NORTH CENTRAL ARIZONA WATER DEMAND STUDY

Phase I Report

FINAL, June 2002

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An examination of water use, water conservation and alternative supplies in non-reservation communities on the Coconino Plateau

Final Revised Version, June 2002

(incorporates corrections based on stakeholder comments on the March 2002 Draft Report)

by

Richard Pinkham
Rocky Mountain Institute
1739 Snowmass Creek Road
Snowmass CO 81654
(970) 927-3851

and

Bill Davis
Planning and Management Consultants, Ltd.
6352 South U.S. Highway 51
P.O. Box 1316
Carbondale IL 62903
(618) 549-2832

A report submitted to the Coconino Plateau Water Advisory Council

Cover photos

Clockwise from upper left:

Constructed wetlands put wastewater from Kachina Village to use providing wildlife habitat and an aesthetic/recreational amenity.

An ultraviolet disinfection unit at the South Grand Canyon Sanitary District wastewater treatment plant.

Sprinkler irrigation (and overspray) at the Northern Arizona University track and field complex.

An ultra-low-flow, electronically activated faucet at the Grand Canyon National Park Canyon View Information Plaza.

Storage tanks and a standpipe maintained by the Doney Park Water Company for the use of residents located beyond its water distribution lines.

All photos by Richard Pinkham, October 2001

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List of Acronyms

Arizona Corporation Commission	ACC
Arizona Department of Environmental Quality	ADEQ
Arizona Department of Economic Security	ADES
Arizona Department of Water Resources	ADWR
Census county division	CCD
Census designated places	CDP
Canyon Forest Village	CFV
Covenants, conditions and restrictions	CC&Rs
Commercial, institutional and industrial; e.g., "CII water conservation."	CII
Capital improvement plan	CIP
Doney Park Water Company	DPW
Evapotranspiration—the water requirement of plants and associated soils	ET
Forest Highlands Water Company	FHWC
Gallons per capita	GPC
Gallons per capita per day	GPCD
Gallons per day	GPD
Gallons per flush	GPF
Gallons per minute	GPM
Grand Canyon National Park	GCNP
Kachina Village Improvement District	KVID
Municipal and industrial	M&I
Million gallons	MG
Million gallons per day	MGD
Million gallons per year	MGY
Memorandum of understanding	MOU
Named population places	NPP
National Pollution Discharge Elimination System	NPDES
Northern Arizona University	NAU
Planning and Management Consultants, Ltd.	PMCL
Public service announcement	PSA
Pounds per square inch	psi
Polyvinyl chloride—a material used in pipes	PVC
Rocky Mountain Institute	RMI
Small business enterprise	SBE
South Grand Canyon Sanitary District	SGCSD
Tusayan Water Development Association	TWDA
Ultra low-flush toilet; a toilet designed to use 1.6 gallons per flush or less	ULFT

I. EXECUTIVE SUMMARY

Water resource stakeholders on the Coconino Plateau are wrestling with the question of how to provide sufficient water for current and future needs. Recent droughts, environmental concerns, population and economic growth all raise concerns over the adequacy of water supplies. A pipeline to tap Colorado River water is under study. Conservation and alternative supplies such as wastewater reclamation are important water management strategies in local communities, but have received little attention at the regional level to date.

The *North Central Arizona Water Demand Study, Phase I*, contributes to the discussion by reviewing how water is currently provided and used for residential, commercial, municipal, and industrial purposes on non-reservation lands of the Coconino Plateau, in the area roughly bounded on the south by the Mogollon Rim, on the north by the Colorado River, on the west by the Aubrey Cliffs, and on the east by the communities of Winona toward the south and Page to the north. Specifically, the following communities are included in the study area:

- Bellemont
- Doney Park (including Timberline, Fernwood, Cosnino, Winona)
- Flagstaff
- Flagstaff Ranch
- Forest Highlands
- Fort Valley
- Grand Canyon Village
- Kachina Village
- Mountainaire
- Page
- Parks
- Red Lake
- Tusayan
- Valle
- Williams

This report also describes and evaluates water conservation activities in the study area, and summarizes current and anticipated implementation of alternative supply systems. It sets out a recommended water demand forecasting methodology for a proposed Phase II study.

CURRENT WATER DEMAND

In the year 2000, total water demand in the study area amounted to roughly 5,842 million gallons, or 17,930 acre-feet. This includes both potable and nonpotable demand. In these figures, potable demand is represented for most communities by total drinking water production, which includes metered water use, unmetered use (e.g., fire hydrants) and unaccounted-for water (e.g., distribution system leaks). In some small communities, only metered water-use data could be obtained. Unmetered and unaccounted-for uses in these communities are considered small, so the omission of these uses does not substantially affect the overall demand figures. The figures above and in Table I-1 below also do not include Valle and the rural households supplied by standpipes in Valle. The study team could not obtain water production or metered water use from the two water systems in Valle. Again, because of this community's small size, the overall water-use figures are not substantially affected. Table I-1 uses the "greater than or equal to" figure (≥) to indicate where the slight underestimation occurs. Nonpotable demand includes two components, raw water use and use of reclaimed wastewater effluent. Total demand in the study area in 2000 breaks down as follows:

TABLE I-1
TOTAL DEMAND IN THE STUDY AREA IN 2000

	Millions of gallons	*Acre-feet*	*Portion of Total Demand*
Potable demand	≥4,667.2	≥14,323	80%
Nonpotable demand			
Raw water	247.2	759	4%
Reclaimed wastewater	928.0	2,848	16%
Total demand	≥5,842.4	≥17,930	100%

Water use in most study area communities is predominantly residential and commercial. Because of the strongly tourist-oriented economy of the region, hotels and other tourist services are significant portions of water demand in many communities. Parks, golf courses and other community landscapes are substantial water users in Flagstaff, Page, Williams and the gated communities of Forest Highlands and Flagstaff Ranch (under construction). Irrigation of private landscapes in most communities of the study area appears to be somewhat reduced, compared to more urban areas of the southwestern U.S. In the more rural communities, substantial numbers of homes have no irrigated landscape. Industrial and institutional (e.g., university, hospital, etc.) uses are substantial only in Flagstaff.

Water use in the study area varies significantly from season to season. Landscape irrigation, seasonal home occupancy and tourist traffic result in substantially higher water use in the summer than in winter. For most communities, demand in the peak summer month is about 1.5 to 2.5 times greater than in the low winter month. For Tusayan and Page the increases are roughly 3 and 4 times, respectively.

WATER SUPPLIES

Many communities in the study area rely on ground water for most or all of their water supply. A few communities, notably Bellemont and Fort Valley, have access to perched aquifers at a depth of a few hundred feet. Well depths in other locations are much deeper, from 600–1,100 feet in the southeast (Mountainaire and Kachina Village), to over 3,000 feet in the west and north (Williams, Valle and Tusayan). Drilling deep wells is costly (over $1 million per well) and risky.

Groundwater pumping has also raised concerns over potential impacts on the seeps and springs along the south rim of the Grand Canyon that are supplied by regional aquifers.

Three study area communities use surface water. Page relies entirely on surface water from Lake Powell, though the city is about to develop its first groundwater wells. Williams was entirely reliant on surface water until a few years ago. Its five reservoirs are unreliable in extended dry periods. Williams now has three producing wells. Flagstaff also uses surface water. In wet years Lake Mary has provided as much as 70 percent of the city's water supply. In most years it provides less, and has come close to drying up in a few years. Page and Williams treat most of their surface supplies for potable purposes and use some raw surface water for golf course irrigation. Flagstaff treats all of its surface water for potable uses.

Several portions of the study area, especially Parks and Red Lake, continue to develop despite lack of any local water supplies. Surface water sources do not exist in these locations, and depth to groundwater makes drilling of individual or small community wells cost-prohibitive. These areas instead rely on hauling of water from standpipes in Flagstaff, Doney Park, Bellemont, Williams, Valle and Tusayan.

Alternative supplies are already important, and growing, as a water source in the study area. Wastewater reclamation and reuse, accomplished via treatment at a centralized wastewater treatment plant and reclaimed water redistribution lines to points of use, is now practiced in seven communities: Flagstaff, Forest Highlands, Grand Canyon Village, Page, Tusayan, Valle and Williams. Reclaimed wastewater now provides for 16 percent of total water demand in the study area. More notably, it provides substantial service in at least six communities:

TABLE I-2
COMMUNITIES USING RECLAIMED WASTEWATER AS A SIGNIFICANT SUPPLY

	Reclaimed wastewater portion of total demand
Flagstaff	15%
Forest Highlands	19%
Grand Canyon Village	22%
Page	22%
Tusayan	40%
Williams	19%

Development now underway at the Bellemont Travel Center and Flagstaff Ranch will include wastewater reclamation as an important water supply. Flagstaff is aggressively seeking to move additional customers from potable supplies to its substantial reclaimed water supplies. Forest Highlands has in place an agreement to draw reclaimed water from Kachina Village as needed and available. Williams plans to add reclaimed water storage in the future, increasing its wastewater reuse substantially. And Grand Canyon Village, Tusayan and Valle all have in place the infrastructure to allow for increased use of reclaimed water.

Rainwater harvesting is another important alternative supply. A five-acre Hypalon catchment basin at the Grand Canyon airport in Tusayan provides virtually all the *potable* water used by the airport complex and a dozen nearby homes. This system meets 6 percent of the total water demand in Tusayan. A second notable system is under construction at Flagstaff Ranch. It will use a French drain (a trench filled with gravel and bottomed with a perforated pipe to capture drainage) to divert local pavement and subsurface runoff to a holding pond for golf course irrigation. It is likely that a number of individual homes in the study area, particularly in water hauling locales, practice rooftop rainwater harvesting, but the contribution of these systems cannot be easily quantified.

In addition to increased rainwater harvesting and expanded use of centralized wastewater facilities to reclaim water, the future will likely see onsite wastewater treatment and graywater reuse making contributions to local water supplies. The Arizona Department of Environmental Quality (ADEQ) has recently enacted regulatory changes that will make use of onsite wastewater and graywater supplies more permissible and less costly. The potential for alternative supplies to meet an increasing portion of total water demand in the study area is significant and merits further study.

WATER EFFICIENCY AND CONSERVATION

The sophistication, level of effort, and corresponding results of water efficiency and conservation activities—"water demand management"—vary substantially throughout the study area. Flagstaff has the most extensive and notable water efficiency and conservation program. Its efforts are commensurate with those of other similarly sized and situated water utilities. Flagstaff's educational programs—e.g., televised public service announcements, newspaper inserts and school programs—also benefit other Coconino County communities by raising conservation consciousness beyond the city limits as well as within. Williams has recently made important strides in building an efficiency and conservation program. Page, for its size and concern over adequacy of current supplies for future growth, is remarkable for not having implemented a serious water efficiency and conservation program. In most other communities, conservation rate structures, or simply the high price of water, provide the main motivating factor for customers to implement water efficiency measures or practice water-wise behaviors. It appears that high prices have become a conservation tool mostly by default, because of the high cost of providing water in this region, rather than as a conscious water conservation strategy. Only Doney Park Water Company (DPW), Flagstaff and Kachina Village have what the study team considers to be effective conservation rate structures.

With a few exceptions, *active* intervention to increase water efficiency by local water providers or planning and building officials is very limited in the study area. Active intervention includes incentives such as rebates, giveaways and bill credits; regulations on fixtures, landscape, irrigation systems, etc.; audits and technical assistance; system measures such as ongoing distribution leak testing; and other programs. Even educational programming—a fairly low-cost, but largely *passive* approach—is nonexistent or thin in many study area communities.

The county and some local governments do have in place some regulations on fixtures. However, in almost all cases, these regulations are vague—they simply require "low flow" fixtures, without specifying flow rates. Thus, local plumbing standards, unless more vigorously specified and enforced on a case-by-case basis in development reviews, simply default to the national plumbing standards in place since 1994. Those standards no longer represent best available technology.

Much more could be done in the study area with respect to water-efficient technologies and water-wise behaviors and landscaping choices. The potential for study area stakeholders to produce significant additional water savings in existing development, and to reduce the water demand of new development, is significant. This report identifies 23 efficiency and conservation *measures*—technologies and management practices that reduce water demand—that are probably appropriate in the study area. Additional industry-specific measures would be available in the commercial, institutional and industrial sectors. The report also identifies 20 applicable *implementation techniques*—ways of encouraging or requiring end-users to adopt efficiency and conservation measures. These measures and programs should be further studied for their suitability and water savings. Some are appropriate for implementation by individual water systems, while others could be mounted through regional cooperation.

DEMAND FORECASTING

Recent water resource planning efforts in the study area have used the estimates of future water demand developed by the Arizona Department of Water Resources (ADWR) in its *Phase 1 – North Central Arizona Regional Water Study* report (1999, hereafter referred to as the ADWR Water Supply Study). The report provides a very brief discussion of water demand for each community, but the methodology used to estimate the water demand for each area is not well documented.

The authors of *this* study *(The North Central Arizona Water Demand Study – Phase I Report)* have many reservations about the ADWR demand estimates, which are detailed later. Further, the ADWR Water Supply Study attempts to estimate the new supply increment needed over current supplies. Those estimates do not account for recently developed supply sources in Tusayan and Williams. They also make problematic assumptions about needs for new sources: Tusayan, Williams, and Grand Canyon National Park are assumed to completely abandon their existing supplies and wastewater reuse systems in favor of a new supply source.

Additional water demand forecasts are reported in the *Flagstaff Area Regional Land Use and Transportation Plan* (2001), the *Page General Plan Update* (BRW, Inc. and Sunregion Associates, Inc. 1995), and the *Final Statement for Tusayan Growth* (U.S. Forest Service 1999). In most cases, the assumptions and methods used for the demand forecasts in these documents are not clear.

A more thorough analysis of future water demand is highly recommended. Assumptions and linkages between water use, population growth and other growth factors should be carefully researched and clearly specified. Contributions that water conservation and alternative supplies could make to the overall water resources situation should be evaluated.

This report outlines the demand forecasting methodology proposed for Phase II of *The North Central Arizona Water Demand Study*. Phase II is designed to provide water resource managers and decision-makers with information about future water demand and potential effects of demand management and alternative supply options. The intent is to provide a thorough and accurate assessment of water demand under baseline and conservation/alternative supply scenarios. Given the available data and local water use patterns, the authors recommend that the demand forecasting system include two separate analyses:

- *Forecasting of potable water demand with water-use models.* These models will be based on population projections, in conjunction with water-use rates determined through analyses of the local determinants of water demand. The sophistication of these analyses will vary by location and water-use sector according to the availability of necessary data.

- *Forecasting of nonpotable water demand and displacement of potable water demand with nonpotable alternative supplies.* Currently available data does not permit modeling of nonpotable use. The forecasts will instead be developed through an assessment of existing and potential applications of alternative supplies.

The authors propose using the population projections of the Arizona Department of Economic Security (ADES) as the future population input for water demand modeling. This data set employs the most credible methodology and provides internal consistency for both county-level population projections and subcounty projections that closely match water system geographies. Alternative population scenarios could also be evaluated, if desired.

The potable water demand models in Phase II will employ a methodology that: (a) allows for adjustment of model inputs to reflect expected changes or defined scenarios for future local economic conditions; and (b) allows for specification of water conservation scenarios. The methodology will do so by employing factors for water use per account and accounts per population. The overall procedure will be as follows:

1. Conduct regression analysis to determine appropriate baseline water-use rates (water use per account) for each location and sector (customer class) where adequate data exists. For example, an attempt will be made to “normalize” historic water-use rates for historic variations in weather and changes in water rates.

2. Assemble a system of specific models of potable water demand for each community and sector using water-use rates based on statistically significant regression results or other approaches for communities/sectors where regression analysis is not feasible or effective.

3. Adjust the models for expected future changes in demographic and economic conditions.

4. Estimate future potable water demand by location using the models and population projections (i.e., estimate baseline water demand).

5. Estimate water demand by location for scenarios of increased water efficiency and conservation activity.

6. Conduct sensitivity testing and forecast demand under additional scenarios as needed and appropriate.

Forecasts of nonpotable water demand must reflect the physical configurations of water infrastructure and patterns of water use in each community. The social acceptability of alternative supplies must also be considered. The study team will meet with water system managers in each community to discuss opportunities and constraints for using raw water and various alternative supplies, and to obtain their informed judgments on future new uses of nonpotable water and future displacement of potable water uses with nonpotable supplies. In addition, past and emerging experiences of communities around the country with the full range of alternative supplies will be examined, as reflected in the water resources and water conservation literature.

Total water demand forecasts will be developed for each study area community and three proposed forecast scenarios:

- Baseline (current and planned demand management and alternative supply activities);
- Moderate conservation and alternative supply investment (increased activity); and
- Aggressive conservation and alternative supply investment (a full range of state-of-the-art measures and programs).

This report presents a proposed workplan for Phase II, and notes a number of issues and concerns that must be resolved prior to initiation of Phase II. Costs for Phase II will depend on how some of these questions are to be addressed, the number of forecast scenarios, etc. The estimated cost range is $75,000 to $150,000.

RECOMMENDATION

Effective programs across the country have conclusively shown that water efficiency and conservation should be considered a “supply” of water—an already developed resource that when tapped can help defer, downsize or avoid altogether costly new water supply infrastructure. This is especially true when water efficiency and conservation are considered together with water reuse and other alternative supplies in a thorough, integrated evaluation of available options for meeting water needs.

Demand management and conventional and alternative supplies must all be considered if a community or region is to develop the most cost-effective approach to meeting human and environmental water needs. Conventional supply options, from new wells to an imported water pipeline, are getting considerable attention in the study area. As with any integrated water resource planning process, a detailed and accurate water demand forecast is required to (1) provide an understanding of both current and anticipated water-use patterns and (2) establish the baseline for the analysis of alternatives. The Phase II water demand study is recommended, in order to provide both a better understanding of future needs, and to add a sound evaluation of water conservation and alternative supply development to the "resource mix" available for consideration by regional water stakeholders.

II. INTRODUCTION

This report presents the results of the first phase of a water demand and alternative supply study for the Coconino Plateau. The study area is roughly defined as all non-reservation lands from the Mogollon Rim on the south and the Colorado River on the north, bounded on the west by the Aubrey Cliffs and on the east by the communities of Winona toward the south and Page to the north. This report details and summarizes existing conditions: current water supply systems, water demand, water conservation activities and the use of wastewater reclamation and other alternative supplies. It also presents a qualitative assessment of the potential for expanding the contributions of water conservation and alternative supplies to the regions water resource mix. The report briefly evaluates available projections of future water demand, and proposes a methodology for improved water demand forecasts and further evaluation of alternative supplies.

WHY A DEMAND STUDY?

Water Supply Concerns

North Central Arizona needs a water plan that addresses a range of social, economic and environmental conditions and concerns:

- The Arizona Department of Economic Security projects that the regions population will nearly double from 96,125 persons in the year 2000 to 184,650 in 2050 (Heffernon and Muro 2001, p. 54; this includes both reservation and non-reservation population). Communities in the region consider currently developed supplies inadequate to support population and economic growth.

- Existing surface supplies of communities such as Flagstaff and Williams are very drought-sensitive, and the potential for additional surface water development on the Coconino Plateau is extremely limited.

- Tapping ground water sources is expensive due to the great depth of the regional aquifer—at least 1,500 feet in most places, and much deeper in many other locations.

- Current and increased ground water withdrawals may have an adverse affect on seeps, springs and streams that are dependent on ground water flows. Particular concern exists for these resources along the south rim of the Grand Canyon, in the GCNP and in the Havasupai Reservation.

- Recreational resources such as Kaibab Lake, in the Kaibab National Forest, and tourist services in GCNP are drought-sensitive or water-limited.

Regional Initiatives and Studies

Stakeholders in the region recognize that information on water resources, water use and water supply options in the region is currently insufficient for effective planning. Government entities have recently come together to sponsor and collaborate on a number of studies.

Eleven local, state, Federal and tribal governments and agencies have signed a Memorandum of Understanding (MOU) establishing the North Central Arizona Regional Water Study. The signatories include:

- Arizona Department of Water Resources
- Grand Canyon National Park
- Kaibab National Forest
- U.S. Geological Survey
- Havasupai Tribe
- Navajo Nation
- City of Flagstaff
- City of Williams
- Village of Tusayan
- Coconino County
- City of Page

The objective of the MOU is to cooperatively develop regional water plans and identify future water supplies and water development scenarios. The Arizona Department of Water Resources (ADWR), a signatory to the MOU, began the planning process by completing a report, *Phase 1 – North Central Arizona Regional Water Study* (1999, hereafter referred to as the ADWR Water Supply Study), that provides a brief overview of water resource concerns in the area, current water demand and current supplies, projected water use, conventional supply options and pipeline delivery alternatives for a Colorado River supply source.

Subsequently, the U.S. Bureau of Reclamation undertook an appraisal level peer review study of the water delivery options in the ADWR Water Supply Study (U.S. Bureau of Reclamation 2000). The Bureau's study examines the conveyance routes in the ADWR Water Supply Study and modified routes; sizes the systems; and estimates construction, operating and maintenance and replacement costs. Also, the Morrison Institute has completed a study of the growth issues surrounding expanded water supply (Heffernon and Murro 2001).

Currently, the U.S. Geological Survey is preparing a hydrologic baseline for the region by collecting all currently available data on ground and surface water flows. Among other tasks, this study will inventory water withdrawals from the regional aquifer and assess trends in spring and seep flows. It aims to prepare a regional water budget and a ground water hydrology model.

Water resource stakeholders in the region are continuing to discuss water-related issues and to cooperate on studies and initiatives. The Coconino Plateau Water Advisory Council carries forward the regional collaborative approach established by the MOU and will advise local governments and the ADWR.

Other studies are needed if the region is to establish adequate and cost-effective water systems. One key effort should be to accurately assess future water demand and the potential effects of water demand management.

Water Demand Management and Alternative Supplies

Throughout the country implementation of water demand management and use of alternative supplies have allowed many communities to downsize, defer or avoid altogether new water infrastructure, while providing for growth. *Water demand management* encompasses the popular term "*water conservation.*" However, the term water conservation is rather imprecise—it can include any of the following notions:

- *Water-use efficiency*, or simply, *water efficiency*—providing the same or better level of end-use service, e.g., toilet-flushing or showering, with less water;
- *Wise water use*—"water-conserving behaviors" such as not letting the water run while shaving or brushing one's teeth, and "water-wise choices" such as installing low-water-use plants or xeric landscaping instead of conventional turf; and
- *Curtailment*—where certain uses are foregone or reduced, e.g., prohibitions on lawn watering or car washing during a drought water emergency.

It is important to keep these distinctions in mind. Many people use the term water conservation without specifying its meaning. Since the public sometimes equates "conservation" with curtailment and reduced quality of life, this study frequently uses instead the phrase "*water efficiency and conservation*." This keeps the commonly recognized word "conservation," but adds the word "efficiency" to emphasize that the main objective is to provide desired levels of service with the least amount of water possible, and to encourage water-wise behaviors and choices; curtailment of desirable water services is only a last resort in extreme times. This study uses "water demand management" and "water efficiency and conservation" as synonyms that indicate efficient and wise use of water, but not curtailment. These terms can be validly applied to both *measures* (actual changes in end-use technologies or water-use practices, e.g., replacing fixtures with more efficient models or changing irrigation schedules) and to *programs* (actions taken by agencies, water suppliers, and others to encourage or require implementation of measures, e.g. developing inclining block water rate structures or enacting flow standards for fixtures).

The term "*alternative supplies*" can include:

- *Graywater reuse*—capturing water from lavatory sinks, showers and washing machines for reuse in landscape irrigation and sometimes toilet flushing;
- *Water recycling*—using water leftover from one commercial or industrial process for another process that can utilize lower quality water;
- *Rainwater harvesting*—collecting precipitation from rooftops or pavements, typically for nonpotable uses, though roof runoff is sometimes used as a potable water supply; and

- *Wastewater reclamation and reuse*—treatment of wastewater, typically at a centralized treatment plant, and redistribution to serve needs that can be satisfied by lower quality water, such as landscape irrigation and toilet flushing.

Sometimes people refer to use of alternative supplies as water demand management. For instance, the study team observed that some people in the region referred to wastewater reclamation as "water conservation." Technically, and for the purposes of this report, use of alternative supplies is not a demand management measure or program. It is instead, like development of conventional water supplies, one way of providing for water demand that remains after the application of water demand management. However, use of alternative supplies is functionally similar to water demand management in that it can reduce the need for new conventional supplies. Alternative supplies are especially important to comprehensive water management in arid regions. Thus, this study addresses the potential of both demand management and alternative supplies.

Comprehensive Water Resource Planning

Accepted practice in the water resources field requires that demand management and conventional and alternative supply development be evaluated on an equivalent basis, through least cost planning and integrated resource planning approaches (e.g., see American Water Works Association 1993). Good planning is a multi-faceted, step-wise process. The planning process includes:

- Identification and involvement of all stakeholders;
- Articulation of key concerns and decision-making criteria;
- Analysis of existing water use;
- Quantification of future water needs;
- Development of conceptual design and cost estimates for a variety of alternatives to meet water needs;
- Evaluation of all water resource options on a comparable basis, including surface and ground water development, transfers, efficiency and conservation, reuse and other alternative supplies;
- Selection of projects and programs that best meet identified decision criteria (e.g., quantity of water provided, cost, level of risk, environmental and social impact, etc.); and finally,
- Detailed planning for chosen options.

Clearly, evaluating water demand, water efficiency and conservation, and alternative supply sources is an essential step for effective regional water resource planning. It is vital to thoroughly understand baseline water use and ways to affect and provide for future needs by managing demand, reusing already developed water and harvesting rainwater. This is recognized in the above-mentioned MOU between stakeholders in North Central Arizona. In addition to evaluation of regional water supply development, three of the six action items of the MOU concern water demand and conservation (not defined, but probably considered to include reuse and other alternative supplies):

(a) Evaluate present and future water supply demands and needs. …

(c) Identify and develop water conservation measures that can be applied in the region to reduce existing and future demand for water in the north central region of Arizona. …

(e) Based on available scientific knowledge, develop and evaluate alternatives for water supply and development, water conservation and resource and aquifer protection that are consistent with Federal and state law and that best serve the public.

Given the substantial investments in water resources infrastructure contemplated in the region, thorough and accurate assessment of demand under baseline and conservation/reuse scenarios should be a prerequisite for further planning and decision-making. The recent ADWR Water Supply Study initiated this process: it presents a brief analysis of current water demand. It and some other documents present rough projections of future demand. However, further study is warranted for several reasons:

- None of the available studies evaluate the potential contributions of water efficiency and conservation, nor do they assess alternative supply potential.
- None of the available studies disaggregate demand into seasonal, sectoral or functional (end-use) components. Disaggregating demand information and demand forecasts will significantly increase understanding of water use in the region, may improve the accuracy of the forecasts, allow development of effectively targeted water efficiency and conservation measures and indicate where alternative supplies could be employed.
- Current studies do not make explicit the assumptions and methods used in their projections of future water demand. Area decision-makers need water demand forecasts based on clearly defined information, assumptions and methodologies.

