devices, in-home plumbing, water softeners, graywater use, etc.)
2) Develop an extensive water conservation web page on the City's website. The existing web page is woefully insufficient and buried several windows deep into the City website.
3) Help facilitating the City's water conservation rebate program.
4) Develop water conservation tips on water bills (already done, but not at the level that it could be).
5) Develop a "How to Guide" brochure for customers (winter visitors and weekend home owners) whose primary residence is not in Lake Havasu City. The guide will explain steps to take to reduce water consumption, water leaks and water waste when not living in the City.
6) Develop a program to collect or educate how to properly dispose of unused pharmaceuticals instead of flushing them down the drain.

7) Develop an awareness campaign to inform residents of Colorado River shortage year projections and how it will impact their life, their neighborhood, and their community. This will include educating citizens about the City's shortage response strategies.

9.1.2 Conversion of potable water irrigation to effluent or well water

Lake Havasu City is in the final year of its wastewater expansion program with over 20,000 septic tanks decommissioned by program's end in the summer of 2011. Wastewater treatment volumes are projected to expand to near 5 MGD, increasing effluent availability for reuse. This topic is extensively covered in Section 5.0, Effluent Reuse, including the addition of new customers that currently use potable water for irrigation who may be converted within the next five years. As noted in Section 5.2, effluent not used directly for reuse will be stored in the subsurface during the winter and recovered in the summer to mitigate the effects of seasonal irrigation demand and minimize effluent losses. Further potential customers are briefly discussed in Section 9.2 below.

The Colorado River Aquifer that underlies Lake Havasu City has a water table elevation substantially above the accounting surface upslope from Lake Havasu's shoreline. A water source study conducted by the City in the mid 1990's included drilling a few exploration tests, two of which were developed as monitoring wells. None of the exploration tests yielded enough water volume to make them useful for municipal purposes. One particular well, however, has a water table elevation over 70 feet above the accounting surface elevation and is proposed to be utilized in a pilot project as a small scale irrigation well for landscaping around City Hall and the City's police station. Irrigation system lines in place currently convey potable water, but can be modified to transport well water instead. The City will closely monitor well water consumption and water table levels to determine whether this activity will have any long term changes. Total expected annual savings to the City's Colorado River water allocation will be approximately 20 ac-ft. If this project is successful, then the City will explore other city property sites such as neighborhood parks that might also be served by groundwater.

9.1.3 Other measures scheduled to implement over the next 5 years

Even small reductions in consumption spread out over such a large user base can potentially realize significant savings. To this end, there are several other conservation activities recommended for completion within the next five years.

1) Study the feasibility of draining pool water into the sewer system so that it can be recycled.
2) Examine alternatives to conventional water softeners and reverse osmosis systems that generate very little to no water waste. Regeneration cycles in current softeners consume between 30 and 40 gallons of water that becomes the brine. The reverse osmosis process uses between 3-5 gallons for every 1 gallon of clean water produced. Water softeners using salt also increase effluent total dissolved solid content, which degrades effluent quality for irrigation. The practice of periodically flushing turf areas to dissolve salt build-up is also a waste of water.
3) Complete an effluent reuse master plan and a revised wastewater operations plan.

4) The City will be issuing to citizens water stop valves for bubbler irrigation systems, which prevent water waste in case a bubbler head or riser is broken.
5) The City will install flushless urinals in all of its government and public facilities.
6) Certain turf areas may be reduced at city sites and at sites owned by the Lake Havasu Unified School District. More xeriscaping projects are scheduled.

9.2 Water Conservation Measures under Consideration

9.2.1 Future Wastewater Recycling

Lake Havasu City's annual wastewater volume is only ¼ of the potable water delivered to customers. Most of the water delivered that is not returned via the sewer system is used for home, commercial, park or school irrigation with a smaller quantity used in construction and industry. Potable water used for irrigation percolates into the subsurface, evaporates or is consumed by plants. In all these cases, the water is irretrievable, so Lake Havasu City will be examining options to permanently increase the above ratio. Converting irrigators to effluent, as mentioned in Section 5 and above in Section 9.1.2 will help, yet the extent to which effluent is used for irrigation depends on its availability. As the City grows, there will be opportunities for new developments to increase water efficiency, including incorporating graywater and/or effluent plumbing. Effluent plumbing for irrigation would probably be restricted to larger residential developments outside the City's IDD. The City is not configured for this irrigation method to residences within the IDD, yet a limited graywater irrigation plumbing system can be installed in existing homes and businesses. More extensive graywater plumbing could be installed during new construction. To the extent that either of these alternative water uses are realized will determine the amount of effluent generated at the City's three wastewater treatment plants as development moves ahead.