Requirements of Recent State Legislation

A detailed water demand study will also assist compliance with requirements of Arizona’s Growing Smarter Plus legislation, A.R.S. § 9-461.05D and §11-821.C.3, which requires cities and counties over certain population thresholds to include a water resource element in general or comprehensive plans. A water resources element is required of Flagstaff. Coconino County is on the cusp of needing to prepare this element, as current census figures, which may be revised, put its population just under the 125,000 threshold. Affected entities must develop a water supply budget and a plan for securing additional water if the water budget falls short. Phase II of this study will provide projections of demand under a baseline scenario (the starting point for a water supply budget) and increased conservation/alternative supply scenarios (essential to any plans to address supply shortfalls).

STUDY OBJECTIVES, SCOPE AND METHODS

The overall study (Phases I and II) has three objectives:

- Accurately forecast water demand based on anticipated growth and current trends and activities affecting water use;
- Develop scenarios and forecast demand under conditions of increased water efficiency and conservation; and
- Estimate the potential contributions of alternative supplies to meeting water demand.

These objectives imply two related tasks: development of an appropriate demand forecasting approach and development of appropriate efficiency/conservation and alternative supply scenarios. Both require a detailed understanding of current water use in the study area. Specification of the forecasting approach and scenarios depends on a variety of factors, including quality and comprehensiveness of available data; needs for additional data and the costs and returns on producing it; sectoral water-use patterns; the nature and extent of current and planned efficiency/conservation and alternative supply programs and geographic subdivision of the study area, as necessitated by planning objectives or by data availability.

In order to develop the most cost-effective approach to demand forecasting, this study was proposed as a two-phase project. The Phase I proposal was approved by the Coconino Plateau Water Advisory Council in mid-2001. It was funded by the Grand Canyon Trust, Coconino County, the City of Flagstaff and the National Park Service (GCNP).

The objectives of Phase I (this report) are to:

- Compile existing data and information on current water demand, water efficiency and conservation activities and alternative supplies in the region;
- Develop qualitative evaluations of current levels of conservation/alternative supply effort and the potential for further gains; and
- Develop a recommended methodology and workplan for demand forecasting and estimation of potential contributions of alternative supplies to meeting future demand.

The scope of this study includes all non-reservation lands of the Coconino Plateau (defined specifically in the next section of this report). Reservation lands were not included because other studies are underway or proposed to address water demand on reservations. This study focuses on Municipal and Industrial (M&I) water uses—all residential, commercial, industrial, institutional, public and other urban and suburban uses, as well as rural household uses of water. Ranching, livestock watering and other agricultural uses are not addressed except to the extent that rural “ranchettes” use water provided by community water systems (e.g., watering of horses in the Doney Park area by households connected to the Doney Park Water Company system).

The study team visited the Coconino Plateau in October of 2001 and met with managers and representatives of many of the community water systems in the study area, and with other stakeholders and information sources. The team gathered data, documents, perspectives and other information on local water systems and growth potential in the various cities, communities and rural residential areas. Subsequent to the fieldwork, numerous calls were made to many of the interviewed individuals and additional persons to obtain further information. Some of the organizations asked to provide water production or water-use data would not do so. However, most were highly cooperative. The team endeavored to develop a substantial understanding of each water system and several rural areas that do not presently have community water systems. The available data was compiled and evaluated with respect to water demand forecasting, and a recommended methodology for Phase II was developed.

Following sections of this report present summary information and tables on current conditions in the study area: population and economy, water resources and water supply systems, water efficiency and conservation activities, use of alternative supplies, and water demand. The efficiency/conservation and alternative supply sections include the study team’s qualitative professional judgments on the value of further investigating these water management tools. Existing water demand projections are then evaluated, and the recommended Phase II methodology and workplan is presented. The report concludes with some observations and recommendations.

Appendix A of the report provides detailed descriptions and discussions for each of the water systems in the study area, and basic information on several rural areas now served by individual wells or hauling of water. While this information is provided as an appendix, it is highly significant, and it is recommended that readers review this section carefully. Understanding local conditions and opportunities is key to understanding the water needs of the study area as a whole. Appendix B lists all the stakeholders contacted for the Phase I study. Appendix C describes the study team.

III. STUDY AREA

Roughly, the study area is defined as all non-reservation lands of the Coconino Plateau from the Mogollon Rim to the south to the Colorado River to the north, bounded on the west by the Aubrey Cliffs and on the east by the communities of Winona toward the south and Page to the north. Specifically, the study area is comprised of the communities shown in Table III-1. Each of the study area communities and their water systems are described in detail in Appendix A. Note that study area boundaries identified in the ADWR *North Central Arizona Regional Water Study* (1999) are different from those in the Morrison Institute *Growth on the Coconino Plateau* (Heffernon and Muro 2001), and different from those outlined for this Phase I water demand study. The study area must be clearly defined prior to the proposed Phase II analysis.

The economy of the Coconino Plateau is largely driven by the tourism industry and by industries and institutions located in the City of Flagstaff. The tourism economy is related to the Grand Canyon and other natural and historic sites in the region. Second home development is also an important economic force, as the higher elevation and cooler climate makes the area appealing to residents of Southwestern U.S. desert cities, especially the nearby Phoenix metropolitan area. Some second home developers target a very affluent market—witness recent development of gated golf course communities such as Forest Highlands and Flagstaff Ranch.

Flagstaff's economy centers on tourist services, retailing and other businesses that serve the region, Northern Arizona University (NAU), government and some industry and other institutions. The economies of other incorporated areas—Williams and Page—are based largely on tourism.

Unincorporated areas of the county have developed in a variety of patterns. The predominant use of nonagricultural lands is for residential development, with some scattered commercial centers along major highways, such as Tusayan, Valle and Bellemont. Most residential areas are non-divided or subdivided into large lots (2+ acres in some areas, 5+ acres in many). Some older subdivisions are platted in lots of one acre or less. Many have not developed. Those that have tend to be more modest income areas. Mountainaire and Kachina Village are good examples of these rural, moderate density subdivisions. Many of the existing but undeveloped subdivisions do not have water, electricity and telephone service. Newer subdivisions tend to be moderate income (e.g., Doney Park) to higher income areas (e.g., golf course communities).

Historical population growth of the study area is shown in Table III-2. Note that not all communities listed in Table III-1 are included in Table III-2. Historical population data is not compiled by the U.S. Bureau of the Census for Bellemont, Flagstaff Ranch, Forest Highlands, or Red Lake. Also, the Arizona Department of Economic Security (ADES) does not prepare population projections (Table III-3) for those communities, nor for Valle. Allocating populations to closely match the boundaries of water systems and rural communities listed in Table III-1 will require examination of more detailed population data and population geographies (e.g. census tracts) as available from the Census Bureau or ADES, a task reserved for the Phase II study.

TABLE III-1
STUDY AREA COMMUNITIES AND WATER SERVICES

Community	*Description*	*Water Service**
Bellemont	Unincorporated development by I-40 exit, plus Navajo Army Depot	One private water company and one private water system; Army Depot system
Doney Park (Incl. Timberline, Fernwood, Cosnino, Winona)	Unincorporated; dispersed low-density subdivisions and individual homes	Member-owned cooperative
Flagstaff	Incorporated	City utility; also, 3 private water companies serve small, unincorporated areas within the city limits
Flagstaff Ranch	Unincorporated; private golf course community now under construction	Private water company
Forest Highlands	Unincorporated; private golf course community	Private water company
Fort Valley	Unincorporated; dispersed homes & low-density subdivisions	Individual wells & some water hauling
Grand Canyon Village	Unincorporated; National Park community	Park Service water system
Kachina Village	Unincorporated; large medium-density subdivision	County-operated water utility
Mountainaire	Unincorporated; large medium-density subdivision	Private water company
Page	Incorporated	City utility
Parks	Unincorporated; dispersed homes & low-density subdivisions	Water hauling & some individual wells
Red Lake	Unincorporated; dispersed homes & low-density subdivisions	Water hauling
Tusayan	Unincorporated commercial district and community	Two private water systems operating through a non-profit water retailer; airport complex water system
Valle	Unincorporated commercial district & community, plus dispersed homes & low to medium density subdivisions in surrounding area	Two private water systems; rural areas served by water hauling
Williams	Incorporated	City utility

*Private water companies are regulated by the Arizona Corporations Commission. Private water systems are not.

TABLE III-2 HISTORICAL POPULATION OF STUDY AREA					
	1970[2]	1980	1990	1997	2000[3]
Coconino County[1]	48,326	75,008	96,591	115,920	124,575
Doney Park/Timberline	Not Avail.	3,550	5,504	7,294	Not Avail.
Flagstaff	26,117	34,743	45,857	57,093	62,710
Fort Valley	Not Avail.	350	534	625	Not Avail.
Grand Canyon Village	1,011	1,348	1,499	1,617	1,460
Kachina Village	Not Avail.	1,250	1,711	2,074	2,664
Mountainaire	Not Avail.	500	738	865	1,014
Page	1,409	4,907	6,598	8,413	9,570
Parks	Not Avail.	950	603	886	1,137
Tusayan	Not Avail.	500	555	613	562
Valle	Not Avail.	Not Avail.	123	Not Avail.	553[4]
Williams	2,386	2,266	2,532	2,759	2,905

[1] Population of the entire county. Includes named places below, other areas within the study area, and areas within the county but outside the study area.

[2] 1970 subcounty populations may be available in archived data not available on the Internet.

[3] Initial Census estimates put the 2000 county population at 116,320. Estimates have been revised upward by the Census Bureau for Flagstaff, Williams, Page, and the county. Remaining population estimates may also be revised soon. Estimates for Doney Park/Timberline and Fort Valley are pending.

[4] Valle population derived from Census tract 18, U. S. Census 2000 Redistricting Data.

Sources: U.S. Census Bureau and ADES.

FUTURE GROWTH AND DEVELOPMENT

Future water demand is driven by future growth and development. In Coconino County, drivers for future growth are expected to be the same as those of recent growth: tourism, key institutions such as NAU, second home development and limited industrial and commercial development. The recent Morrison Institute growth study for the Coconino Plateau (Hefferon and Muro 2001) discusses growth drivers and scenarios in detail.

Within the study area, the location of growth is enabled and constrained by:

- Availability of private land
- Proximity to highways
- Availability of water
- Availability of wastewater disposal (or suitable soil conditions for septic)
- Availability of fire protection
- Provision of paved streets, electricity and telephone service
- Zoning restrictions limiting development to large lots
- Preservation of natural resource areas
- Preservation of clear and dark nighttime sky conditions

The federal government or the state own much of the study area. Outside of incorporated areas, privately held land is scattered in large and small parcels throughout the region. Much of the private land between Williams and the GCNP occurs in checkerboard sections adjacent to National Forest or State Trust lands.

The *Coconino County Subdivision Ordinance* requires subdivisions with lot sizes less than five acres to have a community water system. Many of the older subdivisions with small lots were platted before this rule was enacted, but they face serious constraints to substantial development, including unavailability of water or other utilities and amenities. Development within these subdivisions is limited to those individuals willing to haul water and live "off the grid."

Given the lack of surface water and the expense of accessing ground water in this region, high-density development in rural areas of the study area is unlikely in the absence of an imported water pipeline. Most rural growth will occur as scattered homes and low-density subdivisions with larger lot sizes. Such development does not produce dramatic absolute increases in population and water demand. Exceptions may include areas with perched aquifers such as Bellemont and Fort Valley. Also possible are substantial initiatives by well-funded developers who can afford the expense and risk of deep well drilling or development of their own imported supplies. This type of development is most likely in extremely high-value locations such as the Tusayan area, as shown by the Canyon Forest Village proposal.

There is potential for conversion of privately held agricultural land from livestock grazing to 40-acre ranchettes. However, such conversion is limited by access to roads, water and other utilities.

The U.S. Forest Service or the Arizona State Land Trust manages much land within Coconino County. Land held by the Forest Service is generally not available for future development, although parcels on the margin of Forest Service holdings may be traded for privately held parcels within the Forest Service holdings. Land held by the Arizona State Land Trust is managed for maximum economic return to the state. Proceeds from the lease or sale of this land are used by the state for funding school and prison programs. Most land trust parcels are leased for livestock grazing until a developer or other potential user makes a request for reclassification of use. In this way, these state lands can become available for development. Most of the land trust parcels in the study area are interspersed in checkerboard patterns with private land and in some places with National Forest land. This pattern can make access and future development difficult. However, parcels in strategic locations, such as along major highways, are likely to face increasing pressure for reclassification and development. The Morrison Institute includes an extensive discussion of conversion of State Land Trust lands.

While development in much of the study area faces significant constraints, development in many of the rural areas around Flagstaff is beginning to approach buildout given existing zoning. (See, for example, the discussions of growth prospects for Doney Park, Kachina Village and Mountainaire in their respective water system profiles in Appendix A). Because developable land around Flagstaff is becoming scarce, pressures for up-zoning of lands will increase, and rising land and housing prices are likely to drive more development activity to more distant rural areas.

Development of multifamily housing and mobile home parks in the county is largely restricted by current zoning to incorporated areas, and some unincorporated areas such as Tusayan and Kachina Village, in order to assure proper utility and fire protection services. Commercial development is closely controlled and generally limited to areas in proximity to existing development. Industrial growth in the county is limited to municipal areas, and faces many planning and zoning constraints regarding air and noise pollution and impacts on community quality of life.

The net result of all these drivers for and constraints on growth is of course difficult for anyone to predict. The best available population projections for the county and specific subareas are produced by the ADES. The ADES produces population projections based on historical data from the decennial census, demographic cohort change rates and information on development patterns from regional Councils of Governments or counties. For Coconino County, the county government provides input to the ADES on subcounty growth patterns. Because of the county input into the ADES projections for the county subareas, the ADES projections are generally well accepted by local governments. The current set of population projections were developed in 1997. A new set of population projections are anticipated about March 2002. The 1997 ADES projections for Coconino County and subareas of the county are made to the year 2050. Table III-3 summarizes the population projections for the named county subareas identified as being within the study area. It is projected that the population of the county and the study area will nearly double in the next fifty years.

TABLE III-3
SELECTED COCONINO COUNTY SUBCOUNTY
POPULATION PROJECTIONS

	1997	*2000*	*2010*	*2020*	*2030*	*2040*	*2050*
Coconino County[1]	115,920	123,329	147,352	169,343	189,868	211,616	235,707
Black Bill/Doney Park	5,340	5,794	6,989	8,374	9,655	10,998	12,472
Timberline/Fernwood	1,954	2,185	2,748	3,360	3,953	4,607	5,359
Flagstaff	57,093	60,708	71,981	81,972	91,529	101,907	113,684
Fort Valley	625	660	754	863	964	1,068	1,182
Grand Canyon Village	1,617	1,688	1,888	2,048	2,214	2,406	2,639
Kachina Village	2,074	2,215	2,683	3,120	3,522	3,941	4,397
Mountainaire	865	915	1,046	1,199	1,340	1,486	1,646
Page	8,413	9,046	11,128	13,057	14,841	16,714	18,770
Parks	886	1,022	1,335	1,604	1,898	2,256	2,701
Tusayan	613	680	819	890	996	1,152	1,372
Williams	2,759	2,912	3,310	3,601	3,925	4,323	4,826
Study area subtotal[2]	82,239	87,825	104,681	120,088	134,837	150,858	169,048

[1] Population of the entire county. Includes named places below, other areas within the study area, and areas within the county but outside the study area.

[2]The study area subtotal does not include population in rural areas outside of named places. The exact geographies of these areas have not yet been determined.

Source: ADES, Research Administration, Population Statistics Unit, 1997

IV. WATER RESOURCES

Most of the water systems in the study area rely on ground water as their primary or exclusive water source. Well depth varies across the region and is a significant factor in the cost of supplying water. In some areas shallow wells access a perched aquifer that provides small flows. This is often the case for domestic wells in unincorporated areas. South of Flagstaff, wells in Mountainaire and Kachina Park are 600 to 800 feet deep. In Flagstaff and Doney Park, wells are 1,000 to 2,000 feet deep. Wells in Tusayan, Valle and Williams reach depths of 3,000 feet or more. Drilling deep wells is expensive and the costs of pumping energy and pump repair are high. Table IV-1 summarizes well depths at selected locations in the study area.

TABLE IV-1
SUMMARY OF WELL DEPTHS IN STUDY AREA

Location	*# of Wells*	*Depth (feet)*	*Capacity (GPM)*
Bellemont	6	150-250	2 at 120-180 Others not obtained
Doney Park	6	1,580-1,780	30-610
Flagstaff	18	1,000-2,000	200-1,650
Forest Highlands	8	1,200-1,350	85-150
Fort Valley	About 200	200 or less	Not obtained
Kachina Village	5	600-1,100	Not obtained
Mountainaire	2	800-1,120	75-120
Tusayan	3	3,000+	Not obtained
Valle	2	3,000+	Not obtained
Williams	3	1,400-3,600	25-240

Sources: Arizona Corporation Commission 2001; Coconino County area plans; *Flagstaff Area Regional Land Use and Transportation Plan* 2001; interviews with water system managers.

A few water systems have substantial surface water sources. The City of Page relies exclusively upon Lake Powell for its water source, but will soon drill its first well. The primary source for the City of Williams is surface water from a number of reservoirs and small impoundments. This community was entirely dependent on surface water until recently. The City of Flagstaff has well fields for its primary water supply and draws water from Lake Mary during summer peak demand.

In some areas development has occurred without access to water. Tusayan, at the south entrance to the Grand Canyon, and Valle, at the junction of highways 64 and 180, are two examples in which the tourism industry spurred commercial development without water. Water for these areas was trucked from Williams, Bellemont and other distant sources before wells were drilled in 1994. Many homes in unincorporated areas are served by either commercial bulk water haulers or by homeowners hauling their own water. Most water utilities in the study area provide bulk water sales via standpipes that provide water to metered accounts or by coin-operated meters. Although the water from these standpipe water sales is not likely to be used within the particular utility's service area, it is likely that most of this water is used within the study area. Standpipe systems are described in some detail in the water system profiles, while standpipe water use is summarized in the chapter on current water demand.

The use of reclaimed wastewater is common throughout the study area. Flagstaff, Forest Highlands, Grand Canyon Village, Page, Tusayan, Valle and Williams currently use reclaimed water for irrigation purposes. The South Grand Canyon Sanitary District (SGCSD) in Tusayan has a state-of-the art water reclamation program that provides local businesses with reclaimed water for toilet flushing as well as irrigation. Chapter VI describes alternative supplies in detail.

Water efficiency and conservation provides an important new "supply" of water in some study area communities. The next chapter describes current efforts and potential measures and programs.

V. WATER EFFICIENCY AND CONSERVATION

The sophistication, level of effort and corresponding results of water efficiency and conservation activities (water demand management) vary substantially throughout the study area. Some are token efforts, others compare well to programs around the country, and are substantial enough to affect water demand.[1] All could be improved—in many cases, dramatically. Opportunities for increased water efficiency and conservation are discussed in a later subsection. First, the next section presents the study team's findings and impressions regarding current and recent efficiency and conservation activities for the county and for each community. The system profiles provided in Appendix A of this report give considerable additional detail.

CURRENT POLICIES AND EFFORTS

County Water Efficiency and Conservation Policies

At the county level, the *Coconino County Comprehensive Plan* and some of the local area plans set out policies that could require substantial water efficiency and conservation efforts for new development in unincorporated areas. Many of these policies have been in effect for some time. The results they achieve rest on how strongly they are interpreted and enforced. Their generality can be both a weakness and strength.

The *Comprehensive Plan* contains a policy in its Natural Resources and Environmental Quality section that authorizes the county to promote efficiency and conservation when it considers development proposals, as follows:

> Water conservation shall be a factor for consideration for the approval of all new major developments requiring Commission or Board approval. Installation of best available technology water-saving devices and use of low water using plants shall be encouraged.

This policy is particularly notable for its use of the term "best available technology." The current national standards on maximum water-use rates for plumbing fixtures no longer represent best available technology. The county has in place a policy that allows it to demand fixtures that exceed the national plumbing standards. Whether it does so on particular proposals, and to what degree, is not clear to the study team. What is clear is that most of the local area plans have only vague language encouraging or requiring "low water using fixtures" (or similar language). No specific flow rate requirements are included in any of the area plans. Nor are they included in the *Coconino County Building Code Guidelines*, the *Coconino County Zoning Ordinance* or the *Coconino County Subdivision Ordinance*. In fact, the only notable water efficiency and

[1] The exact impacts of efficiency and conservation programs are hard to determine without statistical analysis to normalize water use data for yearly and seasonal variations in weather, economic activity, and demographics.

conservation provision in any of the three documents mentioned is a provision in the *Subdivision Ordinance* that separate meters for each unit in a condominium complex *may* be required.

The *Comprehensive Plan* also addresses landscape water use in its Vegetation and Wildlife section, with the following policy:

> The use of indigenous plants shall be encouraged for all new landscaping. To further this policy, a native plant list shall be adopted. Vegetation requiring significant amounts of water shall be discouraged.

The purpose of promoting indigenous plants includes water conservation; as such plants typically use less water than most imported plant species. Some of the area plans include similar policies. Once again, the efficacy of such policies lies in how they are interpreted and enforced on a case-by-case basis.

Local Water Efficiency and Conservation Policies and Activities

Significant water efficiency and conservation policies and efforts in each community are summarized in Table VI-1. Within the study area, Flagstaff has the most extensive and notable water efficiency and conservation program. Its efforts are commensurate with those of other similarly sized and situated water utilities. Flagstaff's educational programs—e.g., televised public service announcements, newspaper inserts and some other activities—also benefit other Coconino County communities by raising conservation consciousness beyond the city limits as well as within. Williams has recently made important strides in building an efficiency and conservation program. Page, for its size and concern over adequacy of current supplies for future growth, is remarkable for not having implemented a serious water efficiency and conservation program. In most other communities, conservation rate structures, or simply the high price of water, provide the main motivating factor for customers to implement water efficiency measures or practice water-wise behaviors. It appears that high prices have become a conservation tool mostly by default, because of the high cost of providing water in this region, rather than as a conscious water conservation strategy (as in a carefully thought-through water conservation rate structure). With a few exceptions, *active* intervention—regulations, incentives, system measures such as distribution leak testing—by local water providers or planning and building officials to increase local water efficiency, is very limited in the study area. Even educational programming—a fairly low-cost, but largely *passive* approach—is nonexistent or thin in many study area communities.

Table VI-2 provides a summary of water and sewer rates charged in various systems, as well as standpipe rates charged to water haulers. Monthly service charges are usually designed to pay the costs of treating and pumping water. Volumetric charges may also be used as water conservation incentives when structured in an increasing block-rate design. Doney Park Water, Flagstaff and Kachina Village have what the study team considers to be effective conservation rate structures. Sewer charges are often associated with volumetric water consumption, and can also provide a conservation incentive when well designed for this purpose.

TABLE V-1 CURRENT WATER EFFICIENCY AND CONSERVATION ACTIVITIES, BY COMMUNITY*					
Community	*Conservation Rate Structure?*	*Ordinances & Policies*	*Incentives*	*Educational Programs*	*Other*
Bellemont	No	None of note	None	None	None of note
Doney Park	Yes: price decreases from small base block to 2nd tier, but increases substantially from 2nd to 3rd tier; plus summertime surcharge on 3rd tier water use	Area plan includes extensive but mostly vague conservation policies; however, its emphasis on xeri-scape & its call for the county & DPW to cooperate on conservation education are notable	None	Articles in quarterly newsletter; presentations at annual meeting; some events co-sponsored with City of Flagstaff	Notify customers of spikes in monthly water use (possible leaks); active distribution system leak detection program
Flagstaff	Yes: three increasing price tiers for single-family residential & landscape meters, with a significant price increase from the 2nd to 3rd tier	4-step water shortage ordinance	Rebates up to $100 for old toilet change-outs to 1.6 GPF models	Home show booths; school curricula; free displays for rest-aurants; televised PSAs in summer; newspaper inserts; on-hold messages for phone calls to city hall	Standing “Water Conservation Committee” of eight city staff develops/runs programs
Flagstaff Ranch	Rate schedule not yet developed	CC&Rs will include turf limitations	None	None	None
Forest Highlands	No	Turf prohibitions for yards of newer residences	None	Tried education, results were disappointing	Notify customers of spikes in monthly water use; computer con-trolled golf-course irri-gation system incor-porates soil moisture sensors
Fort Valley	N/A (individual water systems)	None of note	None	None	Some residents haul water—high costs of doing so probably motivate some retrofitting & conservative water use

TABLE V-1 CURRENT WATER EFFICIENCY AND CONSERVATION ACTIVITIES, BY COMMUNITY*					
Community	*Conservation Rate Structure?*	*Ordinances & Policies*	*Incentives*	*Educational Programs*	*Other*
Grand Canyon Village	No, but annual surcharges for excessive use	None of note	None	Signs in visitor center restrooms; hotel sheet changes only upon request	Most toilets have been changed-out to 1.6 GPF models in 1998; most urinals are now 0.5 GPF; some waterless urinals
Kachina Village (KVID)	Yes: six tiers with substantial price increases between each tier	Area plan emphasizes xeriscape for all non-single-family development	None; area plan encourages KVID & County Building Division to develop a rebate program	Periodic distribution of educational flyers	High use door hangars placed when staff note monthly use spikes; customer leak surveys provided on request; distribution system leak survey in 1999
Mountainaire	No	None of note	None	None	Nothing of note
Page	Barely: price/1,000 gallons decreases from large base block to 2nd tier; price increases from 2nd to 3rd tier, but insubstantially	None	None	None	Two recent distribution system leak detection/ repair cycles; pressure reduction in 2002 for a problem area
Parks	N/A (individual water systems)	None	None	None	Most residents haul water; high costs probably motivate some retrofitting & conservative water use
Red Lake	N/A (individual water systems)	None	None	None	Most residents haul water; high costs probably motivate some retrofitting & conservative water use

TABLE V-1
CURRENT WATER EFFICIENCY AND CONSERVATION ACTIVITIES, BY COMMUNITY*

Community	*Conservation Rate Structure?*	*Ordinances & Policies*	*Incentives*	*Educational Programs*	*Other*
Tusayan	No	None of note	None	None	High water costs probably motivate some retrofitting & water-conservative behaviors; one lodge reported to use 1.0 GPF toilets
Valle	No	None of note	None; area plan calls for the county to investigate development of incentives for plumbing retrofits	None	High water costs probably motivate some retrofitting & water-conservative behaviors
Williams	Barely: price/1,000 gallons decreases from small base block to 2nd tier; price increases from 2nd to 3rd & 3rd to 4th tiers, but each increase is very small	Lavatory faucets must use less than 2.0 gallons per minute; public restroom faucets must use metering or self-closing faucets; pressure reducing valves required in all new construction & remodeling where line pressure exceeds 50 psi; prohibition against irrigation water flowing onto public streets for more than 10 minutes; 4-step water shortage ordinance	Retrofit rebate program: rebate of $50 for efficient toilet, other rebates for efficient urinals, showerheads, faucets, irrigation timers & drip irrigation for existing turf, conversion of turf to inorganic ground cover	Water bill inserts; school presentations	Notify customers of spikes in monthly water use; recent distribution system leak survey; recent replacement of over 90% of customer meters

*This table notes only policies and activities that exceed requirements of higher-level governments. For instance, construction with “low-flow fixtures” is already required by the national plumbing standards. Unless locally required fixture flow rates exceed the national standards, they are not noted here. Also, vague policies that call for “water conservation measures” but do not define them are not noted.

Sources: Interviews with water system managers; water efficiency and conservation program materials provided by water system managers.

TABLE V-2 SUMMARY OF WATER AND SEWER RATES*		
Utility	*Water*	*Sewer*
Bellemont Water Company	$25.00 per month service charge $ 5.25 per 1,000 gallons *Standpipe: $4.00-$5.25 per 1,000 gallons*	Not applicable; onsite systems
Doney Park (residential/ general non-commercial)	$18.75 per month, 5/8" meter; includes first 1,000 gallons $ 4.30 per 1,000 gallons, for 1,001-5,000 gallons $ 6.90 per 1,000 gallons in excess of 5,000 (winter) $ 8.63 per 1,000 gallons in excess of 5,000 (summer) *Standpipe: $6.90 per 1,000 gallons (winter):* $ 8.63 per 1,000 gallons (summer)	Not applicable; onsite systems
Flagstaff (residential)	$6.48 per month, 3/4" meter $2.83 per 1,000 gallons, up to 5,000 $3.32 per 1,000 gallons, 5,001-15,000 $4.71 per 1,000 gallons, over 15,000 *Standpipe: $5.25 per 1,000 gallons*	$2.73 per 1,000 gallons, flat fee based on winter quarter average water use
Forest Highlands	$25.00 per month $ 2.00 per 1,000 gallons	$30.00 per month $ 2.00 per 1,000 gallons
GCNP	$14.43 per 1,000 gallons	$14.49 per 1,000 gallons
Kachina Village	$14.05 per month $ 1.04 per 1,000 gallons, up to 3000 $ 1.56 per 1,000 gallons, 3,001-6,000 $ 3.12 per 1,000 gallons, 6,001-9,000 $ 6.24 per 1,000 gallons, 9,001-12,000 $10.40 per 1,000 gallons, 12,001-50,000 $16.64 per 1,000 gallons, over 50,000	$18.73 per month $ 2.60 per 1,000 gallons up to 3,000 $ 4.16 per 1,000 gallons, 3,001-6,000 No charge over 6,000 gallons
Mountainaire (Ponderosa Utility Corp.)	$21.00 per month 5/8"-3/4" meter $ 3.30 per 1,000 gallons *Standpipe: $5.70 per 1,000 gallons*	Not applicable; onsite systems
Page	$4.00 base rate, includes first 3,000 gallons $1.25 per 1,000 gallons, 3,001 to winter average $1.35 per 1,000 gallons, over winter average	$2.52 per 1,000 gallons
Tusayan	$50.00 per 1,000 gallons, Airport system $45.00 per 1,000 gallons, Anasazi Water Co. $18.50 per 1,000 gallons, Hydro Resources $ 1.00 per 1,000 gallons, reclaimed water	$13.59 per 1,000 gallons
Valle - Grand Canyon Inn	$10.00 per 1,000 gallons *Standpipe: $12.50-$20.00 per 1,000 gallons*	Not obtained
Williams (residential)	$6.72 per month, includes first 1,000 gallons $3.37 per 1,000 gallons; 1,001 to 10,000 $3.54 per 1,000 gallons; 10,001 to 20,000 $3.72 per 1,000 gallons; 20,001+ *Standpipe: $7.33-$12.52 per 1,000 gallons*	$13.00 flat rate

*Unless otherwise indicated, all rates are general service rates applying to all customers.
Sources: Water and sewer rate schedules provided by water system managers.

POTENTIAL FOR INCREASED EFFICIENCY AND CONSERVATION

Table VI-1 shows that many of the study area communities have very limited water demand management programs. The high prices for water common throughout the study area no doubt motivate some retrofitting activity, some beyond-standard fixture and appliance choices in new development, and some water-conserving behaviors among water users. However, much more could be done with respect to water-efficient technologies, water-wise behaviors and landscape choices that would contribute to satisfying both region-wide and community-specific water needs.

The potential for study area stakeholders to produce significant additional water savings in existing development, and to reduce the water demand of new development, is significant. The following two sections describe some of the opportunities to improve water-use efficiency. The first describes efficiency and conservation *measures*—the technologies and management practices that reduce water demand. The second describes *implementation techniques*—ways of encouraging or requiring end users to adopt efficiency and conservation measures. Not all possible measures and techniques are described, only those most suitable for the study area. There are many nuances and potential obstacles to use of any of these approaches. For example, different brands and models of the same technology often perform better or worse, and implementation programs can be designed and carried out well or very poorly. Any measures and implementation programs chosen for evaluation as part of the conservation scenarios in the Phase II study (see the Phase II methodology section in this report) will be further detailed in the Phase II report.

Water Efficiency and Conservation Measures

Water Provider Measures

A water provider can directly implement some measures. These include:

- *Distribution system leak detection and repair.* Some of the study area water providers are doing a good job tracking down and repairing leaks. Others could do more. Besides checking the distribution system itself, tracking down leaks often also requires a long-term commitment to replacing aging meters in order to reduce meter slippage and allow better accounting of how much water is used where, and how much is lost along the way. Metering any remaining unmetered users (for instance, both Williams and Grand Canyon Village have significant unmetered users) is also required. Ten percent “unaccounted-for” water (the difference between water produced and water sold) is a common “guideline” in the industry. In a water-short region, a rate of 5 percent or less should be sought.

- *Distribution system pressure reductions.* Too high water pressure results in wastefully high flow rates at faucets, showerheads and some other water fixtures. Page and

Flagstaff have noted, and are addressing problem zones where water pressure is too high. Williams has taken an alternative approach, requiring pressure-reducing valves in new buildings where water pressures are high. Other communities may have high-pressure problems. If so, these should be rectified.

Common End-Use Measures

Most water efficiency and conservation measures must be implemented by the end-user. Common end-use technologies, practices and choices include the following. Based on the interviews and visit to the study area, the implementation rate of these measures in north-central Arizona ranges from very low to moderate, meaning there is substantial potential for increased implementation and corresponding demand reductions.

- *Ultra-low-flush toilet*—The Ultra-low-flush toilet (ULFT) uses 1.6 gallons per flush (GPF) or less. These toilets became widely available beginning in the late 1980s, and the Federal standard of 1.6 GPF maximum became effective in 1994. It is likely that many toilets in the study area are still 3.5 GPF or even higher-flush models. Over the coming decades, virtually all these old toilets will be replaced as they wear out, a phenomenon known as "passive water conservation." A good water demand forecast must account for this passive conservation in the baseline forecast. Toilet replacement can be speeded up by "active conservation" programs such as the implementation techniques described below. Further, some very good ULFTs now on the market use as little as 0.8 GPF. Local stakeholders should be encouraged to promote these better models.[2]

- *Dual flush toilet*—The "6/3" toilet, which uses 1.6 gallons (6 liters) or less for a full flush and only 0.8 gallons (3 liters) or less for a urine flush, has recently become available in this country. Given the conservation ethic in much of the study area, local citizens would quickly learn to take advantage of the water savings of dual-flush toilets, as millions of Australians have done for decades. Recent studies by Seattle Public Utilities show that dual flush toilets save an additional 25 percent over standard ULFTs.

- *Waterless urinal*—Waterless urinal have been installed in some restrooms at GCNP, and perhaps in other locations in the study area. They are a now well-proven

[2] Several concerns are often raised about ULFTs. One is that these toilets don't work well and require water-wasting double-flushing and increased cleaning. It is true that some early ULFTs and unfortunately some current models (mostly cheaper ones) do not work well. Very many models work quite well. Customer satisfaction surveys run by large utility replacement programs consistently show that 80 percent or more of participants are satisfied or find their new toilet's performance as good or better than their old toilet (Osann and Young 1998, p. 20-24). There are also significant ongoing discussions among water conservation professionals over the longevity of ULFT savings, due in large part to unperformed or improper flapper replacements after several years' wear. Certain designs do not suffer from this problem. A utility should choose carefully which toilets it promotes, rebates or buys, and should provide consumers with information or sources of information on the performance of available products.

technology that should be considered for wider implementation. As with *any* urinal, odor problems are typically the result of insufficient cleaning schedules.

- *Standard efficient showerheads and faucet*—The national standards for maximum flow rates are 2.5 gallons per minute (GPM) for both showerheads and faucets. Replacing old showerheads and faucets with 2.5 GPM models produces some water savings, but recent research has shown that the savings are typically small, probably because people do not always operate these fixtures at fully throttled maximum flow rates (Mayer et al. 1999). Local utilities should instead promote beyond-standard (lower than standard flow) showerheads and faucets for both replacements and new construction.

- *Beyond-standard showerhead*—Most people find that many 2.0 to 2.2 GPM showerheads provide excellent quality showers (assuming adequate water pressure). Some even find that models with maximum flow rates as low as 1.5 GPM are satisfactory.

- *Beyond-standard faucet*—Faucet heads with 2.2 to 2.5 GPM (commonly called aerators) are necessary for kitchen faucets because of frequent volumetric uses such as pot-filling. For bathroom faucets, however, much lower flow rates are usually adequate. Faucet heads with 1.0 to 1.5 GPM are highly satisfactory to most people for residential bathrooms. For public bathrooms where hand-washing is the predominant use, 0.25 to 0.5 GPM faucet heads that produce multiple small streams of water are quite effective.

- *Fingertip faucet valve*—Some faucet heads have flip levers or buttons that allow a person to turn down the flow to a dribble. This allows one to effectively turn off the tap while maintaining the same hot/cold mix; for instance, while alternating between scrubbing food or dishes and rinsing. This type of faucet head enables a small but significant conservation behavior. A similar but more costly device is the foot pedal valve, which is available for residential as well as commercial applications.

- *Electronic faucet*—For public restrooms, electronic sensors that automatically turn water on and off when hands are present in the sink have improved to a level of reliability worthy of widespread implementation. Such faucets save water over standard faucets and metering (e.g., spring-dosed) faucets.

- *High-efficiency clothes washer*—Now that ULFTs are being widely implemented, water conservation professionals consider the clothes washer the next great "reservoir" of indoor residential water savings. New high-efficiency models, typically designed to spin on a horizontal axis, use one-third to one-half the water of conventional washers. They also save on water-heating energy and on detergent. While still more expensive than conventional washers, costs are coming down. Some utilities offer rebates to promote the horizontal-axis washers.

- *High-efficiency dishwasher*—Dishwasher technology has steadily improved over the years. Today, the water efficiency of dishwashers both in homes and on sales floors varies widely. Small but cumulatively significant water savings are possible if consumers choose the more efficient models.

- *Turf area reduction*—Grass lawns typically account for most of the irrigation water demand for home yards and other landscapes. Simply reducing turf areas, to where they are most needed, can produce significant water savings. Other, less water-intensive plantings and treatments are available for ground covers where turf is not essential.

- *Low-water plants and xeriscape*—Native plants tend to use much less water and tolerate drought better than non-native species, and their use should be encouraged. Xeriscaping is a suite of techniques for producing pleasing landscapes that require no or very little irrigation to supplement natural precipitation. These types of landscapes are becoming more accepted throughout the west, particularly as the economic and environmental costs of standard landscaping become more apparent to people.

- *Efficient irrigation system*—Surface and subsurface drip irrigation, micro-spray systems, bubblers and soaker hoses are typically more efficient than sprinkler systems, especially conventionally installed sprinklers. The type, spacing and aiming of sprinkler heads greatly affect the application uniformity and therefore the potential efficiency of sprinkler systems. With all irrigation systems, proper zoning to match the different water needs of different portions of a landscape is important. Irrigation experts typically find substantial water savings are possible from changing the type, spacing and zoning of irrigation equipment in both residential and larger landscapes.

- *Evapotranspiration-based irrigation scheduling*—Even with the very best irrigation equipment, poor scheduling is all too common. Evapotranspiration (ET) refers to the water requirements of plants and associated soil. Water application in excess of ET requirements is wasteful. Many people water all of their landscape the same amount, and typically more than necessary, throughout the irrigation season. Water utilities or other agencies can calculate ET requirements of representative local landscapes on the basis of typical changes in plant ET requirements from the beginning to the end of the irrigation season, or actual changes based on recent weather, and distribute watering guidelines through a variety of means. Also, programmable irrigation timers provide a crude but "much better than nothing" approach to ET-based irrigation by allowing irrigation schedules to be automatically adjusted for typical ET requirements through the irrigation season. Unfortunately, many people do not know how to properly program their timers, so education must be provided.

- *Rain sensor*—When connected with irrigation controllers, these devices can automatically turn off irrigation systems when rain occurs, saving partial or entire irrigation cycles.

- *Soil moisture sensor*—These devices turn off or delay cycles on an irrigation controller when soil moisture is adequate. Thus, they partially gauge ET and help schedule irrigation in closer agreement with actual plant needs.

- *Commercial, institutional and industrial (CII) measures*—Besides all the measures noted above, CII users often have many specific but fairly straightforward water-saving opportunities. Candidates for increased efficiency include food service and dishwashing equipment and procedures, cooling tower water recycling and adjustment of blow-down cycles, car wash recycling, cleaning and sanitation equipment (e.g., steam sterilizers, autoclaves, floor washing, etc.), recycling of process water, boiler and steam generator water recycling and optimization, ice-making equipment and much more.

Advanced end-use measures

There are many advanced and emerging end-use measures. Some of these are proven technologies that not typically cost-effective for retrofits, but may be worth encouraging in reconstruction and new development. Others are developing technologies that could have significant impacts in the future as the designs are refined, their costs come down or local water costs rise to the point that more expensive water efficiency measures become cost effective.

- *Extreme low-flush toilets.* Toilets using as little as 0.5 GPF are available. Some use special bowl coatings and vacuum withdrawal to insure effective flushing.

- *Waterless toilets.* Vault and composting toilets are now known to many people from highway rest areas and other remote locations. In addition, new waterless designs are being developed in Europe that use a 2-part bowl to separate urine and feces. Keeping these forms of human waste apart greatly facilitates their subsequent management. These "separating toilets" are widely used in seasonal cottages in Scandinavia and are in experimental application in urban areas there as well. They would be particularly appropriate for use in portions of the study area where water is hauled.

- *Hot water recirculation systems.* These plumbing add-ons provide for instant hot water at the tap, saving the water that is wasted when users let water flow while waiting a few seconds, sometimes longer in larger buildings, for cold water in the lines to be cleared. Point-of-use water heaters achieve the same result. Optimized location of conventional water heaters in new construction also helps.

- *Remote dispatch of irrigation systems.* Irrigation scheduling can be optimized by centralized computer control. These systems maintain a running water balance based on actual precipitation and actual ET requirements resulting from recent weather, as measured by one or frequently several small weather stations within the districts they serve. They also incorporate a database of the ET requirements of each particular zone in the irrigation systems they control. The computer then dispatches each zone's irrigation equipment according to actual ET needs and recent precipitation, via cable hookups, phone lines or other telemetry. One model for provision of this service is by subscription, just as one subscribes to cable or other services.

- *Automated customer leak detection.* Advanced meters and associated devices can detect constant low-level flows that indicate leaks. End-users can then be notified of leaks either directly by the device, or more typically through the local utility or another provider of this service that maintains notification information for enrolled customers. This is just one example of how information technology will ultimately lead to "smart buildings" that are highly efficient in their use of water, energy and other resources.

Some of these technologies, like hot water recirculation, provide fairly small water savings. But multiple little savings add up. The fact that technologies for water savings, large and small, continue to emerge and evolve is encouraging news for regions where future water supplies are uncertain.

Implementation Programs

Water providers and other stakeholders have available a host of ways to encourage or require end-users to implement water efficiency and conservation measures. Some of these—rebates and other incentives, for instance—have obvious monetary costs. Others have costs in staff time, equipment, and acquisition of expertise to help develop or run programs. The premise of implementation is that these costs are *investments* that will produce economic returns to the water provider or the community by deferring, downsizing or avoiding altogether new water supply systems, new treatment capacity, upsizing of distribution systems or other costs that would have to be borne in the absence of effective demand management. Here are a few implementation techniques that may be appropriate in the study area.

A key implementation tool is **price**. Some options here include:

- *Conservation rate structures*. Doney Park Water, Flagstaff and Kachina Village are the only local water systems with effective inclining block rate structures. This tool is highly appropriate in this arid region and should be more widely used here.

- *Summer surcharges.* In a region where peak summer use is driving water supply concerns, summer surcharges to encourage more efficient irrigation technologies, water-wise landscapes and other ways to beat the peak are an obvious tool that should be seriously considered. Only Doney Park Water currently makes use of this tool.

Another implementation technique is to provide **technical assistance** to end-users:

- *Large user audits.* Audits of buildings and sites by qualified water efficiency and conservation experts typically identify significant water savings that are highly cost-effective for facility owners. Water utilities should target large customers, typically CII accounts, first. Audits often provide each customer with estimates of financial savings on water, sewer, energy and other business costs. As an example, a major audit program conducted in the 1990s by the Metropolitan Water District of Southern California found savings opportunities averaged 26 percent just for easily identified measures. Because the average payback to customers from the consulting engineers' recommendations was 1.6 years, many customers implemented many of the recommendations (Wilkinson and Wong 1999). Flagstaff offered audits to hotels roughly 15 years ago, but met with some resistance because auditors asked for occupancy rates. Audit spreadsheets could be provided that would allow customers to privately calculate their savings. In any case, large user audit offers should be repeated periodically, perhaps every 10 years.

· *Large landscape audits.* Audits targeting only large landscapes—golf courses, cemeteries, parks and recreation fields, "campuses" of large businesses and institutions, etc.—are particularly cost-effective for both utilities and customers. For landscape audits in particular, but with building audits as well, the audit scope can include evaluation of opportunities for water reuse, as well as efficiency and conservation options.

Legal requirements and policy guidelines are of course a useful implementation tool. Sometimes they are the best way of assuring certain important technologies or behaviors are implemented. Requirements and guidelines can be enacted in municipal and county ordinances, in local and county plans and design review overlays and sometimes by properly empowered local or regional offices of state or Federal agencies. Appropriate tools include:

· *Water waste ordinances.* Local governments could enact and enforce prohibitions against street flooding from irrigation systems, single pass cooling systems in new buildings, non-recirculating systems in all new conveyer car wash and commercial laundry systems, non-recycling decorative water fountains and other unnecessary water uses and wastes. Williams is the only community in the study area that to the authors' knowledge currently has a water waste ordinance (it targets over-irrigation).

· *Turf restrictions.* Municipalities and private developers can cap amounts of turf on private parcels through ordinances and CC&Rs that limit the percentage of a lot that can be covered in grass, or with other parameters. Flagstaff Ranch and Forest Highlands apparently have some such restrictions.

· *Submetering requirements.* Requiring developers of multi-family housing to install meters at each housing unit produces water savings by providing residents with financial feedback on how much water they use as an individual or family.

· *Water shortage ordinances.* While not quite the same type of implementation technique as the others mentioned here, because the hope is to never invoke the ordinance, it is important that all communities have in place plans for times of water shortfalls, so citizens will know what to expect—what actions will be encouraged, required or prohibited.

· *Large users policy.* Some communities—Albuquerque, New Mexico, for instance—have required CII customers using water over a certain threshold volume to develop and implement a conservation plan for their facilities and landscapes.

Water utilities can provide end-users with **financial incentives** for adoption of water efficiency and conservation measures. For instance:

- *Rebates for fixtures, appliances and other technologies.* Rebates are popular with customers, and are especially appropriate for more expensive items such as toilets and efficient clothes washers. Flagstaff and Williams are currently the only study area communities with toilet rebate programs. Clothes washer rebates are a favorite new conservation program across the country that would also be worthwhile in the study area. Specific irrigation equipment, such as drip systems, soil moisture monitors and certain controller devices may also be appropriate for rebates (Williams provides a local example).

- *Fixture giveaways*. Free distribution, by a variety of means, is especially appropriate for water-efficient technologies that can be purchased in low unit bulk costs; for example, beyond-standard showerheads and faucet heads, and fingertip control faucet heads.

- *Turf reduction incentives.* Sometimes called "cash for grass," this type of tool essentially rebates to end-users some of the costs of converting portions of their landscape from turf to lower water-use plants or other ground cover. Williams has such a program in place.

- *Incentive-based hookup fees.* Reductions in hookup fees could be put in place for new development that beats current plumbing codes and/or includes particular measures such as xeriscape, state-of-the art irrigation systems, graywater systems, dual plumbing, etc.

- *Transferable savings programs.* Transferable savings programs require developers to supply water for each new unit by retrofitting existing homes or businesses in the community. They have been used by communities as a way to prevent or lift building moratoriums resulting from water supply shortfalls, and could be used in non-crisis situations as well.

- *Performance contracting <u>with</u> water users.* Performance contracts are initiated by a utility offering to pay customers (usually CII customers) for provable savings. A utility can offer to pay for any savings up to a pre-determined cost per unit (typically less than or equal to its marginal cost for the next feasible supply project), or it can open the offer to competitive bidding, notifying customers it will accept the least-costly proposals up to some maximum amount. The offer also has a service value to the utility in countering any concerns (usually unwarranted) that rate increases will "drive away" CII customers. (Rate increases would be an independent action by the utility; they are not required for performance contracting.)

- *Performance contracting <u>by</u> water users.* A slightly different approach, this is not a direct financial incentive from the water utility, but water utilities can educate large water users about this tool and help put parties together. Also known as the "shared savings" approach, this type of performance contracting is an agreement between a water user and a company that finances retrofitting of a user's fixtures, equipment, etc. This company is paid back a portion of the water, sewer, energy and other costs savings that the water user experiences.

Partnerships with other utilities should be explored. For example, cost sharing with energy utilities is often advantageous. Sharing costs of rebates for water-efficient clothes washers is a particularly appropriate, widely engaged partnership, as these machines save both water and energy. Partnerships can also create mutual efficiencies in program administration and the application of technical expertise.

Regional cooperation should be considered. The implementation techniques noted here can be carried out by individual water systems, or through collaboration among multiple water systems. Given the small size of most of the water providers in the study area, regional cooperation may be necessary to mount some of these efforts, and should offer substantial benefits. A regional approach should achieve economies in administration, in bulk purchase of efficient end-use technologies and in acquisition of technical expertise. Consider, for instance, joint purchase of low-flow faucets and showerheads for giveaways, and potentially bulk orders of other fixtures and appliances. Or consider how multi-entity cooperation to hire an outside expert to perform water audits in several study area communities would benefit all.[3]

Education. Education is mentioned last because while education is often rightfully the first conservation activity communities undertake, it is too often the only one. No community in this arid region should consider education alone a sufficient water conservation program. For those communities without educational programming, beginning this activity is an important step. For those communities now doing good education work, there is always more to be done—new conservation measures and practices to be promoted and taught, and new, more effective ways of reaching people.

- *Demonstration homes.* A useful education tool is to develop one or more homes that implement the full range of the most efficient technologies. Tours familiarize the public with specific technologies and tell the story that efficiency does not have to mean lifestyle restrictions. Collaboration with energy utilities and plumbing, fixture, appliance and irrigation equipment vendors is common in the development of demonstration homes. In lieu of building a dedicated demonstration home, tours of private homes with selected technologies can be arranged.

[3] The Morrison Institute has proposed a study of managerial and legal arrangements necessary to form a regional water authority. This study has not yet been funded. While a regional authority may be desirable, it should also be noted that one is not required in order for regional cooperation on water conservation programs to proceed.

VI. ALTERNATIVE SUPPLIES

Alternative supplies currently in use in the study area include widespread wastewater reclamation and reuse, plus limited graywater reuse, water recycling, and rainwater harvesting. Wastewater reclamation is typically accomplished on a system-wide basis; by treating water at a centralized wastewater treatment plant and redistributing treated effluent to portions of a community. Graywater reuse, water recycling, and rainwater harvesting are typically implemented at the scale of individual buildings or particular sites. Rainwater harvesting systems typically capture rooftop runoff, but can also capture local pavement runoff. They usually capture snowmelt as well.

These techniques are functionally similar to water demand management because they accomplish the same end results—i.e., reduction of potable water demand, and corresponding reductions in withdrawal of water from surface and ground water sources through conventional supply systems. Indeed, some people refer to alternative supplies such as wastewater reclamation or graywater use as "water conservation." For the purposes of this study, the water savings provided by alternative supplies are treated separately from water efficiency and conservation (demand management). Water efficiency and conservation help reduce total demand, and are addressed in the previous chapter. Alternative supplies, discussed in this chapter, then provide one way of meeting the reduced demand, along with conventional supplies.

CURRENT USE OF ALTERNATIVE SUPPLIES

Currently, graywater use in the study area is likely to be very low. No data on graywater use exists in this area. Until recently, ADEQ regulations effectively prohibited graywater reuse by requiring treatment systems that are prohibitively expensive for most applications, especially residential irrigation, the most common graywater use. It is likely that some households operate graywater systems without ADEQ permits, particularly in portions of the study area where residents haul most or all of their water. Households that use graywater are probably a very small portion of all households within the study area. The contribution of graywater to meeting total water demand is probably zero to negligible in any of the municipalities and communities served by water distribution systems, and marginal in other areas.

Water recycling is similar to graywater use; the difference is primarily in scale and application. The term water recycling is commonly applied to commercial and industrial systems that reuse water from one process for another process that can utilize water of a lower quality. One such system known to exist in the study area is the Grand Canyon National Park Lodges' hotel laundry facility. It recycles water from the rinse cycle of large washing machines for the wash cycle of other loads.

Rainwater harvesting (the collection of precipitation from rooftops or pavements) is apparently very limited in the study area, with two notable exceptions discussed below. While the regulatory requirements for rainwater harvesting for nonpotable use are far less onerous than for graywater use, current use appears to be low. Probably most homeowners and businesses are unaware of the options, or they do not use rainwater collection because they do not have significant landscape or stock watering needs or because the costs of installing and maintaining rooftop collection systems and a cistern have not seemed affordable. Again, in areas where water is hauled, it is likely that some residents do collect and use rooftop rainwater and snowmelt.