Increased effluent volumes could translate into more irrigation customers converting from potable water. The Lake Havasu Unified School District irrigates ten facilities, including one high school, two middles schools, six elementary schools and a district office complex, all of which use potable water (230 ac-ft total in 2009). Previous cost-benefit studies have shown that the cost of delivering effluent to each site is not justified, at least from a conventional view of installing effluent pipelines from Arizona State Route 95 near the lake and pumping effluent up slope to each site. An alternative approach has been discussed to transport effluent from the North Regional Wastewater Treatment Plant along a Western Power Administration utility easement through the eastern part of town, which would require little pumping effort and would be up slope of all schools. This line would end at a city park on the southeast most side of the city. The line would not only supply effluent to the park, but could also gravity feed effluent to all schools. This plan probably requires that the City generate more than the 5 MGD effluent total predicted at the end of the wastewater expansion program and would rely on new development to increase effluent volumes. As such, this plan is not scheduled to be implemented within the next five years.

An alternative to adding more customers for effluent use is the eventual shut down of the City's South Intake of lake water to blend with effluent for the London Bridge Golf Course. The South

Intake withdrew almost 500 ac-ft of lake water in 2009. Replacing this water with effluent would add significantly to the City's allocation for potable water treatment. This process should be subordinate to replacing potable water irrigators since the cost of delivering the raw lake water is much lower than delivering treated water. If the effluent total dissolved solid concentration can be significantly lowered over the next five years, the need for blending effluent with lake water will not be great.

9.2.2 Water Meter Technological Upgrades

There are almost 30,000 conventional water meters in Lake Havasu City, all of which need to be manually read and submitted to the City's Finance Department. The current timing between the meter reading and the customer receiving the bill is between three and four weeks. Unless each customer tracks their own water meter readings, that time delay does not let the customer quickly correct their situation if they either have an undetected leak or are overusing water. This is most important during winter water consumption averaging to determine monthly sewer fees (Section 7.1). The City will be exploring the feasibility of modifying all water meters so that they send radio signals to a central receiver that collects and sorts by account customer the amount of water used at any given moment. The usage can also be uploaded to a customer account that can be tracked in real time by the customer, thus eliminating the time delay. The City will also have the capability of closely managing its supply by quickly responding to issues, particularly during Shortages. If grant funding becomes available, this water meter upgrade program may begin within the next five years.

9.2.3 Commercial/Industrial Water Conservation Plans

In Lake Havasu City, commercial users represent 11.4 percent of water consumption; construction/industrial users represent approximately 1.5 percent (Figure 3-2). Thus, there are limited opportunities for reductions in consumption for existing customers. The 2006-2010 water conservation plan stated that Lake Havasu City will require all new commercial/industrial customers using more than 5 acre-feet/year to submit a water conservation plan as part of the building permit review process. Each customer would identify total water usage and any water conservation measure that would be implemented. The plan also requires the use of the best available technology, if it is proven to be cost-effective. These individual conservation plans would be an effective tool for monitoring new commercial or industrial water usage and evaluating impacts of industrial growth on per capita consumption. This requirement has not yet been realized and may not be within the next five years as the general economy is not currently supporting many businesses that use this much water and to be fair, the plans would also have to be required by any other entity that uses more than 5 ac-ft/yr.