One very significant implementation of rainwater harvesting is the system at the Grand Canyon Airport in Tusayan, which captures runoff from the runway. This water is treated and applied to potable as well as nonpotable uses. It provides for nearly 6 percent of total water use in Tusayan. A second notable system is under construction at Flagstaff Ranch. It will use a French drain (a trench filled with gravel and bottomed with a perforated pipe to capture drainage) to divert local pavement and subsurface runoff to a holding pond for golf course irrigation. The development will also harvest runoff from the clubhouse parking lot.

Centralized wastewater reclamation and redistribution for reuse is practiced in many of the study area communities. For some it is a significant water supply. Table V-1 below provides a summary of the systems and uses. The most notable systems are those in Tusayan and Flagstaff. Tusayan is remarkable for its use of reclaimed water to flush toilets in almost all commercial and multi-family buildings. This is a “cutting edge” application and a nationally innovative wastewater reuse system. Grand Canyon Village also practices some reuse for toilet flushing. Flagstaff can be applauded for its continuing effort to expand both the infrastructure for reuse and its number and types of reclaimed water users. These and other communities use reclaimed water as well for irrigation of landscape and golf courses.

Table VII-1, in the “Current Water Demand” chapter, shows that reclaimed water use in the year 2000 provided 928 million gallons of water supply in the study area, satisfying 16% of total demand. This water source displaced water that would otherwise have had to come from surface and ground water sources. Table V-1 below shows that reclaimed water provides for 15 to 22 percent of total water demand in five communities, and 40 percent in Tusayan.

POTENTIAL FOR INCREASED USE OF ALTERNATIVE SUPPLIES

Coconino County’s *Comprehensive Plan* contains policies in its Natural Resources and Environmental Quality section that authorize the county to promote alternative supplies when it considers development proposals and undertakes other review and intergovernmental collaboration functions:

- The County shall encourage the reuse of wastewater where possible to reduce the use of potable water.
- The County shall encourage the conservation and beneficial use of drainage or runoff water.

Similar policy statements occur in some of the local area plans. The degree to which the county “encourages” alternative supplies is not clear.

TABLE VI-1 TYPE, APPLICATION AND SIGNIFICANCE OF WASTEWATER RECLAMATION SYSTEMS BY COMMUNITY			
Community	*System Description*	*Applications*	*Scope/Significance*
Bellemont Travel Center	Under construction; package plant with redistribution lines to new development	Commercial & public landscapes	Summertime wastewater effluent will be reused for irrigation
Flagstaff	Centralized wastewater treatment plants; redistribution lines to portions of the city	Landscape irrigation on golf courses, cemeteries, NAU & many of the city's recreational facilities, public landscapes & school grounds & athletic fields	504 MG of reclaimed water used in 2000—15% of total water demand; 23% of the city's total wastewater effluent was reused in 2000
Flagstaff Ranch	Under construction; tertiary treated effluent will be stored/mixed with ground water in ponds at the golf course.	Golf course irrigation	100% of community's *year-round* wastewater effluent will be stored and used (some evaporates)
Grand Canyon Village	Centralized treatment plant; redistribution lines to portions of the community	Irrigation of an athletic field; toilet flushing at two hotels & the visitor center	Reclaimed wastewater provides for 22% of total demand; roughly 30-35% of the community's wastewater effluent is reused
Kachina Village, Forest Highlands	Tertiary treatment at FH; secondary treatment plus wetlands polishing at KV; treated effluent is mixed with ground water in FH storage tank	Golf course irrigation at Forest Highlands	Reclaimed wastewater provides for 35% of the golf course needs and 19% of total demand for all of FH; 100% of Forest Highland's year-round wastewater effluent is stored and used
Page	Secondary treatment; treated effluent is stored/mixed with raw surface water in lined ponds at the municipal golf course	Golf course irrigation	22% of the total water demand is supplied by reclaimed wastewater; 100% of community's *year-round* wastewater effluent is stored & used (some evaporates)
Tusayan	Tertiary treatment with recirculating sand filters; redistribution lines to most of the community	Toilet flushing in hotels, restaurants, & a dormitory; landscape irrigation	22.4 MG of reclaimed water used in 2000, supplying roughly 40% of the community's total water demand; 46% of the community's wastewater is reused
Valle	Two package plants; one discharges to a storage lagoon	Landscape irrigation for a hotel & a baseball field	Current use is limited; airport terminal & other sites are double-plumbed for future reclaimed water use
Williams	Secondary treatment; treated effluent is stored/mixed with raw surface water in ponds at the municipal golf course	Golf course irrigation	48 MG of reclaimed water used in 2000, 19% of total water demand; 100% of the city's *summertime* wastewater effluent is used

Many study area communities could make significantly more use of alternative supplies. The options include:

- *Graywater reuse.* With the new ADEQ regulations, graywater use is now easier and much cheaper to implement. Increased use of graywater could provide a small contribution to meeting water demand, but an important one, particularly in areas where water is hauled, or where installation of redistribution lines from centralized wastewater treatment plants is especially costly.

- *Water recycling.* Opportunities for increased process reuse of water in commercial and industrial facilities in the study area are likely to exist. These opportunities are frequently uncovered during water use/water efficiency audits, discussed in the previous chapter.

- *Rainwater harvesting.* This practice could be expanded as well, and would provide small but notable contributions. It is especially suitable for homes in water-hauling areas; commercial, institutional, and other buildings where the ratio of rooftop to irrigated area is high; and large pavement areas like parking lots where catch basins facilitate capture of runoff. A specific opportunity may be expansion of the rainwater collection system at the Grand Canyon Airport in Tusayan.

  While rainwater harvesting intercepts a portion of the water that would percolate to groundwater, over the extent of the study area the amounts are insignificant compared to total groundwater recharge, and would remain so even if rainwater harvesting were widely practiced. Rainwater harvesting potential is sometimes constrained by water rights and concern for local surface water flows. Forest Highlands, for instance, has not implemented rainwater collection at a strategic catch basin because the flows such a system would intercept run to Oak Creek, an ADWR-designated "Unique Water of Exceptional Significance." However, most systems are usually considered too small to raise water rights issues.

- *Onsite and cluster wastewater treatment and reuse.* Sand filters and other advanced treatment units can be added to conventional septic systems to produce effluent that is suitable for subsurface drip irrigation of landscapes. Such systems are fairly common in Texas and some other states and allowable under the new ADEQ regulations. They can be implemented at the scale of individual homes or clusters of homes or other buildings. Proper management must be provided for, but this is not a difficult requirement. This type of reuse would be especially appropriate for isolated homes and for subdivisions in areas where centralized sewerage is inappropriate or more expensive than onsite/cluster treatment. Indeed, some of the county's local area plans for unincorporated and unsewered communities, e.g., Doney Park, call for wastewater reuse. Onsite and cluster systems can accomplish this without the high costs of sewering low-density areas or widely dispersed subdivisions.

- *Wastewater "scalping."* Also known as "sewer mining" and "satellite treatment," this practice involves tapping into sewer lines close to points of significant reuse potential, such as commercial, institutional or industrial water users or large landscapes. A portion of the wastewater flow is withdrawn. A variety of small-scale wastewater treatment systems can be used to clean the wastewater to levels required for the intended reuse. Most such schemes return some or all solids to the tapped sewer line. These systems avoid the costs of installing reclaimed water lines and pumping treated effluent from distant, down-gradient wastewater treatment plants.

Onsite/cluster treatment and wastewater scalping—both known as “decentralized” systems—are receiving rapidly increasing attention in the wastewater and water resources fields. New technologies and management practices are making such systems significantly more effective and economical. Congress has funded a national program of research, demonstration and training on decentralized wastewater systems; EPA has issued guidelines on decentralized wastewater management; and a number of studies evaluating the technologies and their costs and benefits are underway or have been completed.[4] Advanced decentralized systems are often appropriate for rural areas where extra treatment is needed to protect the environment or public health, and for many places where wastewater reuse is an important water supply strategy. Some large urban wastewater districts are also implementing decentralized wastewater treatment systems on the edges of expanding cities in lieu of sewer line extensions, and building scalping systems within urban areas. Water resource stakeholders on the Coconino Plateau should give innovative decentralized wastewater treatment/reuse systems serious consideration, in addition to expansion of centralized treatment/reuse systems as described next.

- *Centralized wastewater reclamation and redistribution for reuse.* Table V-1 above implies there are opportunities to increase use of treated effluent from existing or planned centralized wastewater plants within the study area. Only three communities reuse 100% of their year-round wastewater production. Use of 100% of year-round wastewater production is not feasible or appropriate for all communities; nonetheless, several communities could increase their use of wastewater as a water supply. Table V-2 below indicates some of the opportunities to do so and thereby displace use of conventional surface and ground water supplies.

- *Potable reuse.* Wastewater can be treated to levels of sufficient quality that it can be re-introduced to potable water systems. This is sometimes accomplished through percolation basins or injection wells that recharge groundwater, mixing the high-quality treated effluent with a raw groundwater. This is not feasible or cost-effective in most of the study area due to the great depth to groundwater. “Indirect potable reuse” is also practiced, by introducing the highly treated effluent to the upper end of stream and reservoir systems, where it mixes with the raw surface water supply. This approach probably also has limited application in the study area, though it may have some long-run potential. “Direct potable reuse” is also possible; in which highly treated wastewater is introduced directly to the water treatment and distribution system. In most places it has been proposed, the social barriers to direct potable reuse have been insurmountable. Given the many difficulties of engineering potable reuse systems and obtaining their acceptance by the public, this option is not given further

[4] Including a major U.S. EPA-funded study of decentralized wastewater system economics by one of the organizations authoring this study (Rocky Mountain Institute).

consideration in this study. However, it is not dismissed entirely—in coming years it may have a role to play in the region's water supply mix.

The many potential alternative supply options, and the many already known opportunities such as those summarized in Table V-2, mean that alternative supplies should be able to satisfy an important portion of the study area's future water demand. Investigating these options and opportunities in more detail in the Phase II study, in order to quantify those contributions, is an important step toward developing an accurate understanding of the future supply/demand balance on the Coconino Plateau.

As a final note to this section, there are many ways to encourage development and use of alternative supplies. Besides the obvious steps of water utilities and sanitation districts investing in appropriate infrastructure for centralized systems, and requirements for double-plumbing of sites and buildings in areas suitable for reclaimed water supply lines, both centralized and decentralized alternative supplies can be encouraged through some of the implementation techniques described in the water efficiency and conservation section of this report. Of particular relevance are large user audits, large landscape audits, demonstration homes, transferable savings programs and performance contracting programs.

TABLE VI-2 OPPORTUNITIES FOR INCREASED WASTEWATER RECLAMATION AND REUSE, BY COMMUNITY	
Community	*Opportunities*
Bellemont Truck Stop	Reclaimed water will be required for all commercial & public landscape irrigation, entirely displacing those demands on ground water.
Flagstaff	The reclaimed water system has capacity for an additional 3 MGD of use. Flagstaff is aggressively promoting increased use of reclaimed water to help address the unreliability of surface supplies for meeting peak summer demand.
Flagstaff Ranch	All wastewater effluent from the development will be reused, reducing demand on ground water by 10-15%.
Grand Canyon Village	Only 30-35% of the community's wastewater is currently reused. Existing reclaimed water lines through much of the community will allow increased reuse if & when funding for the necessary onsite plumbing at National Park buildings & facilities is available.
Kachina Village, Forest Highlands	Forest Highlands can purchase 8-10 million gallons of reclaimed water per year from Kachina Village, as available, representing 13-20% of Kachina Village's wastewater effluent. This amount could be expanded further if diversion of additional effluent does not adversely affect the constructed wetland habitat at Kachina Village. Potentially, the available effluent could be increased if nearby Mountainaire were sewered and tied into the Kachina Village system.
Page	Because 100% of the community's wastewater effluent is reused on the golf course, significant system expansion is unlikely. However, growth in Page will generate additional effluent that can be used on the golf course, proportionally displacing (minus any new landscape water consumption) current raw water withdrawals from Lake Powell for irrigation of the golf course.
Tusayan	As the community grows, the extensive wastewater reclamation system will be able to serve an important fraction (currently 40% community-wide) of the total new demand. Some additional displacement of current groundwater use (e.g., for residential landscape irrigation) could also occur.
Valle	Reclaimed water lines are in place to service commercial development by the airport. Current & future development will make effluent available for reclamation.
Williams	The city plans to eventually build a storage reservoir for treated effluent produced in the winter. By reusing 100% of its wastewater, Williams will be able to displace remaining raw surface water withdrawals for golf course irrigation (33 MG in 2001) & displace some additional current & future water demand from the city's unreliable surface water supplies.

VII. CURRENT WATER DEMAND

Table VII-1 summarizes available data and estimates for year 2000 total water demand, in millions of gallons (MG). Table VII-2 repeats this data in acre-feet. Note that these tables and their total demand figures include nonpotable water use (raw water use and reclaimed water use). To the authors' knowledge, nonpotable water use is not included as a component of water demand in any other currently available reports for the study area.

Total water demand for the study area in 2000 was about 5,842 million gallons, or 17,930 acre-feet. This figure is a reasonable approximation of water demand in 2000, though actual water demand may vary from it somewhat due to the following considerations:

- For potable water use, total production data was not available for all systems. Total production includes unmetered water use and unaccounted-for water use such as distribution system leaks, and is therefore a better indication of total demand than consumption (billing) data.

- A few small water systems could not provide detailed data. For these systems, water-use figures are based on rough estimates provided by the system managers.

- The operators of the two water systems in Valle would not provide water use data to the study team. Water use could not be reliably estimated in this Phase I study.

- Water use from individual wells in areas such as Fort Valley, Parks, Red Lake and residences scattered around the balance of the study area is not included. However, the number of these wells is very small. These areas are mostly supplied by water hauling from standpipes in the study area. This water use *is* included in the Table VII-1 figures, and is further detailed below.

The systems and populations for which these factors are considerations are small in size and number. Therefore, the impact on the total demand figure of any inaccuracies or omissions is quite small.

The City of Flagstaff represents by far the largest portion of water demand in the study area. Water use in Flagstaff in 2000 totaled 3,438 MG (10,552 acre-feet), or about 60 percent of the total water use in the study area. The next largest water demand occurs in the Page system, with total 2000 water use at 1,195 MG (3,668 acre-feet), or about 21 percent of regional water use. Other water systems, representing small portions of total water use in the study area, are nonetheless extremely important. Uncertainties over future supplies and/or concerns over the environmental impacts of ground water pumping are greatest in communities like Tusayan, Grand Canyon Village, Valle and Williams. Thus meeting future demand in these smaller systems is a key driver for regional water supply proposals.

TABLE VII-1
SUMMARY OF 2000 TOTAL ANNUAL WATER USE IN MILLIONS OF GALLONS

Location	Potable Water		Nonpotable Water		Total Demand*
	Total Production	Consumption (Total Billings)	Raw Water	Reclaimed Water	
Bellemont					
Bellemont Water Co.	*18.5*	*18.5*	*0.0*	*0.0*	*18.5*
Bellemont Truck Stop	*3.6*	-	*0.0*	*0.0*	*3.6*
Navajo Army Depot	*42.9*	*10.0*	*0.0*	*0.0*	*42.9*
Bellemont Total	65.0	-	0.0	0.0	65.0
Doney Park Water	256.0	241.1	0.0	0.0	256.0
Flagstaff (City)	2,934.0	2,902.2	0.0	504.4	3,438.4
Flagstaff (Small Systems)					
Heckethorn Water Co.	*4.3*	*4.3*	*0.0*	*0.0*	*4.3*
Mountain Dell Water	*6.7*	*6.3*	*0.0*	*0.0*	*6.7*
West Village Water Co.	-	*3.7*	*0.0*	*0.0*	*≥3.7*
Flagstaff Small Systems Total	≥14.8	14.3	0.0	0.0	≥14.8
Flagstaff Ranch	-	7.5	0.0	0.0	≥7.5
Forest Highlands	-	110.3	90.4	48.5	≥249.2
GCNP South Rim	151.1	-	0.0	43.8	194.9
Kachina Village	79.0	-	0.0	0.0	79.0
Mountainaire	26.9	23.2	0.0	0.0	26.9
Page	786.1	-	148.7	260.4	1,195.2
Tusayan**	-	34.3	0.0	22.4	≥56.7
Valle (No data provided)	-	-	-	-	-
Williams	202.2	140.5	8.1	48.5	258.8
TOTALS***	≥4,667.2		247.2	928.0	≥5,842.4

*Total demand equals total potable water production plus all nonpotable water use. For systems where total potable water production data is not available, total demand is equal to or greater than (assuming some system leakage occurs) total consumption (billings) plus all nonpotable water use.

**Tusayan figures are for October 2000 through September 2001, which reflects the earliest availability of data from the Tusayan Water Development Association for both its water wholesalers. Also, most reclaimed water users in Tusayan were on-line by October of 2000 or shortly thereafter. Potable water consumption includes 3.3 MG from rainwater harvesting at the Grand Canyon Airport.

***A very small amount of double-counting occurs in the table. The Anasazi Water Company, part of the water system in Tusayan, re-sells some water it obtains from standpipes in other communities. The bottom line potable water and total demand figures slightly underestimate actual use due to: a) lack of unmetered and unaccounted-for water-use data for some communities (those not showing total production figures above); b) non-reporting by Valle water systems.

Sources: Water production and use data provided by water system managers. For some locations, average annual water production or consumption is estimated by water system managers.

TABLE VII-2
SUMMARY OF 2000 TOTAL ANNUAL WATER USE IN ACRE-FEET

Location	*Potable Water*		*Nonpotable Water*		*Total Demand**
	Total Production	*Consumption (Total Billings)*	*Raw Water*	*Reclaimed Water*	
Bellemont					
Bellemont Water Co.	*56.8*	*56.8*	*0.0*	*0.0*	*56.8*
Bellemont Truck Stop	*11.0*	-	*0.0*	*0.0*	*11.0*
Navajo Army Depot	*131.7*	*30.7*	*0.0*	*0.0*	*131.7*
Bellemont Total	199.5	-	0.0	0.0	199.5
Doney Park Water	785.6	739.9	0.0	0.0	785.6
Flagstaff (City)	9,004.1	8,906.6	0.0	1,548.0	10,552.1
Flagstaff (Small Systems)					
Heckethorn Water Co.	*13.2*	*13.2*	*0.0*	*0.0*	*13.2*
Mountain Dell Water	*20.6*	*19.3*	*0.0*	*0.0*	*20.6*
West Village Water Co.	-	*11.4*	*0.0*	*0.0*	*≥11.4*
Flagstaff Small Systems Total	≥45.4	43.9	0.0	0.0	≥45.4
Flagstaff Ranch	-	23.0	0.0	0.0	≥23.0
Forest Highlands	-	338.5	277.4	148.8	≥764.8
GCNP South Rim	463.7	-	0.0	134.4	598.1
Kachina Village	242.4	-	0.0	0.0	242.4
Mountainaire	82.6	71.2	0.0	0.0	82.6
Page	2,412.5	-	456.3	799.1	3,667.9
Tusayan**	-	105.3	0.0	68.7	≥174.0
Valle (No data provided)	-	-	-	-	-
Williams	620.5	431.2	24.9	148.8	794.2
TOTALS***	≥14,323.2		758.6	2,847.9	≥17,929.7

*Total demand equals total potable water production plus all nonpotable water use. For systems where total potable water production data is not available, total demand is equal to or greater than (assuming some system leakage occurs) total consumption (billings) plus all nonpotable water use.

**Tusayan figures are for October 2000 through September 2001, which reflects the earliest availability of data from the Tusayan Water Development Association for both its water wholesalers. Also, most reclaimed water users in Tusayan were on-line by October of 2000 or shortly thereafter. Potable water consumption includes 3.3 MG from rainwater harvesting at the Grand Canyon Airport.

***A very small amount of double-counting occurs in the table. The Anasazi Water Company, part of the water system in Tusayan, re-sells some water it obtains from standpipes in other communities. The bottom line potable water and total demand figures slightly underestimate actual use due to: a) lack of unmetered and unaccounted-for water-use data for some communities (those not showing total production figures above); b) non-reporting by Valle water systems.

Sources: Water production and use data provided by water system managers. For some locations, average annual water production or consumption is estimated by water system managers.

Population and tourism growth, typically key drivers of water demand increases, have reportedly been flat to slow since the mid-1990s. For these and other reasons (e.g., water conservation) water demand has mostly been flat in recent years. Consider the data in Table VII-3. For Flagstaff, total water demand changed little from 1994 to 1999. The year 2000 represents a 15 percent increase over the average use in that period and could be due to the hot weather of 2000. Flagstaff water use in 2000 reflected only a 7 percent increase over a previous high year, 1996. Not shown in the table, which presents total demand for Flagstaff, is the fact that the potable water use component in 2000, at 2,934 million gallons, was less than 11–12 years earlier, when potable use peaked at 3,241 MG in 1988 and 2,946 MG in 1989, prior to implementation of water efficiency/conservation programs and wastewater reuse. For Williams, water billings have been flat since 1994—from 1995 through 2000 they varied only 5 percent from the lowest to highest year. The year 2000 was 2 percent less than the average for that period. Demand has been mostly flat in other systems in recent years, albeit with some fluctuations. This of course does not mean that demand will remain flat in the future. Future demand, normalized for yearly weather variations, will depend on population and economic growth and water efficiency and conservation efforts.

TABLE VII-3
WATER DEMAND OVER RECENT YEARS IN SELECTED COMMUNITIES, IN MILLIONS OF GALLONS

	Flagstaff (Total demand)	*Grand Canyon Village (Potable water production)*	*Page (Potable water production)*	*Tusayan (Total demand)*	*Williams (Potable water production)*
1992	-	-	-	-	159.1
1993	-	-	-	-	162.0
1994	2,913	-	-	-	195.1
1995	2,955	-	-	54.3	202.5
1996	3,203	-	-	-	179.9
1997	2,945	172.0	-	-	195.9
1998	2,901	166.8	760.0	-	189.1
1999	2,962	197.2	769.5	-	190.4
2000	3,438	151.1	786.1	56.7	202.2
2001	-	174.7	748.6	-	190.3

Water demand in most study area communities varies seasonally. This occurs due to irrigation use from roughly April through October, and increased tourist visitation in summer months. For most communities, demand in the peak summer month is about 1.5 to 2.5 times greater than in the low winter month. For Tusayan and Page the increases are roughly 3 and 4 times, respectively.

Data on the City of Flagstaff water consumption provides a detailed example. Figure VII-1 illustrates the 2000 total monthly water consumption in millions of gallons per month for the City of Flagstaff. January, February, March and December average about 170 MG per month. There is a steep increase in water demand from April to June, the peak water-use month, followed by a gradual decline in monthly use throughout the summer and fall. This pattern is typical of the seasonality of water use throughout the study area in which the summer irrigation demand is offset by the *monsoon* season of late summer.

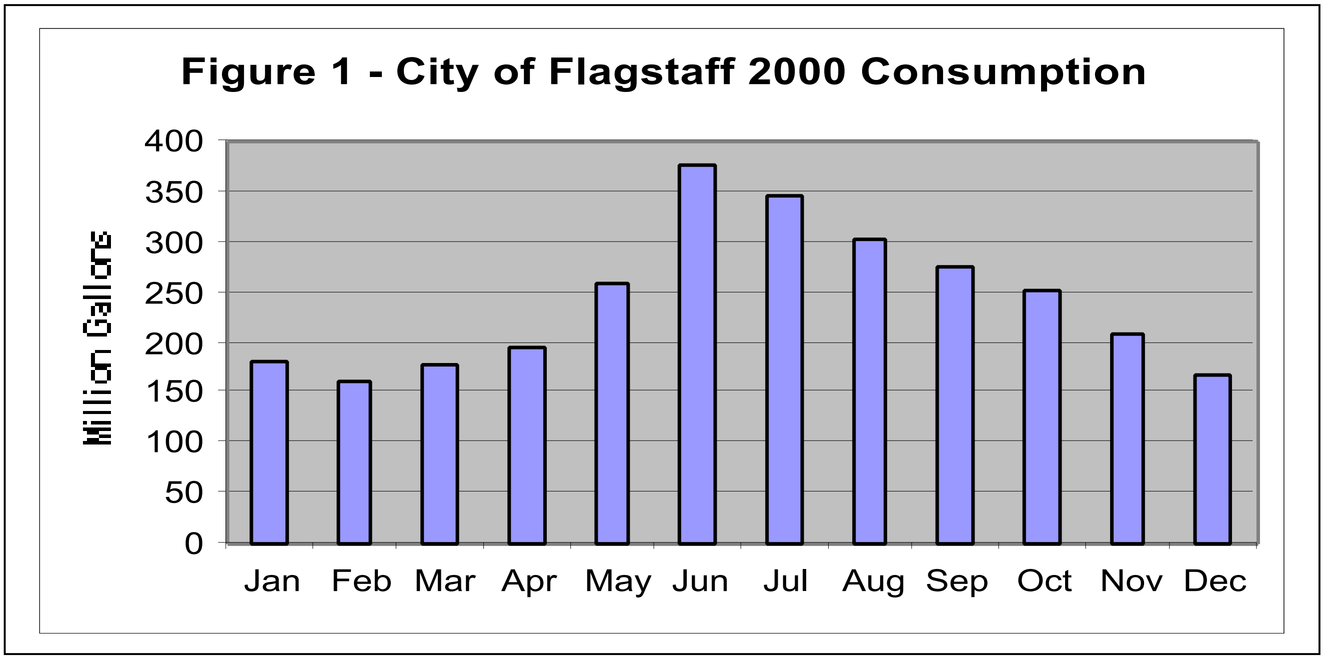

FIGURE VII-1
CITY OF FLAGSTAFF 2000 CONSUMPTION

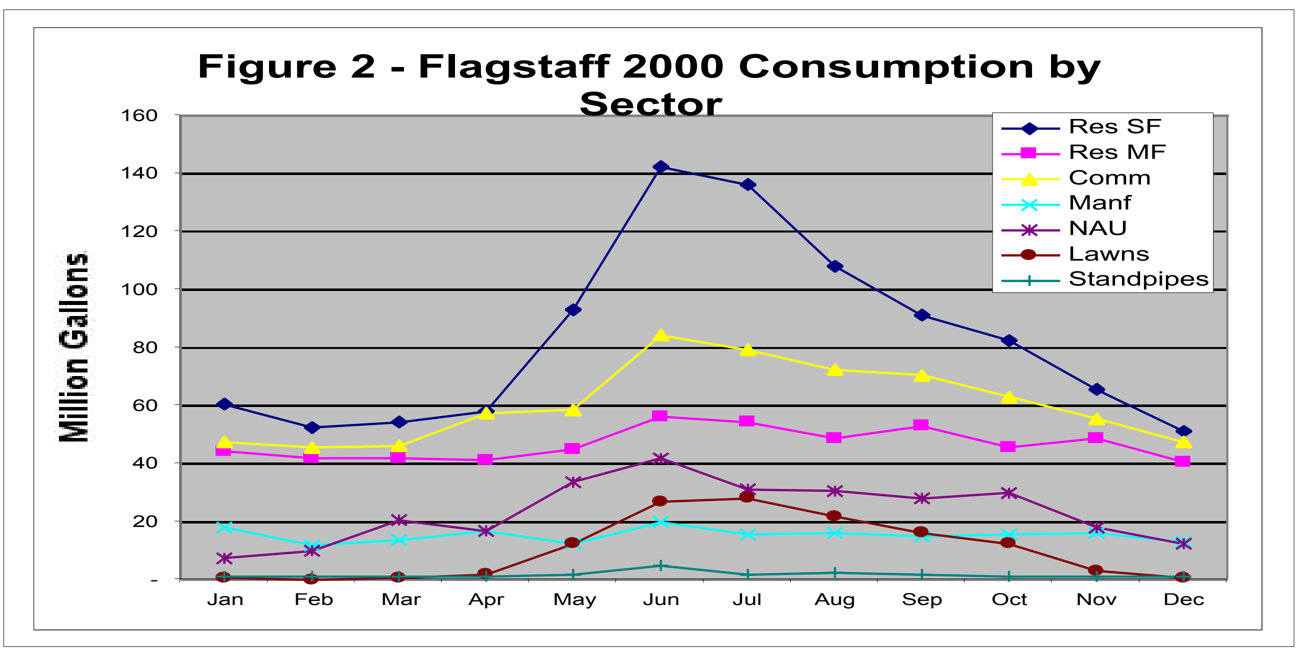

FIGURE VII-2
FLAGSTAFF 2000 CONSUMPTION BY SECTOR

Figure VII-2 illustrates the same data as Figure VII-1, with the water consumption shown by customer sector. The City of Flagstaff separates water customers into ten customer classes as listed in Table VII-4. In 2000, the residential single-family sector used about 34 percent of total water consumed in the city, and the commercial sector used about 25 percent. The monthly demand by sector shown in Figure VII-2 demonstrates that the summer surge in water demand is not equal in all customer sectors. The single-family sector is responsible for the largest component of the increase in water use from April to June with water demand increasing from 60 MG in April up to 140 MG in June. The commercial, lawn meter, and NAU accounts also show large increases in water demand from April to June. The multifamily sector shows a modest increase in water use in the summer months while the manufacturing sector water demand is fairly constant throughout the year. Note that this disaggregation (i.e., separation) of total water demand into sector components helps identify which sectors contribute to peak demand and which sectors may benefit from landscape water conservation programs.

Among utilities other than the City of Flagstaff, water customers are typically separated between residential and commercial accounts, as shown in Table VII-4. Williams and Doney Park Water also maintain separate accounts for bulk water sales. Forest Highlands maintains separate accounts for irrigation of golf courses. Water systems not listed in Table VII-4 have only one customer class.

TABLE VII-4
CUSTOMER CLASSES BY UTILITY

Utility	*Customer Classes*	*Percent of 2000 Potable Water Billings*
Flagstaff	Residential Single-family	34
	Residential Multifamily	17
	Residential Multi-complex	3
	Commercial	25
	Manufacturing	6
	NAU	10
	Lawn Meters	4
	Lawn Meters, Commercial & Schools	<1
	Lawn Meters, Manufacturing	<1
	Standpipe	1
Williams	Residential	36
	Commercial	53
	Water Haulers	3
	Quarter Sales	8
Doney Park Water Co.	Residential	91
	Commercial	8
	Standpipe	1
Forest Highlands	Residential	33
	Commercial	11
	Irrigation	56
Kachina Village	Residential Single-family	98
	Residential Multifamily	1
	Commercial	1
Grand Canyon Village	Park Service	20
	Concessionaire	80

A number of communities maintain standpipes that serve customers who are not physically connected to local water distribution systems. Table VII-5 summarizes available data on standpipe sales in 2000. It reflects water produced and sold to water haulers, both commercial and individual. This water is included within the total production and/or consumption figures by community shown earlier in Tables VII-1 and VII-2. It is possible that some of this water is used outside of the study area. The Williams standpipe may be used by households west of the study area, and the Doney Park and perhaps the Flagstaff standpipes may be used by households to the east. However, based on discussions with managers of those water systems, it appears that such use is very small, if any.

TABLE VII-5
SUMMARY OF STANDPIPE WATER USE IN 2000

Location	*Annual MG*	*Ave. MGD*
Bellemont	14.90	0.041
Doney Park	23.08	0.063
Flagstaff	22.33	0.061
Tusayan	Not provided	-
Valle (2 systems)	Not provided	-
Williams	14.81	0.041
Total	>75.12	>0.206

Table VII-5 does not include a very small amount of standpipe sales made by Flagstaff Ranch Water Company to a handful of small residential haulers and construction contractors at Flagstaff Ranch and other nearby developments. More significantly, the lack of data for standpipes in Tusayan and Valle means that the total figure in Table VII-5 understates standpipe water use in 2000. However, Table VII-5 may overstate typical standpipe use in the region, because standpipe use in Doney Park in 2000 was higher than normal due to highway construction. In 2001, standpipe use in Doney Park totaled 4.203 million gallons, nearly 19 million gallons less than reflected in Table VII-5 for 2000.

VIII. ASSESSMENT OF EXISTING WATER DEMAND FORECASTS

Two main sources for recent water demand forecasts are available: the *Flagstaff Area Regional Land Use and Transportation Plan* (2001), and the ADWR *Phase 1 – North Central Arizona Regional Water Study* (1999). In addition, somewhat older forecasts for Page and Tusayan are available.

"Flagstaff Area Regional Land Use and Transportation Plan"

The July 2001 draft of the regional plan contains estimates of future water demand for four communities in the Flagstaff regional planning area. This area extends north to the San Francisco Peaks and Sunset Crater, east to Winona, south to Kachina Village and Mountainaire and west to Bellemont.

Flagstaff. The estimates of future water demand for the City of Flagstaff multiply the ADES population projections by Flagstaff's 1997-1999 system-wide average per capita water-use rate of 122 gallons per capita (GPC). This plan estimates 11,000 acre-feet, or 10.6 million gallons per day (MGD), will be needed in 2020 for the City of Flagstaff. The same plan also contains projections of water demand in the year 2099 of 27,000 acre-feet per year ("based on 1946 to present extrapolation") and of 75,000 acre-feet per year ("based on 1983-89 extrapolation"). The data used to develop these projections are not identified and the methodologies are not documented.

The draft regional plan also includes water-use projections for three of the community water systems located near Flagstaff. The plan does not describe the methods or assumptions upon which any of these projections are based. For all of them, basic information on growth potential (e.g., available lots) suggests that the regional plan water demand forecasts may be high. The system profiles in this report provide fairly detailed information on growth prospects in these three communities.

Doney Park. The plan states that average daily water demand is expected to increase 40 percent by 2020. The basis of this projection is not provided. It appears somewhat high, given that the Doney Park/Timberline area, at least within the service area of the DPW, is approaching buildout.

Kachina Village. The plan states that average daily water demand is expected to increase 50 percent by 2020. The basis of this projection is not provided. It appears high, given that Kachina Village is very close to buildout.

Mountainaire. The plan states that average daily water demand is expected to increase 62 percent by 2020. The basis of this water demand projection is not provided. It appears high, given that Mountainaire is approaching buildout, and given that ADES projects a population increase of only 30 percent in the same period.

“Page General Plan Update”

The *Page General Plan Update* (BRW, Inc. and Sunregion Associates, Inc. 1995) contains a forecast of annual potable water consumption for 2000-2095. Future water consumption is forecast for three scenarios in which future population estimates are multiplied by three alternate gallons per capita per day (GPCD) rates of water use (280, 255 and 225). The first GPCD rate of use is identified as the “historic GPCD consumption.” According to the 1995 plan projections, water use could increase to 5,385 acre-feet per year by 2045 (exceeding the current use of 2,100 acre-feet per year by 2.5 times) if historic consumption rates continue and the population reaches the predicted level of 17,169. No explanation or description is provided for the assumptions that underlie the lower rates of use.

Tusayan Growth EIS

The *Final Environmental Impact Statement for Tusayan Growth* (U.S. Forest Service 1999) estimated that total water demand (potable and nonpotable) for four Canyon Forest Village alternatives (B, C, G and H) would at buildout range from 91 million gallons per year (MGY) to 153 MGY. The range reflected different project sizes and different water efficiency and conservation assumptions. The projections were reportedly developed with spreadsheets that multiplied facilities at buildout by the assumed water-use rates. The figures do not count growth within the existing 144 acres of private land in the Tusayan core. These four alternatives would have acquired virtually all significant private lands in the Tusayan vicinity outside the Tusayan core, removing them from the potentially developable land base. The other action alternatives were estimated to generate from 29 MGY total demand (E and F) to 36 MGY potable demand plus unspecified nonpotable demand (D, which used existing private land in the Tusayan core to satisfy some of the development objectives). However, these alternatives did not involve Federal acquisition of developable private land and did not estimate the water demand that could be generated by development on those lands.

ADWR “Phase 1 – North Central Arizona Regional Water Study”

The ADWR reported estimates of future water demand for communities in the central Coconino Plateau region in its *Phase 1 – North Central Arizona Regional Water Study* report (1999). These water-use projections are estimated for subcounty areas potentially supplied by the proposed pipeline. The report provides a very brief discussion of water demand for each community, but the methodology used to estimate the water demand for each area is not well documented. Future water demand is estimated from each area’s “particular future demand situation.” Some of the reported estimates were developed by local jurisdictions while others were developed by ADWR. The ADWR projections are shown in Table VIII-1, below.

TABLE VIII-1 ADWR NORTH CENTRAL ARIZONA REGIONAL WATER STUDY WATER DEMAND PROJECTIONS (2000-2050)							
Area	*Units*	*2000*	*2010*	*2020*	*2030*	*2040*	*2050*
Flagstaff	Acre-feet/yr	8,000	10,000	12,000	14,000	16,000	18,000
	Avg MGD	7.14	8.93	10.71	12.50	14.28	16.07
W. Navajo Nation	Acre-feet/yr	500	800	1,300	1,900	2,900	3,700
	Avg MGD	0.45	0.71	1.16	1.70	2.59	3.30
Williams	Acre-feet/yr	600	1,000	1,500	2,000	2,000	2,000
	Avg MGD	0.54	0.89	1.34	1.79	1.79	1.79
Tusayan	Acre-feet/yr	178	350	350	350	350	350
	Avg MGD	0.16	0.31	0.31	0.31	0.31	0.31
Grand Canyon Park	Acre-feet/yr	414	500	580	660	740	800
	Avg MGD	0.37	0.45	0.52	0.59	0.66	0.71
County North of Williams	Acre-feet/yr	400	500	700	800	900	1,000
	Avg MGD	0.36	0.45	0.62	0.71	0.80	0.89
Kaibab Lake	Acre-feet/yr	500	500	500	500	500	500
	Avg MGD	0.45	0.45	0.45	0.45	0.45	0.45
Total	Acre-feet/yr	10,592	13,650	16,930	20,210	23,390	26,350
	Avg MGD	9.46	12.19	15.11	18.04	20.88	23.52

Source: *Phase I – North Central Arizona Regional Water Study* (ADWR 1999), Appendix A, Table 2.

The authors of the current water demand study have many reservations about the ADWR estimates, including those below:

- The report does not mention whether the estimates are meant to represent total demand or only potable demand. If the estimates are meant to reflect potable use only, the year 2000 figure underestimates actual demand by 1,000 acre-feet, or 10 percent, for the four communities that are comparable to the geographies used in this study *(North Central Arizona Water Demand Study – Phase I Report)*. If the estimates are meant to reflect total demand, the year 2000 figure underestimates actual demand by 2,926 acre-feet, or 24%. (The four communities are Flagstaff, Williams, Tusayan, and Grand Canyon National Park. Compare the figures in Table VIII-1 with Table VII-2. Most of the total ADWR underestimate reflects underestimation of demand in Flagstaff.)

- The ADWR estimate of future water demand for the City of Flagstaff is "based on population growth and anticipated increase in industrial demand." As shown in Table

VIII-1, estimated future demand for Flagstaff increases at a rate of 2,000 acre-feet per year every ten years. Thus, the forecast increases from 8,000 acre-feet in 2000 up to 12,000 acre-feet (10.7 MGD) in 2020 (1,000 acre-feet more than the city's own current forecast, see above) and 18,000 acre-feet (16.1 MGD) in 2050. Without documentation of the methodology, one can only deduce that this forecast is a rough estimate. The underlying per capita water-use rate is increasing over time. However, the basis for this increase is not identified. Given that industrial water use comprises only 6 percent of Flagstaff water use in 2000 and given the constraints to industrial growth identified in the Flagstaff regional plan, it is unlikely that future industrial water demand would be a driving force that results in increased gross per capita water use in Flagstaff's future. The estimation of total system demand for a water system the size of Flagstaff with a single water-use value cannot reflect the differences in growth patterns among the various sectors of the city's economy (i.e., residential, commercial, university and industrial). Also, the report mentions that alternative supplies (wastewater reclamation) are used in Flagstaff, but does not specify if this wastewater reuse in Flagstaff is included in the demand projections.

- The ADWR estimate of future water demand for the City of Williams is "based on population growth." However, water demand is constant after 2030 while population continues to increase. Thus, the forecast is not consistent with the brief explanation of methodology. If the per capita rate of use is assumed to change over time, the assumptions underlying this change should be identified.

- Tusayan future water demand is projected to increase until 2010 after which demand is constant "since… no new lodging units are expected to be built after 2010," even though population continues to increase. Thus, there is an underlying assumption that after 2010 the per capita rate will decrease. The factors influencing this changing rate of use should be identified.

- Future water demand for Grand Canyon National Park is expected to almost double by the year 2050 based on unspecified projected growth of visitors. One can only assume ADWR used official park visitation projections as the basis. New visitation projections are due out in early 2002 and are expected to be considerably lower than the previous visitation projections.

- Water demand for the unincorporated area north of Williams is estimated to increase with population and shows a constant rate of 0.25 acre-feet per year per person. The source of this assumption is not identified.

- Five hundred acre-feet per year is included for Kaibab Lake, north of Williams, "to maintain the lake at all times." The study implies that this is a goal of the U.S. Forest Service , the lake's manager. This goal and the source and accuracy of the required water amount could not be established by Kaibab National Forest staff contacted for the current study.

While the ADWR report offers a preliminary estimate of future water demand for portions of the study area, a more thorough analysis is highly recommended. Assumptions and linkages between water use, population growth, and other growth factors should be carefully researched and clearly specified. Contributions that demand management and alternative supplies could make to the overall water resources situation should be evaluated.

The ADWR report also presents a table of “demand from a new supply source” that attempts to estimate the new supply increment needed over current supplies. This table does not account for recently developed supply sources and makes problematic assumptions about needs for new sources. For instance, since publication of the report, Tusayan has brought on-line its significant wastewater reclamation and reuse system. Substantial changes to the water supply system for Williams that were being initiated when the report was prepared (groundwater wells and wastewater reuse) appear not to have been factored in to the estimation of new supply needs for Williams, and the city is assumed to completely abandon its surface water supplies. Tusayan and GCNP are similarly assumed to completely abandon their existing supplies and reuse systems in favor of a new supply source.

As a final note, the ADWR report does not provide future water demand estimates for communities east and south of Flagstaff, or for the City of Page. The subsequent appraisal study by the U.S. Bureau of Reclamation (2000) adds a demand figure for Page. It does not address other communities in the Flagstaff area. The USBR study increases the demand figure for Grand Canyon National Park in the final forecast year (2050). It assumes Williams, Tusayan, GCNP, and Page will completely abandon their current supply systems.

IX. DATA AVAILABLE FOR DEMAND FORECASTING

An objective of this study was to assess the readily available data that could be used to develop water demand forecasts for the study area. The study team sought historical water-use data from utilities in the area, in part to determine what types of water-use models and water-use parameters could be developed. In addition, the team sought historic and projected demographic data, such as population, housing and employment. Historic water use and demographic data can be used to characterize past water-use patterns, which may be used in conjunction with projected demographic data to estimate future water demand.

As shown in Tables III-1 and III-2 in the Chapter III—Study Area that describes the study area, historical and estimated future population data are available for the county and subcounty areas from the ADES. The ADES population projections go out 50 years. They are based on a reasonable methodology that avoids "errors of composition," in which population projections for small local areas are summed—an approach that typically results in over-estimates for the larger geography. Instead, the ADES population projections start with inherently more accurate state and county-level projections, and allocate future population to subareas with the assistance of knowledgeable local sources such as the Coconino County Community Development Department.

Historical housing data are available for the county and subcounty areas from decennial census documents, but no estimates of future housing are available from official state or county sources. County-level historical employment data are also available, but are projected forward only two years. The employment data are not available at subcounty levels.

The *Final Environmental Impact Statement for Tusayan Growth* prepared by the U.S. Forest Service (1999) contains historical data on number of hotel rooms and hotel occupancy rates for selected subcounty areas. This information could be correlated with historical commercial water use for those select locations. However, without projections of future hotel room increases and occupancy rates, the historical water use per room could not be used in estimating future water demand for that sector.

Without projections of housing, employment or other economic variables such as hotel room growth, economic changes could not be used as predictive parameters in a water-use model. For this study area, the only available "driver" for a water-demand forecasting model is population. However, it will be possible to adjust model inputs to account for expected changes or defined scenarios for future local economic conditions. For instance, if ratios between population and sectoral economic activity are expected to change (e.g., population grows more slowly than tourism, as reflected by hotel room growth and occupancy; or vise-versa), this could be reflected by making adjustments using the methodology described later.

The authors propose using the ADES population projections as the future population input for water-demand modeling. This data set employs the most credible methodology and provides internal consistency for both county-level population projections and subcounty projections that closely match water system geographies. The Morrison Institute also provides a credible set of alternative population forecasts in its recent growth study (Heffernon and Muro

2001). These forecasts use the ADES projections as a baseline for alternative scenarios for the Coconino Plateau: low growth, tourism high growth and manufacturing high growth, each estimated with and without increased water availability (from the proposed pipeline). However, these population forecasts are only subdivided into three subareas for the study area—eastern region, western region and Flagstaff area. These geographies do not match the water system geographies upon which the water demand forecasting methodology will be built.

Table IX-1 summarizes the most detailed historical water-use data obtained during interviews with local water utilities. Some other water utilities provided less detailed information; e.g., annual production for one or more years. Average water use (billed consumption) or water production per month per account can be determined for six utilities. This provides us with sufficient detail to develop the forecasting methodology outlined later in the next section. It may be possible to obtain data for additional years from some of the utilities in Table IX-1, and more detailed data from some other utilities. This would allow additional locational specificity in the proposed methodology.

TABLE IX-1 **AVAILABLE WATER PRODUCTION/CONSUMPTION DATA**
Doney Park Monthly consumption and number of accounts, 2000
Flagstaff Weekly production, 1996-2000 Monthly billed consumption and number of accounts by class, 1995-2000
Forest Highlands Annual production, 1989-2000 Monthly consumption and number of accounts by class, Jan 1996-Sept 2001
Kachina Village Monthly production and number of accounts, May 1999-May 2001
Mountainaire Monthly production, consumption and number of accounts, July 1997-Aug 2001
Page Monthly production, 1998-2001
Williams Monthly production, 1992-2001 Monthly billed consumption and number of accounts by class, 2000 Monthly billed consumption by class 1995-1999; monthly number of accounts by class for same period to be provided

The study team also obtained data on reclaimed and raw water use from several utilities. The SGCSD provided monthly reclaimed water use for Tusayan by individual account from October 2000 to September 2001. The City of Flagstaff provided annual reclaimed water use by individual account from 1994 to 2000. Williams provided annual reclaimed water use and raw water use for its single reclaimed/raw water customer, the municipal golf course, for 2001. Some additional data from other communities that use reclaimed or raw water is available or could probably be obtained. The current uses of, and available data on, reclaimed and raw water use is not sufficient to allow modeling of these uses. An alternative forecasting approach is described below.

Water use, particularly outdoor water use, is influenced by weather. Temperature and precipitation, for instance, determine the water needs of landscape, and therefore affect irrigation demand. Weather data are available for the following six stations within the study area:

- Flagstaff Airport
- Sunset Crater National Park
- Fort Valley
- Williams
- Grand Canyon National Park, south rim
- Page

The weather data for each station include long-term historical averages for each month. A preliminary review of monthly temperatures and precipitation for the year 2000 in comparison to the long-term averages shows that the year 2000 was hotter and drier than average at each of these six stations within the study area. Monthly average maximum daily temperature and monthly total precipitation often correlate with monthly water use. The proposed demand forecasting methodology will test for and utilize relationships between weather and water demand.

Water use is also strongly affected by the prices customers pay for using water. The study team has obtained current and historic water and sewer rate schedules for most of the water systems in the study area. This will allow testing for price/use relationships and application of the resulting "price elasticities" to demand forecasting.

X. RECOMMENDED DEMAND FORECASTING APPROACH

Phase II of this study is designed to provide water resource managers and decision-makers with information about future water demand and potential effects of demand management and alternative supply options. The intent is to provide a thorough and accurate assessment of water demand under baseline and conservation/alternative supply scenarios. Given the available data and local water-use patterns, the authors recommend that the demand forecasting system include two separate analyses:

- *Forecasting of potable water demand with water-use models.* These models will be based on population projections, in conjunction with water-use rates determined through analyses of the local determinants of water demand. The sophistication of these analyses will vary by location and water-use sector according to the availability of necessary data.

- *Forecasting of nonpotable water demand and displacement of potable water demand with nonpotable alternative supplies.* Currently available data does not permit modeling of nonpotable use. The forecasts will instead be developed through an assessment of existing and potential applications of alternative supplies.

Following sections describe each of these analyses in detail, and explain the procedure for combining the potable and nonpotable demand forecasts to determine total future water demand. Proposed scenarios for forecasting the effects of greater water demand management and alternative supply development are described. Toward the end of this chapter, some issues and concerns are raised that must be addressed before the forecasting system is developed. A proposed Phase II work plan concludes the chapter.

FORECASTING OF POTABLE WATER DEMAND

Selection of a water demand modeling approach should include mechanisms to:

- Account for varying growth rates of different communities and locations;

- Differentiate different types of water use within communities (e.g., residential vs. commercial);

- Adjust for determinants of water demand such as weather and water rates; and

- Calculate the impact of water efficiency and conservation measures.

Selection of a water demand modeling approach is limited by: (1) the historical water use and demographic data available, and (2) the projection of future demographic parameters. Because projections of future housing units, employment or other demographic parameters besides population are not available for the study area, the estimation of future water demand is limited to a per capita methodology or a per account methodology.

The study team recommends a per account basis for the forecasting methodology. This approach is extremely useful for analyzing and adjusting rates of water use. For example, the estimated rate of water use per account for a given location and sector may change over time due to water efficiency and conservation. Estimating future water demand on a per account basis allows for the modification of the water-use coefficient (gallons per day per account) given future conservation and improvements in water-use efficiency. For maximum usefulness, the per account use rates should be prepared for specific customer classes wherever possible. This allows for fair comparison of water-use rates in different locations and permits the more accurate use of data from other empirical studies on conservation and efficiency. The academic and professional water conservation literature provides a wealth of information that supports the reasonable modification of per account use rates.

Given that the future demographic parameter (i.e., the forecast *driver)* available for this study is population, the water-use rates for the proposed analysis must be tied to population. Therefore, the proposed methodology is to include factors for both: (1) the water use per account, and (2) the ratio of accounts per population, as shown in Equation X-1.

EQUATION X-1
BASIC WATER-USE MODEL

$$Q_{a,s,yr} = [(\text{GPD/account}) \cdot (\text{accounts/population})] \cdot P_{yr}$$

WHERE:

$Q_{a,s,yr}$ = Quantity of water use in GPD for a given area (a), sector or customer class (s), and year (yr)

P_{yr} = Population in year (yr)

This methodology allows the analyst to modify both the rate of water use per account (as in adjustments for future conservation efficiencies) and the ratio of accounts per population for a given sector. The ratio of accounts per population may remain constant, or may change over time. For example, the ratio of residential accounts per population may remain constant over time if one assumes that the average number of persons per household will be constant. The ratio of commercial accounts to population may remain constant if one assumes that commercial growth will be proportional to population growth. The ratio of manufacturing accounts to population may decrease over time if the number of manufacturing accounts remains the same while population increases. This modeling approach allows the analyst to make modifications for changing economic conditions, based on detailed knowledge of the study area. The study team will ask local area sources for input on any such adjustments, and the rationale for all adjustments will be clearly stated in the final report. If necessary, different scenarios for future economic conditions could be developed.

The Equation X-1 shown above is the basic water-use model the team will apply throughout the study area. The overall process will be to:

1. Conduct regression analysis to determine appropriate baseline water-use rates (the term “GDP/account” in the Equation X-1 above) for each location and sector

(customer class) where adequate data exists. For example, an attempt will be made to "normalize" historic water-use rates for historic variations in weather and changes in water rates.

2. Assemble a system of specific models of potable water demand for each community and sector using water-use rates based on statistically significant regression results or other approaches for communities/sectors where regression analysis is not feasible or effective.

3. Adjust the models (specifically, the term "accounts/population" in the Equation X-1 above) for expected changes in demographic and economic conditions.

4. Estimate future potable water demand by location using the models and population projections (i.e., estimate baseline water demand).

5. Estimate water demand by location for scenarios of increased water efficiency and conservation activity.

6. Conduct sensitivity testing and forecast demand under additional scenarios as needed and appropriate.

Step 1—Regression Analysis

A database be created with the available historical data by water system, including water consumption by customer class, corresponding number of customer accounts, corresponding marginal price of water and sewer service, service area population, as well as monthly average of maximum daily temperature and monthly total precipitation from the nearest weather station. Statistical methods such as multiple regression analysis will be used with the database to determine if statistically significant relationships can be derived from the existing data. Relationships between the average monthly water use per account and water rates, temperature and precipitation will be examined.

It is anticipated that the responsiveness (i.e., the *elasticity*) of water consumption with respect to variations in price, temperature and precipitation can be determined for the residential water-use sector at a minimum, and perhaps for other sectors in some communities. These elasticities estimated by the regression analysis can be used to adjust per unit use rates for: (1) differences between observed and normal weather conditions, and (2) differences in water and sewer rates.

For example, the average water use per residential account in 2000 can be adjusted for differences between 2000 actual weather and long-term average weather. Thus, the per account water-use rate is *normalized* for weather (e.g., temperature) as shown in Equation X-2. This equation uses 2000 as an example year. The complete analysis will examine relationships between weather and water use for all time units (years or months) for which data are available.