10.0 PROJECTED RESULTS OF SELECTED MEASURES

10.1 Plan Summary and Monitoring

The water conservation measures and activities discussed in the above sections form the basis for the Lake Havasu City Conservation Plan. Measures in sections five through seven have been successfully implemented in Lake Havasu City, have proven effective, and will not only be continued, but many will be enhanced over the next five years. Additional conservation measures discussed in Section nine, were reviewed for applicability to the Lake Havasu City conservation program, and included in the plan as appropriate. Section eight, Water Supply Stages and Water Shortage Response Plan, is untested yet should provide city leaders many options to mitigate water allocation shortfalls. This section summarizes the Lake Havasu City 2011-2015 Water Conservation Plan, and includes ongoing programs, revisions to ongoing programs, and additional measures that were determined to be feasible and practical for meeting the goals of the program.

Elements of the plan, status, proposed revisions, monitoring techniques, and goals established for the 2011-2015 conservation period are as follows:

1. Water Measurement and Accounting System

Lake Havasu City has two ways to account for water use, diversion meters and billed consumption through user end meters. Ideally, the difference between the diversion volume and the billed consumed should equal the unaccounted water loss in the distribution system. Typical values for annual unaccounted losses range from ~7% to ~10%. From 2007 through 2009, the main diversion meter readings at the City's water treatment plant were significantly different from the billed consumption during the summer high flow periods (up to 20% annually). Much work was done by the City's Water Division to understand and correct the problem. As of calendar year 2010, the meter has been calibrated and now diversion – consumption differences are more in line with expectations.

Accounting procedures and customer billing, the major monitoring tools for water consumption, have continued to improve such that abnormally high water uses within each user category are flagged and sent to the WCO for customer contact. Accounting reports can isolate water user types to track trends in those categories (e.g. single and multi-family residential, commercial, industrial, construction, irrigation, schools, etc.). Water conservation tips may now be written on the water bills to remind customers what activities they can do to lower their water consumption.

2. Water Pricing Structure

The structure of water pricing was modified by the ordinance passed in 1990 to institute an increasing rate structure. All customers are billed according to the increasing rate structure. This conservation measure was very successful in reducing the unit consumption rate. Additional rate structure changes were implemented for July 2000, July 2001, October 2002, July 2003, and July, 2004. This increasing rate structure has been successful in reducing water usage, yet the frequency of rate increases has slowed with the newest rate increase in August 2009. This last rate increase only affected tiers 2 through 4. Tier one rates actually decreased with an accompanying drop in the water volume from 1500 cu. ft. to 1300 cu. ft. to reward customers when they conserve. This last rate hike was established primarily to support 10-year community improvement projects for water distribution upgrades. Declared Colorado River shortages may be realized during this next five year period, and as mentioned in Section 8, a new water rate structure could be approved by City Council to accommodate increased expenses.

3. Public Education and Outreach Program

As stated, an information/education program is vital to the success of any water conservation program. Many of the informational techniques recommended are in place and continuation of these programs is an integral component of this Water Conservation Plan.

This program will be continued and expanded, the focus of efforts will be aligned to accomplish the overall goals of the Water Conservation Plan:

- Establish a volunteer water conservation citizen group to help with presentations and workshops, help develop a\the City's water conservation web site, and other related work.

- Post articles in the local print media promoting various forms of water conservation.

- Continue presentations about water conservation to the 2^{nd} and 4^{th} grade students in our entire public school system.

- Develop an awareness campaign regarding Colorado River shortages and the potential responses adopted by the City to mitigate the shortage's negative impacts.

- Communicate to the public regarding the winter consumption averaging for calculating monthly sewer fees.

- Expand the City's water conservation web site, giving tips for water saving measures, explain winter consumption averaging, provide rebate forms for selected water conservation devices, etc.

- Issue timely water conservation advertising in the local media and on the City's information cable television channel.

The effectiveness of each component of the public education and outreach program will be qualitatively assessed, followed up with an annual assessment of water consumption by category compared to previous annual amounts. In addition, this program will be evaluated based on achieving specific program element goals, for example, successful dissemination of information.

4. Water Conservation Implementation

An official Water Conservation Officer was designated by the City in 2001 and an official Water Resources Coordinator was designated by the City in 2005. Together, the two positions will be responsible for implementing various conservation plan elements and monitoring results.