Thus, the rate of water use may be normalized for weather variations across the time period for which data are available. The normalized rate of use may then be used to estimate future water use without the bias of observed weather conditions.

EQUATION X-2
WATER-USE RATE, NORMALIZED FOR WEATHER

$$GPD_n = GPD_{2000} \bullet (MAXT_{2000}/MAXT_n)^e$$

WHERE:

GPD_n = normalized gallons per day water use

GPD_{2000} = GPD in 2000

$MAXT_{2000}$ = average maximum temperature in 2000

$MAXT_n$ = long-term average maximum temperature

e = elasticity of water use with respect to maximum temperature

The normalized water-use rates can be developed on a monthly or annual basis. It is recommended that monthly water-use rates be developed to reflect the seasonality of water use. This may assist in developing estimates of the seasonal, or outdoor, component of average water use. Analysis of monthly versus minimum monthly water usage per sector can approximate irrigation usage information that may be used in estimating potential demand for nonpotable water.

The variation in water use with respect to water and sewer rates (i.e., price elasticity) may be used to: (1) normalize for historical rate changes (similarly as in Equation X-2 above for temperature), and (2) determine impacts of future rate changes on water demand. For example, an alternative conservation scenario may include increased water and sewer rates to encourage water conservation. The impact of the rate change on future water demand can be evaluated as follows:

EQUATION X-3
THE IMPACT OF THE RATE CHANGE ON FUTURE WATER DEMAND

$$GPD_{yr} = GPD_{2000} \bullet (MP_{2000}/MP_{yr})^e$$

WHERE:

GPD_{yr} = gallons per day water use in year (yr)

GPD_{2000} = gallons per day in 2000

MP_{2000} = marginal price of water and sewer in 2000

MP_{yr} = marginal price of water and sewer in year (yr)

e = elasticity of water use with respect to price

Thus, the rate of water use may be normalized for price changes across the time period for which data are available. In addition, this elasticity may be used in the evaluation of cost impacts of the proposed pipeline on water costs in the study area

Finally, the GPD per account term in Equation X-3 above could be represented as the following when adjusted for both temperature and price:

EQUATION X-4 GPD PER ACCOUNT TERM ADJUSTED FOR BOTH TEMPERATURE AND PRICE
$GPD_n = GPD_{2000} \cdot (MAXT_{2000}/MAXT_n)^{e\text{-}temp} \cdot (MP_{2000}/MP_n)^{e\text{-}price}$

Separation of total water demand into water use by different water use sectors allows for a better understanding of the components of total water demand, allows for separate growth rates of different sectors, and allows for separate assessment of conservation impacts. Thus, the team will perform regression analyses such as those described previously for each of the communities and sectors for which available data is sufficient. Regression analysis may not result in statistically significant water-use rate coefficients for all locations and sectors. Therefore, a system of models based on regression results and other techniques is needed.

Step 2—Assemble a System of Specific Water Use Models

Given variations in data availability, a variety of approaches to specification of the water-use rates in the water-use models for each location/sector is required. In some cases, water-use rates from one location could be applied to other locations. In others, simple division of current use by current accounts or population is the only possible approach.

It is important to note that the degree of analytical effort should be determined by the significance of the results. Water demand for Flagstaff represents about 60 percent of total water use in the region, so it merits considerable attention. However, the water demands of many of the smaller areas are key factors in determining future water resource development needs for the region (especially the need for a regional supply system such as a pipeline). The recommended approach is to design a forecasting system that is flexible to accommodate the various levels of available data from the different locations and regional needs for accurate results. The following system of forecasting models is proposed:

- *Flagstaff*—The development of water-use models based on regression analysis of water use is proposed for the City of Flagstaff for the following sectors:

  Residential Single-family
  Residential Multifamily
  Commercial
  Manufacturing
  Northern Arizona University
  Lawn Meters

It may be possible and warranted to divide the commercial sector into two separate sectors for hotels and all other commercial.

- *Williams*—Regression-based models can probably be developed for the residential and commercial sectors in Williams.
- *Page, Valle, Tusayan and Bellemont*—Residential and commercial sector water-use rates from Williams will be evaluated for application for Page, Valle, Tusayan and Bellemont. Adjustments to the rates of water use per account may be made to account for current conservation efforts in these communities. Ideally, separate water-use rates may be determined for the motel/hotel sector with water use projected on a per room basis. If this level of water-use modeling is possible there would be a separate commercial water sector model for all other commercial water uses. Also, if sufficient data can be obtained from Page and Tusayan, it may be possible to develop water-use models for those communities based on regression analysis of their specific water-use patterns.
- *Grand Canyon National Park*—If historical annual or monthly water consumption within the Park can be obtained or estimated, this data can be correlated with annual Park visitors to determine an average gallons per day per visitor. Park visitation has not grown as rapidly in recent years, and new visitation projections are due to be released in early 2002. These projections will provide the "driver" for water demand forecasts for the Park, if available. Assuming a more disaggregated forecast would be useful and worth the additional expense, and depending on the data that can be obtained from the Park, it may be possible to separately project water demand generated by permanent residents and by visitors.
- *Doney Park, Kachina Village, and Mountainaire (predominantly residential community water systems)*—Baseline models for Doney Park, Kachina Village, and Mountainaire will be developed based on historic system-wide water use per account.
- *Forest Highlands and Flagstaff Ranch (seasonal residential with substantial irrigation)*—Average residential use per account and monthly irrigation per golf course hole from Forest Highlands will be evaluated for use in Flagstaff Ranch. Note that ADES population data does not separately identify population from these residential communities. Examination of 2000 Census population by census tract or block group may permit the population for these areas to be separated from ADES population projections for the corresponding subarea. Water demand projections for these areas may be estimated on a residential per account basis, or developed lot basis, given the percent of lots developed and future projections for development.
- *Fort Valley, Parks, Red Lake, and other (remainder unincorporated housing)*—The remaining population of the study area, including Fort Valley, Parks, and Red Lake, is currently served by standpipe/bulk water sales, and some individual wells. Data on water use in these areas is almost nonexistent. Therefore, forecasts for these areas will be made by applying a reasonable total water use per capita or per household figure to the population projections for named places (Fort Valley, Parks) and remainder areas. The authors anticipate developing an appropriate water use figure by "triangulating" different approaches. For instance, bulk water sales from Flagstaff, Williams, Bellemont, and Doney Park could be aggregated and then divided by the population

of the study area not served by community water systems. Water-use rates from water systems serving rural areas (e.g., Doney Park) could also be useful; such rates could be adjusted down to reflect the higher water costs—and thereby greater conservation incentive—facing households that haul water. Price elasticities from the analyses performed in the other Coconino Plateau communities could provide a basis for this adjustment.

Step 3—Adjust the Models for Expected Changes in Demographic and Economic Conditions

The ratio of accounts per population in the water-use model may be adjusted for specific locations to reflect changing conditions. For example, in the residential sector, the number of persons per household may change over time for an area. Also, the ratio of commercial accounts to general population may change as the commercial sector responds to growth in the tourism industry. Local governments and other information sources will be consulted to determine what changes in local economic and demographic conditions are generally expected. The ratio of accounts to population will then be reviewed for each location and sector and may be modified as needed to reflect changing conditions. Rationales for any such changes will be provided in the final report.

Step 4—Estimate Future Baseline Potable Water Demand Using the Models and Projected Population per Community

Given the water-use coefficients (i.e., water use per account), the ratio of accounts to population, and future population projections, future water use can be estimated for each location and sector. The water demand forecasts will be estimated for the same future year for which ADES population projections are available. Summing all of the local area forecasts will produce the baseline potable water demand forecast for the study area as a whole. The conservation assumptions of the baseline forecasts are described in the "baseline scenario" in Step 5.

Step 5—Estimate Water Demand under Increased Efficiency/Conservation Scenarios

It is recommended that the water demand forecast for the study area be developed for three alternative water efficiency and conservation scenarios.

Baseline Scenario. This water demand forecast will reflect current and expected water conservation efforts as estimated in Step 4. The current water-use-per-account factors incorporate existing conservation activities by water users. This level of conservation effort is assumed to continue into the future. In addition, the National Energy Policy Act of 1992 mandated water-use efficiency standards for the manufacture and sales of toilets, urinals, faucets and showerheads, effective in 1994. Thus, all new construction and any remodeling of preexisting structures will install the more water efficient fixtures. Water savings that result from these efficiency standards are often referred to as *passive savings*. Over time, as the percentage of buildings in a sector that are post-1994 buildings increases, and as fixtures in older building wear out and are replaced, the average water use per building (or per account) may become more water-efficient with respect to indoor water use. In some cases, this improvement in indoor water use is offset by increased outdoor water use due to newer buildings having larger irrigated areas or inefficient automatic irrigation systems. Further, the improved indoor water use may be offset over time by leaky toilet flapper valves and improper maintenance. Thus, a reasonable (i.e., conservative) assumption would be to assume that the current water use per account rates reflect future water-use rates. This assumes that the normal fixture and appliance replacement rates will be maintained into the future. In addition, the per account water-use rates in this scenario could be adjusted for any water conservation programs that are currently planned for implementation. For example, any projects already funded to expand commercial rebate and audit programs could be incorporated into the forecast by reducing the commercial per account water-use rate. It is assumed that current utility investments in water conservation education and leak detection would continue in order to maintain the current level of water-use efficiency. This scenario assumes that water and sewer rates will increase in the future at the rate of future inflation without an increase in real value. That is, future water and sewer rates will remain constant in year 2000 dollars.

Moderate Conservation Investment Scenario. This scenario represents a moderate investment by water providers to improve water-use efficiency above the current level of water use. Such investments may include additional rebate programs, residential and commercial audit programs, landscape restrictions and increased water conservation rates (i.e., increased rates in constant dollars). It is assumed that such conservation investments may vary across subareas due to differences in compliance rates and social acceptability. It is proposed that a list of potential water conservation investments be reviewed by each water provider to determine the degree of likely implementation with respect to cost and customer acceptability. Based on this information and findings in the water efficiency and conservation literature on the savings that the “chosen” investments typically provide, the water use per account rates will be adjusted in each of the local demand forecasting models to reflect anticipated water use savings under the moderate conservation investment scenario. These adjustments will be sensitive to variations in local implementation rates. For instance, for a given conservation measure, the percentage savings in communities that already have strong conservation programs (e.g., Flagstaff) are expected to be less than savings in communities that do not (e.g., Page).

Aggressive Conservation Investment Scenario. This scenario represents an aggressive investment by water providers to improve water-use efficiency. It assumes that a full range of state-of-the-art water conservation technologies and programs will and can be implemented throughout the study area. Such conservation investments may require significant investments and policy changes by local governments. The assumed measures and programs will be detailed in the Phase II report, and appropriate adjustments made to water-use rates in each of the local demand forecasting models.

The magnitude of the cost differences between the scenarios will be indicated.

Step 6—Conduct Sensitivity Testing and Forecast Demand under Additional Scenarios as Needed and Appropriate

The accuracy of the demand forecasts will depend on the accuracy of the population projections, the water-use rates and the weather and price effects that underlie them, and the ratios of population to accounts. Each of those factors depends on analyses or assumptions that will be made in the Phase II study or carried over from other sources (e.g., ADES). To assist decision-makers in evaluating the water demand forecasts, basic sensitivity analysis will be conducted to determine how much the forecasts would vary with changes in key variables or assumptions.

In a similar vein, the study team could prepare demand forecasts for additional scenarios, beyond the three conservation scenarios, as desired by stakeholders and Phase II funders. For example, if other studies show that the cost of pipeline water per unit will allow or require significant reductions or increases in local water rates, the price elasticity information developed in the regression analyses could be used to estimate the effect of those price changes on water demand.

ESTIMATION OF NONPOTABLE DEMAND AND ALTERNATIVE SUPPLY POTENTIAL

In some communities, the water billing data to be used for development of water demand models does not represent all water use. Some communities have developed nonpotable supplies (raw water and alternative supplies such as water reclamation and reuse) to serve portions of their total water demand. New demands for nonpotable water likely will arise over time in many of the communities. Further, nonpotable sources are likely to displace some of the potable water demand projected by the models described above.

Nonpotable water uses are currently limited in number (e.g., reclaimed water use varies from one to a few dozen accounts, depending on the community), and most communities have only implemented nonpotable supply systems quite recently. Therefore, the available data on nonpotable demand is too limited to allow development of a predictive model based on historic uses. Also, because the use of nonpotable water is strongly affected by the decisions of relatively few large water users, and by the physical availability of reclaimed water distribution lines and other nonpotable supply systems, future nonpotable water demand will be best estimated through a detailed, community-specific investigation of potential nonpotable supply systems and opportunities for their use.

Results of the potable demand modeling effort will provide useful information on potential opportunities to use nonpotable supplies. For instance, examination of variations in monthly water demand will help separate indoor use from landscape irrigation use, a likely end-use for nonpotable supply substitution. The potable demand modeling results will also provide upper bounds on the potential of some alternative supplies. For example, some communities currently use or anticipate in the future using 100 percent of their wastewater effluent for golf course irrigation or other applications. Modeling potable water demand and identifying the indoor portion of the demand can provide an estimate of how much wastewater effluent will be available in future years.

The results of these numerical analyses must then be compared to the physical configurations of water infrastructure and water uses in each community. The social acceptability of alternative supplies must also be considered. The study team will meet with water system managers in each community to discuss opportunities and constraints for using raw water and various alternative supplies, and to obtain their informed judgments on future new uses of nonpotable water and future displacement of potable water uses with nonpotable supplies. In addition, past and emerging experiences of communities around the country with the full range of alternative supplies will be examined, as reflected in the water resources and water conservation literature.

These analyses, interviews and literature reviews will allow the development of estimates of future nonpotable demand, according to Equation X-5:

EQUATION X-5
DEVELOPMENT OF ESTIMATES OF FUTURE NONPOTABLE DEMAND

$$TND_{a,s,yr} = ND_{cc} - ND_{cd} + ND_{n} + PD_{md}$$

WHERE:

$TND_{a,s,yr}$ = Total nonpotable demand for a given area (a), sector or customer class (s), and year (yr)

ND_{cc} = Current nonpotable demand continued into the future

ND_{cd} = Current nonpotable demand discontinued in the future

ND_{n} = Nonpotable demand newly generated since the current time (exclusive of displacement of modeled potable demand, the next term)

PD_{md} = Modeled *potable* demand displaced in the future by nonpotable supplies

In a manner parallel to the water efficiency and conservation scenarios, three alternative estimates of nonpotable water use will be developed:

Baseline scenario. This scenario will include current nonpotable uses and nonpotable uses expected by water system managers. For instance, if hookups of specific existing or new accounts to reclaimed water distribution lines are planned, the anticipated reclaimed water use of those accounts will be included in this scenario.

Moderate investment scenario. This scenario will include reasonable expectations of new uses of alternative supplies or displacement of potable water use. For example, the City of Flagstaff currently has 3 MGD of treated effluent available for reuse, many reclaimed water distribution lines in place, and new lines are anticipated. Flagstaff water managers will be interviewed regarding how much of the currently available reclaimed water supply can be reasonably expected to be used within the 50-year time horizon of the Phase II study, and for what types of uses. Based on these and similar discussions in other communities, moderate investment scenario estimates of nonpotable use will be developed that include reasonable expansion of reclaimed and raw water use, and reasonable but likely limited expansion of graywater reuse, decentralized wastewater reuse, and rainwater harvesting.

Aggressive investment scenario. The aggressive investment scenario will include maximum publicly acceptable implementation of state-of-the-art nonpotable supply opportunities that are deemed technically feasible in each study area community. This scenario will be based on knowledge of cutting edge alternative supply technologies and discussions with water managers in the study area.

The magnitude of the cost differences between the scenarios will be indicated.

DERIVATION OF TOTAL WATER DEMAND

One calculation step remains before total water demand forecasts can be derived. Potable water demand as modeled in Equation X-1 must be adjusted for displacement of potable water demand by nonpotable supplies, as follows:

EQUATION X-6
POTABLE WATER DEMAND ADJUSTED FOR DISPLACEMENT BY NONPOTABLE SUPPLIES

$$TPD_{a,s,yr} = PD_m - PD_{md} + ND_r$$

WHERE:

$TPD_{a,s,yr}$ = Total, adjusted potable water demand for a given area (a), sector or customer class (s), and year (yr)

PD_m = Modeled potable demand, the result ($Q_{a,s,yr}$) of Equation X-1

PD_{md} = Modeled potable demand displaced in the future by nonpotable supplies; a term in Equation X-5

ND_r = Nonpotable demand that reverts to potable water sources, a portion of the term “current nonpotable demand discontinued in the future” (ND_{cd}) in Equation X-5. ND_r is likely to be zero unless regulatory changes force discontinuation of use nonpotable supplies, an unlikely development

Total demand for all water uses in future years in each community is represented by Equation X-7:

EQUATION X-7 TOTAL DEMAND FOR ALL WATER USES IN FUTURE YEARS IN EACH COMMUNITY
$TD_{a,s,yr} = TND + TPD + SD$ WHERE: $TD_{a,s,yr}$ = Total water demand for a given area (a), sector or customer class (s), and year (yr) TND = Total nonpotable demand; the result of Equation X-5 TPD = Total, adjusted potable water demand; the result of Equation X-6 SD = System demand

System demand is the difference between total potable water production and billed water consumption, for those communities where total potable water demand is forecasted on the basis of historical billed water use per account. Where total potable water demand is forecasted on the basis of historical production per account, this term equals zero. System demand includes un-metered water uses, system losses through leaks in water distribution lines, fire protection uses, process water use at treatment plants (for systems where the process water is not re-introduced to the supply train), and other accounted-for and unaccounted-for water uses and losses. Study area communities vary in the degree to which they have a "handle" on system demand. Existing system demand rates (production minus consumption) will be used in the baseline forecast scenario, and the system demand rate will be adjusted for water savings such as increased system leak detection and repair in the moderate and aggressive investment scenarios.

Total water demand will be derived, using Equation X-7 for each study area community and each of the three forecasts scenarios:

- Baseline;
- Moderate conservation and alternative supply investment;
- Aggressive conservation and alternative supply investment.

Total water demand for the study area in each scenario will then be calculated by summing the results of Equation X-7 across all study area communities. The final report will include tables showing total demand and each of the factors in Equation X-7 by community. Results will be totaled for the study area.

Issues and Concerns

During the course of the Phase I study, the study team identified a number of issues and concerns that are relevant to the preparation of the Phase II water demand forecasts. Some of these issues may need to be resolved by decisions by the Advisory Counsel. Others only need to be noted here and addressed in Phase II.

- *Resolution of the study area boundaries.* Phase II work will require a clear delineation of study area boundaries. Study area boundaries identified in the ADWR *North Central Arizona Regional Water Study* are different from those in the Morrison Institute *Growth on the Coconino Plateau*, which are different from those of this Phase I report. Does the Phase II study area include Page, Winona, Parks, Munds Park, any of the Tribal lands, etc? The study area must be clearly defined prior to development of the final Phase II cost estimate.

- *"Remainder" population allocations.* ADES population projections for Coconino County are subdivided into census county divisions (CCD), which are further subdivided into census designated places (CDP) and named population places (NPP) with CCD remainder populations. Population projections for the study area can be determined for the CDP and NPP subareas. However, the populations for the CDD remainder areas must be allocated between in/out of study area. The Morrison Institute report, *Growth on the Coconino Plateau*, distributed these "balance of county" populations among the three subregions defined in their report based on 1990 population distributions (See Appendix B of *Growth on the Coconino Plateau*). If the Phase II study area definition coincides with the Morrison Institute study area definition, then the Morrison Institute allocation of the CCD remainder populations may be used. Alternatively, given a clear geographic mapping of the Phase II study area, the ADES could be approached to delineate study area populations based on census tract or block group data. This is largely a technical matter to be addressed when the Phase II work proceeds.

- *Number of future years forecasted.* The end of the time horizon for the Phase II study will be the final year of the ADES population projections. The number of intermediate years forecasted will somewhat affect the costs. The years used in the system of models for potable water demand will correspond with one or more intermediate years in the population data. The estimation of nonpotable supplies will be carefully examined for reasonableness for each selected forecast year and scenario, and the results of each analytical step cross-checked. Stakeholders must decide on the number of intermediate forecast years prior to development of the final Phase II cost estimate.

- *Acceptability of ADES population projections.* The ADES population projections for Coconino County and subareas (developed in 1997) are expected to be updated in early 2002 based on 2000 Census data. Some Census counts within Coconino County have been questioned, and ADES has issued revised 2000 counts for some areas. The revised ADES population projections for Coconino County and subareas would be used as the demographic *driver* of the Phase II water demand forecast and therefore must be acceptable to all stakeholders and the Advisory Council.

The 1997 ADES population projections indicate approximate doubling of population for most of the county subareas by 2050. As noted in the water system profiles and other sections in this Phase I analysis, many subareas are restricted in growth by confining adjacent lands, number of available lots, zoning ordinances regarding lot sizes, and attitudes regarding growth management. Many of the area plans include survey results indicating that current residents wish to maintain the rural character of their environment. Changes in land availability, zoning ordinances, housing characteristics, and lifestyles may be inevitable to accommodate the population growth anticipated over the next 50 years.

It is critical to the acceptance of the water-use projections that the underlying population projections are acceptable. If stakeholders reach consensus on population projections that differ from the ADES projections, the agreed-upon projections will be used. Alternatively, additional population scenarios could be developed, at additional cost.

- *Additional forecast scenarios.* Before preparation of the final Phase II workplan and cost estimate, regional water stakeholders should determine if additional scenarios besides the three conservation scenarios are to be developed. Some useful scenarios could include: alternative population forecasts, price changes due to major new water systems, water demand during drought conditions, and "wild card" development scenarios such as a successful re-proposal for Canyon Forest Village.

PROPOSED PHASE II WORKPLAN

1. Initial meeting—The study team will meet with the Coconino Plateau Advisory Council to review the Phase II study workplan, objectives, and schedule. Finalize delineation of study area. Discussion will include identified issues and additional data needs.

2. Additional data collection—Obtain new ADES population projections, allocate ADES population projections into study area geographies, collect additional available water-use data, collect weather data. Advisory Council should review and approve use of study area population projections.

3. Preparation of conservation data—Prepare detailed listing of potential water conservation initiatives appropriate for the region. Prepare and conduct survey of water providers regarding feasibility and acceptability of conservation initiatives. Efficiencies in water use achieved through similar conservation initiatives will be identified through literature searches.

4. Analysis of potable water-use data—Compile database, estimate elasticities, estimate water use per account rates, estimate account per population rates by water-use sectors as data permit. Adjust account per population rates for expected demographic and economic changes in the study area. Adjust water use per account rates to incorporate impacts of already planned conservation initiatives

5. Estimation of baseline potable demand forecast—Develop baseline water demand forecast from per account water-use rates, rates of accounts per population, and population per subarea. Potable water demand will be estimated by subarea (community), water-use sector, and forecast year. Latest forecast year will be 2050 or later as per available by the ADES population projections.

6. Analysis of conservation data—Assess feasibility and acceptability of potential conservation initiatives based on survey of water providers and review of water conservation literature. Formulate set of initiatives for moderate investment conservation scenario and aggressive investment conservation scenario.

7. Specification of conservation scenario parameters—Assumptions regarding conservation efficiencies will be applied to the per account water-use rates. Rates of accounts per population may also be modified to reflect demographic changes and acceptability of conservation by subarea. Two sets of rates will be established to reflect the moderate and aggressive investment scenarios.

8. Estimation of potable demand under conservation scenarios—Water demand will be estimated by sector, subarea and year with the modified sets of rates for the moderate and aggressive conservation investment scenarios.

9. Alternative supply data development—Analyze potable water demand forecasts to determine available supplies of wastewater effluent and identify opportunities for substitution of nonpotable water. Meet with local water providers to discuss local infrastructure configurations and anticipated and potential uses of raw water and alternative supplies.

10. Estimation of nonpotable demand—Based on analysis of available data, discussions with water providers, literature reviews and other sources, develop estimates of nonpotable water demand under baseline, moderate investment and aggressive investment scenarios.

11. Calculation of total demand—Adjust potable demand forecasts for displacement by nonpotable supplies. Estimate system demand under the 3 conservation/alternative supply scenarios. Calculate total demand for each scenario by subarea, water-use sector, and forecast year, as the sum of adjusted potable demand, nonpotable demand and system demand.

12. Sensitivity analysis—Calculate sensitivity of the demand forecasts to changes in key data.

13. Prepare draft report—The study team will prepare a draft report that documents the data collection process, data analysis, assumptions and presents the estimated water demand forecasts for the baseline, moderate and aggressive conservation/alternative supply scenarios. The report will include the sensitivity analysis results, discussion of the magnitude of differences in cost for the 3 scenarios, references for cited literature, lists of persons contacted for information and the water system profiles and other material from the Phase I report, modified as needed, based on the research for and results of the Phase II study. The report will also provide key observations on water use, discussion of implications of the forecasts for water planning in the region, and other recommendations of the study team deemed useful to regional water resource stakeholders.

14. Presentation of results—The draft report will be printed and provided to the Advisory Council and additional stakeholders designated by the council for review and comment. The study team will meet with the Advisory Council and designated stakeholders to present and discuss the findings.

15. Edit and submit final report—After an appropriate review period (e.g., four weeks) by the Advisory Council and designated stakeholders, the study team will prepare written responses to all written comments. The report will be edited and revised as deemed appropriate. A final printed report will be submitted to the Advisory Council and designated stakeholders, and an electronic version provided to the Advisory Council.

PHASE II COSTS

Costs for Phase II will depend on specific resolution of the issues and concerns noted above. For instance, costs will be affected by the definition of the study area, the degree to which ADES population forecast geographies match the final study area sub-geographies, whether alternative population scenarios are requested, the number of intermediate years to be forecasted, and the number of forecast scenarios (e.g. the number of conservation/alternative supply scenarios, scenarios for water price changes due to major new water systems or other reasons, scenarios for “wild card” developments, etc.) The estimated cost range is $75,000 to $150,000.

XI. CONCLUSIONS AND RECOMMENDATIONS

This section offers some summary points on water use in the study area, and a few perspectives and recommendations for consideration by regional water stakeholders. To begin, the study team noted the following remarkable or important aspects of water use on the Coconino Plateau:

- Substantial barriers to increasing local water supplies include depth to groundwater, concerns over the environmental impacts of groundwater pumping, and limited availability of low reliability surface water.

- Importing water via a pipeline is one obvious solution to providing future water supplies. However, other solutions such as increased water conservation effort and increased use of reclaimed water and other alternative supplies have received little attention. Even more striking, little effort has so far been put into understanding existing demand and developing sound water demand forecasts.

- An increasing policy emphasis on water efficiency and conservation appears to be underway at the county level, as seen in the county's area plans. The plans prepared in the mid to late 1990s make greater mention of water conservation than those done earlier. The most recent plan, for the Doney Park, Timberline and Fernwood area, was drafted in January of 2001. It includes the most detailed water conservation provisions of any of the area plans, an 8-point policy statement (see the Doney Park system profile).

- However, many of the policies mentioned in the area plans are already required by law and regulations of higher governments; for instance, the national plumbing standards found in the Federal Energy Policy Act of 1992. Others are non-specific and could be very weakly interpreted.

- Water efficiency and conservation efforts by local governments and utilities run the gamut from a well-rounded program in Flagstaff to communities with no significant efficiency and conservation activities.

- Similarly, the "conservation ethic" of the public varies from obviously strong in Flagstaff, which has had conservation education programs and other conservation activities in place for many years, to very low, as self-reported by interviewees in communities such as Kachina Village and Page.

- Water rates in most of the study area communities are quite high relative to national average rates. High water rates are the primary water conservation tool in most study area communities. In most cases, this is probably more by default, due to high water system costs, than by design. Only three entities have well-designed inclining block rate structures ("conservation rates"), indicating an aggressive strategy to use rates to promote efficiency and conservation. Strong correlations between water costs and water use have been demonstrated in many other regions. While the relationship between water demand and the conservation rate structures and overall high rates in this study area has not been evaluated (and would require more detailed billing records), it is expected that the inclining block rates are effective.

- A significant amount of reuse of treated wastewater effluent occurs. Tusayan is especially notable for the extensive use it makes of reclaimed water for toilet flushing. Another notable use occurs at Kachina Village, where wastewater effluent provides wildlife habitat in constructed wetlands. Many systems use reclaimed water to irrigate golf courses and other landscapes. In other regions of the country, treated wastewater effluent is often used to recharge groundwater. Due to local well depths, this is not possible in the study area. Local innovation in using wastewater as a resource here is significant.

- Wastewater reuse is clearly set to expand in several communities, and will inevitably do so as the costs of attaining new potable supplies continue to rise.

- Capturing stormwater runoff for water supply is a small but significant local practice. Examples include the Grand Canyon Airport system, and a system now under construction at Flagstaff Ranch.

- Compared to many parts of the southwestern United States, there is a low to very low incidence of irrigated landscape in most portions of the study area. Flagstaff is one exception; rates of landscape water use there appear to be higher, perhaps approaching the incidence of irrigated landscape in other Southwest cities.

- The number of households in the study area that are entirely dependent on hauling of water is remarkable. The study team knows of few other areas where this practice so prevalent, and where growth appears to be fairly robust in spite of the lack of water system connections or easy access to ground water.

WATER DEMAND AND WATER SYSTEM PLANNING

Based on the authors' research in the study area and knowledge of water efficiency and conservation, it seems likely that a variety of factors will dampen increases in future water demand in the study area:

- Installation of more efficient models as existing fixtures, appliances, and irrigation systems wear out will provide "automatic" water savings in already developed areas.

- Many additional, proven efficiency and conservation measures are increasingly likely to be adopted. The region's high water rates will assure this happens to some degree whether or not local utilities actively promote water efficiency and conservation. And the region's supply difficulties create strong incentives for local water utilities to seriously consider and develop stronger water conservation programs.

- Technologies for increased water efficiency will continue to evolve, and new ones will emerge. The breadth and depth of available water efficiency and conservation measures and programs continues to expand nationally, and many of the innovations will no doubt be suitable for application in the study area.

- Significant new end-uses of water are either not needed in this region (e.g., misting systems for outdoor space cooling) or are unlikely due to high water costs (e.g., significant increases in the prevalence of residential swimming pools). A possible exception could be snowmaking at the Arizona Snowbowl. New industrial facilities with high water demand would also be an exception, but such facilities are discouraged by planning policies in many of the study area communities.

Local and regional water system planners should take thorough account of these and other factors dampening water demand growth, as well as typically considered drivers of demand such as population and economic growth. Expensive mistakes could result if passive and active water savings are not seriously considered.

Some analysts suggest that tightening up water-use efficiency by implementing demand management limits the options available to water managers during future drought emergencies. This is the issue of so-called “demand hardening.” The problem is largely perceptual, rather than real. It is important to distinguish between demand management and “drought response.” Demand management emphasizes measures that typically require years for widespread implementation and produce long-term water savings, e.g., replacing fixtures and appliances with more water-efficient models. These measures, and the programs to implement them, cannot typically produce significant community-wide savings in a drought-response timeframe. Drought response emphasizes short-term behavioral measures and programs, e.g. reduced lawn watering or in extreme conditions outright bans on lawn watering, car washing, etc. These measures can quickly produce significant savings, and are available even if long-term demand management measures have already been implemented. Because of the importance of periodic droughts in this region, this issue will be discussed further in the Phase II report, in conjunction with the specification of demand management scenarios and implementation recommendations.

WATER AND GROWTH

The relationship between water availability and growth is a key regional issue. The Morrison Institute growth study (Heffernon and Muro 2001) to some extent sidestepped this controversy. It used ADES population projections as a starting point, and noted that “ADES projections tacitly assume that the region’s ability to meet water demand in the future will not differ substantially from its ability to meet demand now, so overall growth figures should not be affected by the source of water” (p. 8). As a result, it states “Pipeline water will have little impact on total population growth for the region” (p. 8). Nevertheless, in preparing alternative population forecasts, the study’s demographers do make judgments that a pipeline will increase study area population somewhat. The largest difference is in the “Tourism High Growth” scenario, for which the “with pipeline” projection shows a population increase for the western subregion (Grand Canyon Village south to Williams and Parks) of 11,750 (61 percent gain) in

2050 over the "Tourism High Growth, without pipeline" projection for 2050 (p. 65). This is widely regarded as the subregion of the study area with the greatest lack of water relative to its development potential, so the increased population projection for a pipeline scenario fits with general expectations.[5]

Answering the pipeline/growth question is well beyond the scope of this study. However, some points and perspectives are offered for local stakeholders to consider.

Clearly, a lack of water did not prevent some development from occurring in places like Tusayan and Valle prior to availability of local well water. Developers, local residents and businesses paid the high financial costs and endured the hassles of hauling water because these were desirable locations. They continue to pay costs for local well water that are substantially more than the costs paid by most Arizona urban residents.

High costs for hauling water similarly have not prevented residential development in many low-density residential enclaves scattered throughout the study area. Examples include Parks and Red Lake. And proposals such as Canyon Forest Village demonstrate that for valuable locations, developers will go to extreme lengths to overcome local unavailability of water.

At the same time, the effect of limited water availability as a psychological "brake" on the actions of stakeholders must be considered. Limited water supplies and the impacts of additional local ground water development are clearly high on the minds of local public officials. These conditions must also deter many small to medium size development companies that do not have the financial and technical capacity to organize complex non-local water supply schemes. Thus, given that high prices do not seem to be a showstopper for continued growth, two key questions raised by increased water availability from a pipeline are:

- Will a changed perception of the availability of water release the psychological brakes of potential developers and lead to more development proposals?
- Will more proposals, in a milieu that includes more available water and reduced environmental impacts of local ground water withdrawals, lead planning and zoning officials and political decision-makers to be more permissive of development?

RECOMMENDATIONS

Effective programs across the country have shown conclusively that water efficiency and conservation should be considered a "supply" of water—an already developed resource that when tapped can help defer, downsize or avoid altogether new water supply infrastructure. This is especially true when water efficiency and conservation are considered together with water

[5] The net regional total population increase in 2050 with the pipeline is projected in the Morrison Institute study at about 10,000. The lower net figure is because the Flagstaff subregion is projected to have lower population with the pipeline than without, as some development shifts to less expensive land in the western subregion that becomes feasible for development due to the pipeline.

reuse and other alternative supplies in a thorough, integrated evaluation of available options for meeting water needs. Demand management and conventional and alternative supplies must all be considered if a community or region is to develop the most cost-effective approach to meeting human and environmental water needs. Conventional supply options, from new wells to an imported water pipeline, are getting considerable attention in the study area. As with any integrated water resource planning process, a detailed and accurate water demand forecast is required to: (1) provide an understanding of both current and anticipated water-use patterns, and (2) establish the baseline for the analysis of alternatives. The Phase II water demand study is recommended, in order to provide both a better understanding of future needs, and to add a sound evaluation of water conservation and alternative supply development to the “resource mix” available for consideration by regional water stakeholders.

The water demand forecasting effort proposed in this report is an important step toward sound water system planning for the Coconino Plateau. Much more demand-side research and analysis could be done. At some point, some of the local water systems, the Advisory Council or other stakeholders should invest in baseline water-use studies. These studies would use sophisticated meter reading, data logging and flow trace interpretation technologies, applied to stratified random samples of water users, to develop robust data on exactly how much water is used for specific end uses—toilet flushing, showers, landscape irrigation, etc.—in particular customer classes. This information would be invaluable in developing water efficiency and conservation programs and in further demand forecasting studies.

REFERENCES

Information sources also included personal and phone interviews with water system managers and personnel of other agencies and stakeholder organizations. Interviewed individuals also provided various system-specific publications and data sheets. See the sources given for each water system profile in Appendix A, and the list of stakeholders in Appendix B.

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APPENDIX A

WATER SYSTEM PROFILES

APPENDIX A: WATER SYSTEM PROFILES

This section provides a detailed review of each of the major water systems currently operating in the study area. The discussions for each system fall into the following subsections:

- *Service Area and Water System.* Describes the size and nature of the locality, sources of supply, treatment and storage facilities, standpipes for non-local users and the local wastewater system(s).
- *Alternative Supplies.* Discusses any current and anticipated systems to reuse treated wastewater. Also addresses rainwater harvesting and graywater use in some locations.
- *Water Metering and Rates.* Notes the local extent of metering of end-users, current water and sewer rates and any notable recent changes in rates.
- *Water Efficiency and Conservation.* Describes past, current and anticipated efforts, policies and regulations. Local policies and regulations that simply repeat but do not go beyond those of higher-level governments (e.g., national plumbing standards) are not noted.
- *Water Use.* Provides summary data and discussion of current and recent water use in the locality, noting aspects such as sectoral use, seasonal use patterns, etc. where information is available.
- *Growth and Future Water System Development.* Summarizes growth prospects and constraints, available water demand projections and current local plans or proposals for addressing the system's supply/demand balance in future years.
- *Sources.* Lists relevant citations to the references provided at the end of the report.

Individual wells and very small community systems are not separately described. However, for significant developing areas in unincorporated portions of the study area—e.g., Fort Valley, Parks and Red Lake—this report provides a brief description of water sources and development patterns.

BELLEMONT

Service Areas and Water Systems: Bellemont is an unincorporated area centered on Interstate 40 exit roughly 7 to 8 miles west of the Flagstaff city limits. According to the *Bellemont Area Plan*, adopted by Coconino County in 1985, there are 594 acres of private land in Bellemont, surrounded by National Forest and the Navajo Army Depot. Two private water systems serve this area, which is sparsely built with commercial and light industrial facilities and a small number of residences. A new residential and commercial subdivision is under construction. A third water system, for the Army Depot, is also discussed here. Historic population data and projections of population for Bellemont are not available from ADES.

Bellemont Water Company

The Bellemont Water Company is a private company regulated by the Arizona Corporation Commission (ACC). Bellemont Water Company operates two separate systems. The original system, built by the Sante Fe Railroad near the original town-site many years ago, includes 2 wells, a 203,000-gallon storage tank and a standpipe with meters for a small number of users. A newer system, located closer to I-40 and built by the water company in 1989, has 3 wells, a 100,000-gallon storage tank and standpipes accessed through both a pre-paid card system and quarter sales. The new system also has 8 connected and metered customers (6 in a commercial subdivision, plus a tavern and one house, all south of I-40).

The area plan indicates that the old wells tap a shallow aquifer, roughly 150-200 feet deep. The deepest of the new wells is 225 feet deep. The owner reports that the wells are affected by periodic droughts. Well flows have been as high as 360 GPM. In the current drought, only one well is in operation, with a yield of about 100 GPM. Since October of 2001, reduced well yield has meant that the company has had to cut back on water sales to haulers. It does so by limiting the hours when the standpipes are accessible.

All the company's metered users are served by individual onsite wastewater systems (e.g., septic systems).

Bellemont Travel Center

A truck stop complex on the north side of I-40 has its own water system. According to the owner, the system includes four wells. Most have been in place since the 1960s. The wells are drilled 250 feet deep, and the static water level is typically about 35 feet deep.

This system currently serves a Texaco gas/service station, restaurant and convenience store. Historically the truck stop has also maintained a standpipe, with an associated 3,000-gallon storage tank. A new 258,000-gallon storage tank was under construction during the study team's fieldwork in October of 2001. The standpipe was not open for business at that time.

The truck stop water system will shortly serve a residential and commercial subdivision. Crews were installing utility lines in the fall of 2001 for a first phase of development that will include 133 single-family lots, a 60-room hotel and some additional commercial space. The owner anticipates someday building a second phase with 100-150 single-family lots. Further, a proposed, roughly 100-unit, RV park is now going through the county zoning process.

Currently an evaporative lagoon sewage treatment system serves the truck stop. The owner will soon retire this system and construct a community-owned wastewater treatment package plant to serve the truck stop and new development. National Pollution Discharge Elimination System (NPDES) and ADEQ wastewater reuse permits are already in place for this system. The initial wastewater capacity will be 37,000 GPD. The permit will allow up to 150,000 GPD, more than enough for all the currently envisioned development.

Navajo Army Depot

The Navajo Army Depot is operated by the Arizona National Guard for the purposes of troop training and munitions storage. The base totals 29,000 acres, all south of I-40 in Bellemont. Its water supply comes from several springs in a perched aquifer. Shallow wells (30-45 feet deep) collect water for the main system. A large pond also collects surface discharge from the springs, but is only used as a water source when the well flows slow down during droughts. Base personnel expressed some concern that increased ground water withdrawals for the new development north of the highway could affect the base's water supplies.

A drinking water package plant with a maximum capacity of 200 GPM (288,000 GPD) treats all collected water prior to distribution to a 500,000-gallon storage tank and 24 miles of water lines. A separate dry pipe fire suppression sprinkler and deluge system with a 1 MG storage tank also exists on base. The system serves 69 single-family housing units, most of which are occupied year-round; a variety of administration and shop buildings; a barracks area that houses as many as 600 troops in the summer; common area and household lawns and an Arizona Department of Transportation rest area along I-40.

A 1940s-era trickling filter/Imhoff tank wastewater treatment plant currently serves the base. A new 60,000 GPD wastewater treatment package plant is now in design. It will be in operation by the summer of 2003.

Alternative Supplies: No alternative supplies are known to be currently in use in the Bellemont area. The new subdivision under construction near the truck stop includes in its covenants, conditions and restrictions a provision that all communal (e.g., roadside) and commercial landscape must use treated wastewater effluent for irrigation. The new wastewater system for the Navajo Army Depot will irrigate a forest meadow area in order to dispose of wastewater effluent through evapotranspiration. This system will not displace any existing potable water demand and is therefore not a true reuse system. The base determined that configuring the system to serve lawns or other uses with treated wastewater effluent is not affordable.

Water Metering and Rates: The Bellemont Water Companies water rates are in Table A-1 below.

TABLE A-1 BELLEMONT WATER COMPANY WATER RATES	
	Rate per 1,000 gallons
Old (Santa Fe) system, standpipe	$5.25
New system, connected accounts ($25/month service charge, plus volume charges)	$4.00
New system, standpipe, card accounts	$4.00
New system, standpipe, quarter sales	$4.50

The truck stop standpipe sold water before construction of the new storage tank for $5.50 per 1,000 gallons. The new rates for water haulers have not been determined yet, but will employ a card system similar to that used in Williams. All users in the new subdivision will be metered. The owner anticipates that the rate structure will be very similar to the structure in place in Flagstaff for residential and commercial classes, and the rate levels will be within 10 percent of the Flagstaff rates.

Most individual facilities on the army base are not metered. The base uses a master meter to charge a combined water and sewer rate to the contractor who operates the housing complex. The current charge is $4.53 per 1,000 gallons.

Water Efficiency and Conservation: The current area plan, now over 15 years old, includes only the most basic water efficiency and conservation policy:

> The conservation of water resources shall be a major consideration in all new building construction and shall be enhanced through such programs as the installation of water saving plumbing fixtures and separate water meters for individual units in all new construction within the Bellemont Study Area. (p. 9)

The extent to which water-efficient fixtures and other measures have been retrofitted into commercial and residential buildings and landscapes in the area is not known. No programs for accelerated retrofitting of old fixtures and appliances exist in the area.

Lawn areas on civilian properties in the vicinity of the I-40 interchange are non-existent to very limited, as is probably the case for homes that haul water from the Bellemont standpipes. The army base has perhaps 2 to 3 acres of irrigated landscape around common buildings, plus lawns in its housing complex.

System leakage for the Bellemont Water Company and the existing truck stop system is probably very low given the small size of these systems. The Bellemont Water Company reported it has found and repaired a couple of leaks in the last three to four years. It watches meter readings for spikes that could indicate leaks. The army base system probably has some leaks, but the base engineer reports that pressure tests have not identified any large leaks. Also, the base is now underway with a 5-year program to replace all the aged valves and hydrants in the system.

Water Use: Following are figures and estimates of water use for the three Bellemont water systems.

Bellemont Water Company

According to its year 2000 annual report submitted to the ACC, the Bellemont Water Company pumped and sold 18.463 MG. According to the system manager, roughly 25 percent of sales are to the 8 connected accounts and the remainder is to haulers. Assuming this breakdown, water use in 2000 was as follows:

TABLE A-2
BELLEMONT WATER COMPANY–WATER USE IN 2000

Type	*Amount*
Metered local use	4.6 MG
Standpipe use	13.8 MG
Total	18.5 MG

Among the connected accounts, the largest use by far is SCA, formerly Wisconsin Tissue, which uses water in its manufacturing processes. Commercial haulers account for more than half of the standpipe sales. In drought periods commercial haulers cut back on their use of the Bellemont Water Company's standpipes and instead haul from other locations, predominantly Flagstaff.

The system manager estimates that use goes up by about 25 percent in the June to September period, compared to winter months.

Bellemont Travel Center

The travel center owner did not provide detailed water-use data for this study, but indicated that the truck stop complex water use currently averaged around 7,000 GPD, and standpipe water sales typically have historically averaged around 3,000 GPD. Assuming these figures, this would put current annual water demand at:

TABLE A-3
BELLEMONT TRAVEL CENTER CURRENT ANNUAL WATER DEMAND

Type	*Amount*
Truck stop complex local use	2.6 MG
Standpipe use	1.1 MG
Total	3.7 MG

Navajo Army Depot

The depot provided figures for water billed to the Wherry housing complex, and total production supplied to the distribution system, as follows. The difference would include industrial and administrative uses, common area landscapes, the I-40 rest stop and system use and unaccounted-for water.

TABLE A-4 NAVAJO ARMY DEPOT WATER USE		
	2000	*2001*
Housing complex—billed use	9.999 MG	10.180 MG
Total production	42.872 MG	43.486 MG

Total Bellemont Water Use

Adding the data and estimates above produces the following figures for total year 2000 water use in Bellemont or satisfied by wells in Bellemont:

TABLE A-5 WATER USE IN BELLEMONT–TOTAL YEAR 2000	
	Amount
Bellemont local use	50.0 MG
Bellemont standpipes use	14.9 MG
Total Bellemont use	65.0 MG

Growth and Water System Development: Development activity near the Bellemont Travel Center is described above. The center's water system owner believes he has adequate water for this development, but will drill a deep well if and when needed. Substantial areas of vacant private land remain on the south side of I-40. The Bellemont area in general suffers from expansive and low-percolation-rate soils and seasonally high water tables. Thus, development here, though attractive due to proximity to Flagstaff, could be expensive.

Sources:

Bellemont Water Company. Annual report to the Utilities Division of the Arizona Corporations Commission, calendar year 2000.

Coconino County. 1985 (adopted July 1). *Bellemont Area Plan.* Flagstaff, AZ: Coconino County Community Development Department.

Flagstaff Area Regional Land Use and Transportation Plan. 2001 (July). Draft obtained from City of Flagstaff Utilities Department.

Hollister, Cullen. Director of Engineering, Camp Navajo, Arizona National Guard. Phone interview and written communications.

McClain, Nona. Manager, Bellemont Water Company. Phone interviews.

McCleve, Lonnie. General Partner, Bellemont Travel Center. Personal and phone interviews.

DONEY PARK AND VICINITY

Service Area and Water System: Subdivisions and individual residences and businesses northeast and east of Flagstaff make up the 62.5 square mile study area encompassed in the *Doney Park Timberline Fernwood Area Plan*, a January 2001 draft amendment to the *Coconino County Comprehensive Plan*. Thirty-one percent of the land in this area is privately owned. This region is served by the DPW, by individual wells, and by hauling of water to residences. The DPW, a not-for-profit member-owned cooperative, provides water to the vast majority of residences and businesses in the region. DPW's service area includes the unincorporated communities known as Doney Park, located mostly east of U.S. Highway 89; Timberline and Fernwood (a.k.a. Black Bill Park), located further north along highway 89; Cosnino, located southeast of Doney Park off of Townsend-Winona Road and Winona, located further east where Townsend-Winona Road meets Interstate 40.

The 1990 census population for the Black Bill/Doney Park and Timberline/Fernwood areas combined was 5,504. The 1997 population, according to ADES, was 7,294. The 2000 Census has not yet released data for these subcounty areas. As of August of 2001, DPW served 2,687 residential accounts, 104 commercial accounts and 2 wholesale customers located outside the DPW service area (Sunset Crater Volcano National Monument and a National Park Service horse camp).

The DPW's water source is groundwater, tapped by six wells ranging in depth from 1,581 to 1,781 feet. Static water levels in these wells range from 1,261 to 1,504 feet. Four of the wells yield 30 to 120 GPM; two yield 570 and 610 GPM. A seventh well is no longer in production. The company has 29 storage tanks with a total capacity of four million gallons. Most are small (less than 20,000 gallons).

The DPW maintains an extensive network of water distribution lines and booster pumps through much of the region. Because of the expense of extending lines to remote locations, which is borne by the property owners served, and due to the cost of drilling private wells, some property owners choose to haul water. The DPW maintains a standpipe for these users. Some may also haul water from standpipes maintained by the city of Flagstaff.

All water users in this region utilize individual onsite wastewater systems, e.g. septic systems.

Alternative Supplies: No formal programs for alternative supplies currently exist. The DPW's manager believes some residences—certainly less than 10 percent—within the service area practice rainwater harvesting. Some may also reuse graywater, but this is reportedly not commonly acknowledged because state regulations did not permit graywater use until recently. The *Doney Park Timberline Fernwood Area Plan* encourages reuse of treated wastewater and graywater, and "water recapture systems" (see below).

Water Metering and Rates: All water users are individually metered. Rates are as follows:

TABLE A-6 DONEY PARK METERED WATER RATES	
Base Rate/Class	*Volumetric Charges*
General, per month: $18.75 for up to 1,000 gallons (5/8 inch meter	1,000-5,000 gallons: $4.30 per 1,000 Over 5,000 gallons (winter): $6.90 per 1,000 Over 5,000 gallons (May, June, July and August): $8.63 per 1,000
Commercial, per month: $27.00 for up to 1,000 gallons (5/8 inch meter)	1,000-5,000 gallons: $4.30 per 1,000 Over 5,000 gallons (winter): $6.90 per 1,000 Over 5,000 gallons (May, June, July and August): $8.63 per 1,000
Standpipe	$6.90 per 1,000 (winter) $8.63 per 1,000 (May, June, July and August)

These rates have been in effect since 1995. No rate changes are anticipated at the current time.

Water Efficiency and Conservation: The DPW considers price signals its primary water conservation tool. It also supports educational efforts. These include discussion of water conservation in the quarterly DPW newsletter, usually a presentation at the annual meeting in June and an educational event at a local school co-sponsored with the City of Flagstaff in 1999. The DPW also benefits from water conservation TV commercials sponsored by Flagstaff and xeriscaping seminars put on by local nurseries.

The DPW billing staff monitor for large spikes in monthly water use. They notify account holders when spikes are noticed and provide instruction on how to check for leaks.

Unaccounted-for water amounts to approximately 6 percent system-wide. The DPW actively monitors for leaks in the distribution system. The company owns a sophisticated ground-penetrating radar system, which allows it to find old PVC pipes that do not have tracer wires.

Irrigation-dependent landscaping in this area is not extensive. Many homes have no such landscaping. Many have a few trees, shrubs and flowers, but no turf. The DPWs manager estimates that less than half of the residences in the area maintain turf. The higher density subdivisions reportedly have a higher incidence of irrigated landscape.

The *Doney Park Timberline Fernwood Area Plan* includes the most extensive water conservation policy statement of any of the Coconino County area plans. The plan’s water service policies include the following provisions (p. 26-27 of the January 2001 draft):

> The County shall work with DPW to develop and implement specific water conservation policies (e.g., xeriscaping, low-flow toilets, etc.) and shall provide education and incentives for residential implementation of such policies. Because

of the limited resources of DPW, the following water conservation measures shall be supported:

a. Commercial and industrial development shall be limited to low-volume water users.

b. Continued use of water-saving plumbing fixtures shall be required for all commercial and industrial development.

c. The use of drought resistant and/or low water using plants shall be required for landscaping for all development requiring County approval.

d. The use of drought resistant and/or low water using plants for landscaping for single-family dwellings shall be encouraged.

e. Use of water-saving plumbing fixtures in single-family dwellings shall continue to be required.

f. The County shall continue to work with DPW in a public awareness program to educate property owners within the planning area about the problems peculiar to the area and individual conservation measures that can be practiced. This policy should be directed with special emphasis toward new residents prior to construction.

g. The reuse of treated wastewater/graywater shall be encouraged wherever possible for both residential and commercial irrigation and for commercial/industrial purposes.

h. The County shall create policies and fee structure to facilitate the implementation of environmentally friendly water recapture systems.

The area plan's Design Review Overlay Zone further specifies Design Review Guidelines for landscape water efficiency measures for all new commercial, industrial, public and semi-public uses (single-family residential development is specifically excepted):

> Landscaping shall emphasize xeriscape techniques using indigenous plant species and similar species adapted to the local environment. (p. 49)
>
> Landscaping plans shall include a mix of landscape materials such as crushed rock and boulders and a variety of plant types and sizes. All landscape plantings shall be provided with a low-flow irrigation system sufficient to establish and maintain them in a healthy condition. (p. 49)

Water Use: Metered water consumption in 2000 was as follows:

TABLE A-7
DONEY PARK METERED WATER CONSUMPTION IN 2000

Connected accounts	*Standpipe*	*Fire hydrants*	*Total consumption*	*Total production*
216.772 MG	24.288 MG	0.083 MG	241.143 MG	256.001 MG (Ave 0.7 MGD)

Daily average water use per metered account ranged from a low of 156 GPD in winter up to 276 GPD in summer. The annual average daily use per meter in 2000 was 204 GPD.