5. Free Water Audit Program

Lake Havasu City currently conducts a customer audit program (residential and non-residential) to assist in determining normal water usage and identifying potential water waste issues. Audits may originate in one of the following ways; the City's customer service may alert the WCO to an account's unusually high water consumption, the WCO may observe an irrigation leak and contact the customer, or most frequently, the customer receives a high water bill and contacts the WCO to schedule an audit. The WCO suggests what corrective action the customer needs to do in order to alleviate the high usage. Monitoring of this program consists of tracking audit requests and monitoring post audit water consumption.

6. Water Regulations

City ordinances to mandate low water use landscape materials for new developments in zoning classification R3 (multi-family) and above and to mandate low flow plumbing fixtures in new construction have been in effect for over 20 years.. They have been very effective and no anticipated revisions are expected. The new no waste of water ordinance will be helpful during water shortages, yet this regulation may be modified to suit the intended purpose. Effectiveness of this regulation will be monitored through tracking the monthly diversions and comparing those with previous year monthly totals.

7. Distribution System Audit Program

Distribution system audits are conducted on an on-going basis by the City's Water Division to find leaks and inefficiencies in the system. The overall goal is to maintain "Billing Date Difference and Unaccounted Losses" below 10 percent. The City's Fire Department also regularly inspects fire hydrants and standpipes to ensure proper operation and integrity.

8. Water Shortage Response Plan

An official water shortage response plan, defined in Section 8 and approved by the City Council in 2010, provides a flexible means to mitigate a variety of shortage scenarios. The plan promotes early voluntary water conservation through public education followed by more restrictive measures during harsh conditions. The goals of this program are to make sure the City uses the most effectively strategy to get through shortage periods. Daily water diversion volumes will be monitored and evaluated for success.

9. Wastewater Reclamation and Recycling Program

This has been an element of the existing Lake Havasu City conservation program for some time. It is an important conservation measure that is a major component of the City's management plans, which identify both short-term and long-term goals.

The short-term (2011-2015) conservation goal is to increase usage of treated wastewater and reduce the volume of water disposed in the Island percolation ponds. This requires storing through subsurface injection, increasing effluent volumes during the winter and pumping that water out of the ground to supply more customers during the summer. Metering of effluent use (reuse, storage and percolation) is in place. Monitoring of the increased usage will be performed using existing monthly reports of effluent reuse, combined with metered percolation volumes. An effluent reuse plan is under development to organize future operations and to schedule new customers.

10.2 Projected Results

The billed per capita consumption average for 2009 was 206 gpcd, yet that number does not include unaccounted water losses within the distribution system. Unfortunately, metering problems between 2007 and 2009 for the water diversion from the Colorado River aquifer have not yielded an accurate account of what water was really diverted. The meter system over measured as much as 35% compared to consumption volumes during the warmer season, higher demand period, but was much closer aligned to consumption rates during the winter months. Yet the 2009 diversion of 15,683 ac-ft is equivalent to 252 gpcd. Multiple meter testing events and subsequent recalibration have helped to close the diversion / consumption gap in 2010. Lake Havasu City's Water Division went through a recent five year leak detection program for the entire city, has been following the progress of the City's sewer expansion program by replacing older, rupture prone PVC water service lines to customers with wrapped copper lines and has established a more efficient leak repair operation to minimize losses. Unaccounted loss estimates range from 7% to 12%, so if 10% is used, then the estimated true diversion/consumption per capita rate for 2009 was 226 gpcd. To achieve a usage rate goal between 220 and 200 gpcd, total water savings of approximately 10 to 30 gpcd will be necessary.

Based on discussions in earlier sections, the conservation measures that will be most instrumental in achieving conservation goals for the 2011-2015 period are wastewater reuse and programs that target residential irrigation consumption. This will be accomplished through a combination of an intensive public education program and conversion of potable water irrigators to effluent or to groundwater not associated with the Colorado River. As mentioned in section 5, the City will complete its wastewater expansion program in mid-2011 and should be generating between 4.5 and 5 MGD of effluent from its three wastewater treatment plants. Converting current entities in Table 5-1 from potable water to effluent irrigation or non-Colorado river influenced groundwater will amount to between 400 and 700 ac-ft per year savings (~6 to 11 gpcd). This savings, by itself, is enough to lower the City's per capita consumption to within the goal range, yet residential irrigation is the single largest category of consumption and must be addressed for successful long term water management. The proposed citizen volunteer group will help with public education on this topic particularly from the perspective irrigation scheduling and its relation to winter consumption averaging and residential monthly sewer fees, to adjustments for weather conditions (short-term events and seasonal variations), and to landscape styles (e.g. xeriscaping, native plantings, etc.). Total residential consumption was reduced by over 10% (~23 gpcd) from 2005 to 2009, most of which is attributed to scaling back irrigation. A stronger education push over the next five years to foster wide spread efficient irrigation practices along with rebate programs and possible technological changes such as efficient water softeners and reverse osmosis systems, is expected to further reduce residential consumption up to another 10% (~20 gpcd).

The estimated savings presented herein total up to 31 gpcd, representing a reduction of current consumption levels to 200 gpcd or lower.

11.0 ENVIRONMENTAL REVIEW

As part of the application process to obtain the additional Colorado River water allotment of 4,349 ac-ft/yr, Lake Havasu City was required to submit an Environmental Assessment for its service area. The Environmental Assessment was prepared pursuant to the requirements of the National Environmental Policy Act (NEPA), and focused primarily on the 28 square mile area outside the boundaries of the Lake Havasu Irrigation and Drainage District (IDD) (i.e., the expanded service area). The area within the IDD was already committed to urban development as part of the original water allocation contract. The final Environmental Assessment, prepared by Willdan Associates, was completed in June 1992.

The water conservation plan outlined in this document focuses on the current expanded water service area, which was established in 1995 and covered by the 1992 Environmental Assessment report. Water savings generated by the elements of this plan are not intended to provide for further expansion of the service area, or to alter the proposed land uses identified in City planning documents by allowing more intense development. Rather, water savings projected from the elements of this plan will be used to reduce the amount of additional water allocations to be obtained by Lake Havasu City to meet projected demands within the service area. Consequently, because no new impacts relative to service area or land use have been generated by this water conservation plan, no environmental impacts beyond those identified in the 1992 Environmental Assessment are anticipated.

Should the City implement conservation practices, either during the 2011-2015 conservation period or in the future that require environmental compliance, possible environmental reviews may be required.

12.0 IMPLEMENTATION SCHEDULE AND BUDGET

The implementation schedule for the conservation program components discussed in this conservation plan is summarized in Table 12-1. All plan elements are scheduled for implementation during the 2011-2015 conservation period.

TABLE 12-1. IMPLEMENTATION SCHEDULE FOR CONSERVATION PLAN

DESCRIPTION	TIMEFRAME	BUDGET
Water measurement and accounting system	2011 -2015	No Direct Costs
Water conservation community campaign.	2011-2015	$8,000/year
Water Resources Coordinator	Hired in 2005	Salaried
Water Conservation Officer	Hired in 2001	Salaried/BOR Grant
Distribution system audit program	2011 -2015	$1,000,000 in 5-year CIP Plan
Effluent recharge and recovery program	2011 -2015	$5,000,000 in 5-year CIP Plan
Xeriscape workshops with our local master gardeners and K-12 education program.	2011 -2015	$6,000/year
Develop a citizen volunteer water conservation group.	2011 -2015	No Direct Costs
Develop a web-based and brochure water conservation educational program.	2011 -2015	To be added to the 2011-2012 FY budget
Establish City rebate program for water conserving devices.	2011 - 2015	Variable - $60,000 for 2010-2011 FY budget.
Add effluent irrigation to Rotary Park and other entities.	2011 - 2015	To be added to the 2011-2012 FY budget
Establish small-scale non-Colorado River water irrigation wells for local public area landscaping.	2011-2015	To be budgeted beginning in the 2011-2012 budget and succeeding years.
Public flushless urinal installations	2010-2011	$25,000 for FY 2010-2011
Turf reductions on city property	2011-2015	No Direct Costs
Initiate replacing conventional water softeners and R/O systems with ones that do not waste much water.	2012-2015	Future grant funded rebate program?
Implement swimming pool water discharge program.	2011-2015	No Direct Costs
End South Intake Use	2013-2015?	No Direct Costs