Standpipe use in 2000 was higher than normal due to highway construction. In 2001, standpipe use totaled 4.203 million gallons. Connected account metered use in 2001, at 213.300 million gallons, was slightly less than in 2000.

The peak water-use month is June. Water use tapers off somewhat in July and August due to the monsoon rains and, according to the DPW manager, "sticker shock" from June water bills. Water use then picks up again in September and October. Seasonal occupation is not a significant factor in seasonal water-use patterns, as almost all homes in the DPW service area are full-time residences.

Ninety-one percent of accounts are residential accounts. The commercial accounts are offices, car lots, convenience stores and other business that are not intensive water users. The DPW board does not welcome high water using businesses. It recently fought a car wash proposal within its service area, and the county denied the proposal.

Growth and Water System Development: Growth has been steady in the DPW service area in recent years. The utility has opened roughly 80 to 110 accounts per year for the last 6 years, with a high of 150 new accounts in 1997.

Most undeveloped land in the DPW area is zoned for 2.5-acre minimum lot sizes. According to DPW, buildout at existing zoning within the current service area would raise the total accounts from 2,793 as of August 2001 to 5,500.

According to its manager, DPW's service area is not likely to expand significantly. There is not much private land in the region that is not already within the service area, and the DPW Board of Directors is unlikely to expand the service area without provision of offsetting infrastructure, such as wells, by a developer. The DPW expects to serve the existing service area to buildout with its existing wells.

The *Doney Park Timberline Fernwood Area Plan* provides an extensive discussion of lot sizes and lot buildout figures that are roughly commensurate with the DPW service area figures. As of January 2000, there were 3,380 lots or parcels in the area plan study area, with about 90 percent occupied. Subdivision of remaining large parcels at current zoning densities would yield 4,737 parcels. Based on development rates for the four years ending in 2000 (72 new homes per year vs. 128 new homes per year for the four years ending in 1996), if all available land were developed at current zoning, buildout would occur between 2015 and 2020. It is worth noting that ADES projects continued significant population growth beyond 2020. The ADES population projections for Black Bill/Doney Park and Timberline/Fernwood are 11,734 by 2020, a 47 percent increase over 2000 and 17,831 by 2050. These projections might require a shift in housing characteristics, changes in the current zoning ordinances and possible development of adjoining Forest Service holdings.

The July 2001 draft *Flagstaff Area Regional Land Use and Transportation Plan* states that average daily water demand is expected to increase 40 percent by 2020 (p. 154). The basis of this projection is not clear.

Sources:

Coconino County. 2001 (July). *Doney Park Timberline Fernwood Area Plan* (Draft). Flagstaff, AZ: Coconino County Community Development Department.

Doney Park Water Company. Annual report to the Utilities Division of the Arizona Corporations Commission, calendar year 2000. Various data tables, 2000. Consumer Confidence Report, 2001. Water rates.

Flagstaff Area Regional Land Use and Transportation Plan. 2001 (July). Draft obtained from City of Flagstaff Utilities Department.

Linville, Bill. General Manager, Doney Park Water Company. Personal interview.

FLAGSTAFF

Service Area and Water System: Flagstaff is by far the largest community in the study area. As the regional business center, it has the most diverse economy, with significant employers including NAU, a number of industrial facilities, all levels of government and many retail and service businesses. As well, the city is a hub for regional tourist activities. It had a total of 4,700 hotel rooms in 1998. The year-round census population in 1990 was 45,857; the 2000 population was 62,710.

The *Flagstaff Area Regional Land Use and Transportation Plan* (July 2001 draft) provides detailed information on the city's water and wastewater systems. Highlights are provided here. Three additional, independent water systems—all very small—serve unincorporated pockets within the city limits of Flagstaff and are described separately.

Flagstaff's potable water supply includes surface water and ground water. Upper Lake Mary, a manmade reservoir, has a capacity of 5 billion gallons. Inflows to the lake vary substantially from year to year. On a long-term basis, the reliable annual yield is estimated to be 855 MG. A second surface water source is the Inner Basin of the San Francisco Peaks. Wells also access the water available from this source. The long-term reliable annual yield of the Inner Basin is estimated to be 241 MG.

The city's groundwater sources include 6 wells near Lower Lake Mary, 10 wells in the Woody Mountain well field and 2 new wells in parks within city limits, on the east side. Most are 1,000-2,000 feet deep. These wells can reliably produce 3,554 MGY.

In total, the city's current potable supplies have long-term reliable yields as follows:

TABLE A-8
FLAGSTAFF POTABLE SUPPLIES, LONG-TERM RELIABLE YIELDS

	Millions of gallons per year	*Acre-feet per year*
Upper Lake Mary	855	2,624
Inner Basin	241	740
Groundwater	3,554	10,907
Total	4,650	14,270

In wet years, as much as 70 percent of the city's water supply is drawn from Lake Mary, and the well fields are rested. Dry years have occurred when Lake Mary has been drawn down nearly to empty. In an extended drought, both Lake Mary and the Inner Basin supplies could be unavailable, and Flagstaff would have to rely on its groundwater supplies alone. The city's groundwater supplies are currently sufficient to satisfy all its demand (though some peak summer day shortfalls could be possible). The city is actively pursuing a variety of approaches, detailed below, to address its future supply/demand balance.

Flagstaff has two water treatment plants. The Lake Mary Water Treatment Plant has a capacity of 8 MGD, and the Reservoir Filtration Plant, which services the Inner Basin sources, has a capacity of 2.5 MGD. Storage capacity across the system is 22.9 MG.

The water system includes bulk water sales from three standpipes located in northeast, central and southeast portions of the city. These offer coin-operated (quarter) sales as well as metered sales for water haulers. The city also provides a number of metered hydrants for the Coconino National Forest to use in filling trucks for fire fighting. Standpipe water sales in 2000 totaled 22.3 MG, or about 0.8 percent of total consumptive use for the City.

The city has two wastewater treatment plants. The Wildcat Hill Wastewater Treatment Plant has a capacity of 6 MGD. The Rio de Flag Wastewater Reclamation Plant can treat up to 4 MGD. The collection system is almost entirely a gravity flow system. A few facilities are too low to utilize gravity flow; these have been required to build and maintain their own pumping systems. Infiltration and inflow in wet weather have historically caused sewer overflows in some portions of the collection system. The city has addressed some of the problems. It will eventually have to build a sewage pump station to address one difficult area.

Alternative Supplies: Since 1980, effluent from the city's wastewater plants has been used for golf course irrigation. A 1990 bond issue allowed the city to build the 4 MGD Rio de Flag Wastewater Reclamation Plant to increase wastewater treatment capacity and provide reclaimed water distribution on the west side of Flagstaff. Construction was completed in 1993. Since that time, Flagstaff has extended the distribution system. Current reclaimed water users—27 accounts as of 2000—include two golf courses, cemeteries, NAU and many of the city's recreational facilities, public landscapes and school grounds and athletic fields. In 2000, 504 MG—23 percent of the city's sewage effluent—was reused. A new golf course will use reclaimed water beginning in 2002.

Further extensions of the reclaimed water lines are anticipated; as they are less costly than drilling new groundwater wells ($2-2.5 million per well). Four more schools and two more parks will be connected in the next two years. The potential for expansion of reclaimed water use is significant—at the present time, the city can produce about 3.5 MGD of reclaimed water, and about 3 MGD are not yet utilized. Continued growth will increase the potential effluent supply, and the city could produce additional reclaimed water with existing treatment capacity by increasing reclaimed water storage facilities. Thus, the city expects reclaimed water use will be an important part of meeting future water demand, particularly peak summer irrigation demand.

The city is actively recruiting new reclaimed water customers. The cost of connecting to the system is rebated to the customer, giving an added incentive to the reduced water rate for reclaimed water. In addition to more commercial/institutional landscape customers, the city hopes to eventually connect some residential landscapes, now that ADEQ reuse regulations have changed to allow this. While there are currently no non-irrigation accounts on the system, the water is of sufficient quality for many industrial uses. The city has prepared some analyses of cost savings for industrial customers. City staff has visited the Tusayan reclaimed water system, but toilet use of reclaimed water has not been implemented in Flagstaff to date. It should be noted that new water uses that would not displace current or anticipated potable water demand have also been proposed. These include snowmaking use at the Arizona Snowbowl and winter filling of Lower Lake Mary for fishing.

Surprisingly, the largest private landscape owner in the city, Northern Arizona University, uses reclaimed water on only one athletic field. With sponsorship from the city, NAU, and Arizona Public Service, an engineering graduate student, Abigail Roanhorse, is currently preparing a feasibility study of converting the campus irrigation system to reclaimed water. Because NAU's peak day irrigation demand is equivalent to a 400-500 GPM well, the water supply benefits to the city of such a conversion are very significant. The study will inventory the irrigation system, develop a preliminary reclaimed water distribution system design and prepare an economic analysis of benefits to the university.

The extent of rainwater harvesting and graywater use at individual houses or other buildings in Flagstaff is not known, but is probably very small.

Water Metering and Rates: All water users in Flagstaff are metered. Most multi-family buildings are sub-metered. Some shopping centers and trailer parks use master meters instead of sub-metering each tenant. Current water and sewer rates are shown in Table A-9. All are billed on a monthly basis except for off-peak reclaimed water use.

The city has used its rate structure as a conservation tool. In 1990 it changed from a declining block structure to a two-tier inclining block structure for single-family homes. In 1997, the third tier was added, increasing costs for very high water uses (and the 1st and 2nd tier rates were reduced to give savings to average users). These changes reportedly produced noticeable reductions in water use in subsequent years. A new sewer rate schedule will go into effect in July of 2002.

Water Efficiency and Conservation: Flagstaff has an active water efficiency and conservation program. Three main groups promote and administer the city's water conservation efforts, as described by the director of the utilities division:

> First, the city has a Water Commission made up of appointed citizens that serve in an advisory capacity on water issues to the City Council. They are not paid and are selected from applicants who share strong interests in the development and use of the City's water resources. This commission evaluates the progress of water conservation efforts and determines if satisfactory results are being obtained. Basically, if the commission believes the efforts need to be stronger or new conservation measures should be put into place, a recommendation is made to the Utilities Department and City Council. The most significant conservation measures that have evolved from this group have to do with rate structures…
>
> The Utilities Administration Division is the second group that plays an active role in the water conservation efforts. It is responsible for bringing initiatives to the Water Commission such as the bond program to construct the City's water reclamation plant and dual water distribution system. This division does the planning, provides for design and construction and determines how the system will operate…
>
> Finally, the responsibility for the continuity of the City's water conservation program is its Water Conservation Committee. Made up of employee representatives from various City departments, the 8-member committee is

presently chaired by the supervisor of the water reclamation plant. Having been in existence for over 16 years and having its own operating budget, the committee has many successful conservation programs and initiatives to its credit. (Ron Doba, pers. comm. 2001)

In addition to the wastewater reclamation system and the inclining block conservation rate structure described previous sections, Flagstaff has undertaken the following water efficiency and conservation activities:

- A toilet rebate program. Customers receive a rebate of 50 percent of the cost or up to $100 per toilet being changed out. This amount is in-line with typical rebates offered by other cities nationwide. Initiated in fiscal year 1991/92, the program has rebated change-outs of 3,382 toilets.

- Conservation education. The Water Conservation Committee designs and staffs booths at home shows and other events in the community. It puts together education programs for local schools, including curricula for teachers and elementary school puppet shows. It provides tabletop water conservation messages to restaurants at no charge. Each summer, the committee has public service announcements on water conservation televised. The city runs conservation messages in the local newspaper about every week, and an insert section every quarter. In addition, taped water conservation messages are played to customers calling city hall that are put on hold.

- Conservation demonstrations. The city has developed xeriscape demonstration gardens at the water reclamation plant, the city library and a neighborhood water line booster station. It regularly provides tours of the reclamation facilities to the public. The conservation committee has held xeriscape competitions for private landscapes.

- Water shortage conservation ordinance. Adopted in 1988, the ordinance establishes levels of mandatory conservation practices to be put in place during water shortages. It defines four levels of resource status, and four corresponding water conservation levels with increasingly stringent advisories, restrictions and prohibitions on specific water uses (e.g., landscape irrigation, car washing, pool filling, ornamental fountains, etc.) To date, the city has not had to invoke the ordinance.

- A hotel audit program. Conducted about 15 years ago, this included distribution of free low-flow showerheads. Unfortunately, water savings produced by the program could not be determined because hotels were unwilling to give out their occupancy rates.

According to the utilities director, Flagstaff is an environmentally conscious city. The population endorses water conservation. While it is hard to sort out the exact impacts of the water conservation efforts without normalizing for variations in weather and the economy from year-to-year, the water-use figures below do show that water use has not risen as fast as population, indicating that conservation measures are having an effect.

TABLE A-9 CURRENT WATER AND SEWER RATES	
Water-meter charge	$6.48 for a 3/4" meter, plus 9 charge increments up to: $207.60 for a 12" meter
Water-volumetric charges	
Single-family residential	$2.83/1,000 gallons, 0 to 5,000 gallons $3.32/1,000 gallons, next 10,000 gallons $4.71/1,000 gallons, over 15,000 gallons
Multi-family, mobile home, commercial, church and schools	$2.97/1,000 gallons
NAU	$2.62/1,000 gallons*
Industrial	$2.70/1,000 gallons
Landscape meters	$2.83/1,000 gallons, 0 to 5,000 gallons $3.32/1,000 gallons, next 10,000 gallons $4.71/1,000 gallons, over 15,000 gallons
Sewer (no base charge; all charges are volumetric and based on water use)**	
Single -family, multiple-family and mobile home residential	$2.73/1,000 gallons***
Hotels, motels	$3.58/1,000 gallons
Restaurants	$4.42/1,000 gallons
Industrial laundries	$3.92/1,000 gallons
Car washes, laundromats, commercial, industrial	$2.67/1,000 gallons
NAU	$2.35/1,000 gallons*
Waste haulers	$80.00/1,000 gallons
Standpipe water	$5.25/1,000 gallons
Reclaimed water on-peak (users without their own storage capacity)	
NAU	$2.01/1,000 gallons*
Industrial	$2.06/1,000 gallons
All other irrigation (city, hospital, schools)	$2.81/1,000 gallons
Reclaimed water off-peak/as available delivery (users with their own storage), high volume users; billed annually	$1.00/1,000 gallons, 1st 50 MGY $0.80/1,000 gallons, 2nd 50 MGY $0.60/1,000 gallons, 3rd 50 MGY $0.40/1,000 gallons, 4th 50 MGY $0.20/1,000 gallons, all units over 200 MGY

*The rate for NAU is less because the university maintains many of the distribution/collection lines, valves, etc. on campus, saving the city time and expense.

**Additional charges for grease, sludge, sump waste, high biochemical oxygen demand and high-suspended solids are also imposed.

***Flat fee each month based on winter quarter average water use. All other sewer charges are based on actual water use each month.

City staff continue to evaluate possible new conservation initiatives. The Water Conservation Committee is currently considering a rebate program for residential hot water recirculating systems.

In addition to the general efficiency/conservation suggestions provided elsewhere in this report, the study team noted a few specific, potentially "missed opportunities" in Flagstaff. Flagstaff does not have a full-time water conservation coordinator, as do some cities of its size. However, the Water Conservation Committee appears to successfully fill many of the same functions. The city does not have any turf area limitation ordinances in place. These are common in many Southwest cities. Also, the utilities director indicated that Flagstaff does not have a precise handle on unaccounted-for water. A discrepancy between production and billings exists, but how much meter slippage is occurring is not clear. The city does not have an active leak detection program. Leaks are thought to show up readily due to shallow line depths, and are fixed as they become evident. The capital improvement plan is also replacing over the long term a number of undersized mains, which are likely suspects to develop leaks, as they are usually older pipes.

The city's largest water customer, by far, is NAU, which uses about 8 to 10 percent of annual consumption in Flagstaff. Water efficiency at the university is probably low. The Roanhorse study mentioned in the alternative supply section above has found that the application rates of the majority of landscape sprinklers on campus exceed the soils absorption capacity, resulting in water wasting runoff. (This is likely to be true for many other landscapes in Flagstaff.)

Water Use: Total water demand in Flagstaff consists of potable water production, which includes billed water and unaccounted-for water, plus reclaimed water use. Water production includes process water use at the treatment plant, because that water is recycled back into the water supply system. The city provided the following historical data in table A-10.

TABLE A-10
FLAGSTAFF WATER USE, HISTORICAL DATA

	Potable Water Production (MGY)	*Reclaimed Water Use (MGY)*	*Total Water Demand (MGY)*	*Total Water Demand (Acre-feet/yr)*
1985	2,365	0	2,365	7,258
1986	2,221	0	2,221	6,816
1987	2,499	0	2,499	7,669
1988	3,241	0	3,241	9,946
1989	2,946	0	2,946	9,041
1990	2,748	0	2,748	8,433
1991	2,650	0	2,650	8,133
1992	2,490	0	2,490	7,642
1993	2,678	Partial year	>2,678	>8,219
1994	2,523	390	2,913	8,940
1995	2,562	393	2,955	9,069
1996	2,750	453	3,203	9,830
1997	2,591	354	2,945	9,038
1998	2,588	313	2,901	8,903
1999	2,602	360	2,962	9,090
2000	2,934	504	3,438	10,551

Flagstaff has the most detailed information available in the study area on sectoral and seasonal water-use patterns. A sectoral water-use analysis (i.e., examining changes within just the residential sector and other sectors), normalized for annual weather variations and possibly economic conditions, would likely show the impacts of Flagstaff's water conservation activities.

Figure VII-1 and Figure VII-2 presented earlier in this report show the seasonal variations and relative magnitude of water use among Flagstaff's customer classes. Peak summer demand in Flagstaff is about double the average winter demand. Average and peak day use in 1998, both still reflective of current conditions, were 7.2 and 12.9 MG, respectively.

It is clear from the study team's fieldwork that landscape water use in Flagstaff is much more widespread than in many other communities in the study area. This is as expected for an urban/suburban community of Flagstaff's size. Use of evaporative coolers, a significant water use in some Southwest cities, is small in Flagstaff.

Growth and Water System Development: After reductions and steadiness—despite increasing population and new employers—in potable water demand during the 1990s resulting from rate structure changes, implementation of the water reclamation system and conservation programs, the city utilities director believes that potable water use is beginning to move upward again.

The *Flagstaff Area Regional Land Use and Transportation Plan* (July 2001 draft) discusses Flagstaff's future water needs in some detail. Significant population growth is expected to continue for the foreseeable future. While some localized infrastructure and other constraints exist, there is no reason to expect these cannot be overcome or growth will not continue in other portions of the city.

Based on the ADES population projections and the system-wide average per capita water use of 122 GPD for 1997-99, the regional plan projects Flagstaff's potable water demand will be 11,000 acre-feet per year in 2020. Potable supplies are 14,270 acre-feet per year currently. Total demand would also include reclaimed water use, but that use is not projected. Reclaimed water would also add to the total available water supply but is not counted by the city in the regional plan's supply figures because its use is discretionary. Should reclaimed water use be disallowed or should large numbers of users choose to use potable water instead—both unlikely developments—the city's potable water demand would increase.

While the near-term supply/demand balance is positive, problems could still be experienced. A drought of three years or more would stress the city's water supplies. Wells decrease in capacity and reliability as they age. Peak summertime demand could exceed available capacity. Peak demand in 2020 is projected to be 17.8 MGD, less than the current supply of 27.3 MGD if all sources are on-line, but significantly more than the current, reliable groundwater sources alone—10.8 MGD if all wells are working at capacity. For these reasons, Flagstaff is pursuing the following options to improve the supply/demand balance:

- Additional wells. The city hopes ongoing USGS studies will help the city locate sites for additional 6 to 8 wells before 2020. Its capital improvement plan provides for two new wells by 2010.

- Possible participation in the proposed Lake Powell pipeline. According to the draft regional plan, Flagstaff's interest in the proposed Lake Powell pipeline is to replace surface water from Upper Lake Mary during years that surface water is not available due to poor runoff. The regional plan also mentions a possible pipeline from Clear Creek.
- Expansion of the reclaimed water system and promotion of its use.
- Continuation and expansion of the water efficiency and conservation programs. Additional savings from these efforts are not included in the demand projection above.
- Water re-purification. Potable water reuse has been proposed, but is not currently feasible because of public perception issues.

The city expects its wastewater treatment plants will have adequate capacity for growth anticipated through 2020.

The regional plan also presents projections for water use in 2099 of 27,000 acre-feet per year (based on extrapolation of historical rates of use from 1949 to the present) and 75,000 acre-feet per year (based on a continual increase in water use at the rate experienced 1983 through 1989—8 percent per year). Water projections based on extrapolation of past water-use patterns are biased by the time period selected for the extrapolation without an understanding of changes in demographics and water-use efficiency during the selected time period.

In addition to general recommendations in other sections of this report, it is worth noting here that Flagstaff is in a somewhat different and more advantageous position to address future water demand than some other study area communities. The higher prevalence of landscape water use in Flagstaff presents the city with both a "burden" and an opportunity. Increased landscape irrigation efficiency, substitution of reclaimed for potable water, and incremental conversions to xeriscape over the long-term provide many cities with some of their best ways to defer, downsize, or avoid water supply expansions. Flagstaff is similarly situated with respect to commercial, institutional, and industrial water uses—these uses are prime "targets" for initiatives. In the study team's experience, no communities have yet fully tapped the opportunities for efficiencies and source substitution in these sectors.

Sources:

City of Flagstaff. Data sheets on potable water production, potable water billings/consumption by class, reclaimed water billings by account. Rate ordinances.

Doba, Ron. Utilities Director, City of Flagstaff. Personal interview and written communications.

Flagstaff Area Regional Land Use and Transportation Plan. 2001 (July). Draft obtained from City of Flagstaff Utilities Department.

Roanhorse, Abigail. Undated (apparently 2001). "Reclaimed Water Feasibility Study for the Campus of Northern Arizona University." 5 page study status report obtained from the author.

U.S. Forest Service. 1999 (July). *Final Environmental Impact Statement for Tusayan Growth, Coconino County, Arizona*. Williams, AZ: U.S. Department of Agriculture, Forest Service, Kaibab National Forest.

FLAGSTAFF AREA—SMALL SYSTEMS

Three small water systems, independent of the City of Flagstaff and regulated by the ACC, are located in unincorporated pockets within the Flagstaff city limits. Their annual reports to the ACC Utilities Division for calendar year 2000 provide the following information:

TABLE A-11
FLAGSTAFF AREA SMALL WATER SYSTEMS

Company	*Water source*	*Storage*	*Production*	*Water sold*	*Number of Customers*
Heckethorn Water Company	1 well @ 55 GPM	16,000 gallons	4.334 MG	4.334 MG	44
Mountain Dell Water, Inc.	2 wells @ 15 & 19 GPM	40,000 gallons	6.701 MG	6.255 MG	86
West Village Water Company	1 well @ 35 GPM	Not reported	Not reported	3.735 MG	72
Totals	4 wells	>56,000 gallons	>14.770 MG	14.324 MG	202

The total water demand represented by these systems is dwarfed by the City of Flagstaff's water demand. They have an insignificant impact on the local water supply/demand balance. For this reason, the study team did not further investigate these systems.

Sources:

Heckethorn Water Company. Annual report to the Utilities Division of the Arizona Corporations Commission, calendar year 2000.

Mountain Dell Water, Inc. Annual report to the Utilities Division of the Arizona Corporations Commission, calendar year 2000.

West Village Water Company. Annual report to the Utilities Division of the Arizona Corporations Commission, calendar year 2000.

FLAGSTAFF RANCH

Service Area and Water System: Flagstaff Ranch is an 850 acre development located along Interstate 40 just west of the Flagstaff city limits. The area is in initial stages of development. It includes three sections:

- The Flagstaff Ranch Golf Club Residential Community. This is a private golf course master planned community of 408 acres. Approved for 525 residential units by the county, the developer plans 455 units: 297 single-family detached units, 90 townhomes, and 68 condominiums. The golf course will have 18 holes and a practice range. A clubhouse, community center, sales office, and maintenance facility are included. The course is now under development. Residential development will follow in coming years.

- The Westwood residential sector. Its roughly 40 currently built units will increase to 80 at buildout.

- The Flagstaff Business Park. Current occupants of this area around the I-40/Flagstaff Ranch Road interchange include Waste Management and a Coca-Cola distributing center. A convenience store is likely, and hotels and other commercial and industrial establishments are possible.

Domestic water is and will be provided by the private Flagstaff Ranch Water Company. Its system currently uses a single well and a 595,000-gallon storage tank. In addition to connected users, the water company currently sells water via a standpipe to about a half-dozen bulk water users, including the Woody Mountain trailer park, several small haulers, and construction water users.

The golf course will develop additional wells for irrigation, and will provide some water to the water company for domestic use. The course will include ponds for additional storage.

Each portion of the development has or will provide its own wastewater services. For instance, the Westwood residential complex uses a cluster system of individual treatment tanks for each unit, with the effluent piped to common disposal field. The existing commercial users each have onsite treatment and disposal systems. A separate system for the golf course, the Flagstaff Ranch Mutual Waste Water Company, is under construction.

Alternative Supplies: The golf course's wastewater treatment plant will produce tertiary treated effluent. One hundred percent of the effluent will be reused. It will be mixed in the golf course ponds with groundwater and subsequently applied to the course for irrigation. The developer anticipates that treated effluent will provide for perhaps 10 to 15 percent of the irrigation needs.

Additionally, surface runoff and subsurface flows from the business park area drain toward the golf course. A French drain will intercept and route these flows to a golf course storage/irrigation pond. Another storage/irrigation pond will capture runoff from the clubhouse parking lot.

Water Metering and Rates: Water rates for current users are as follows:

TABLE A-12
FLAGSTAFF RANCH WATER COMPANY WATER RATES

	Monthly Service Charge	*Volume Charge*
Domestic	$27.00 (includes 1,000 gallons)	$2.95 per 1,000 gallons
Commercial	$90.00	$2.95 per 1,000 gallons
Bulk (standpipe)	$27.00 (includes 1,000 gallons)	$5.30 per 1,000 gallons

Water Efficiency and Conservation: The golf course developer noted that turf on residential properties will only be allowed within a limited (30 foot) building envelope on each lot. He expects that many residents will choose to forego turf areas.

Water Use: Current water use is small given the newness of the development. The water company sold 7.5 MG in 2000 to 56 customers. Over half of the water sales were to construction water users.

The golf course developer expects that the housing units in that community will be primarily secondary residences. Given this and the large seasonal needs of the golf course, water use will vary significantly from winter to summer.

Growth and Water System Development: Planned growth is outlined in the service area description above. The golf course, once established, will have significant irrigation requirements. The developer estimates it will use 50 to 60 MGY. He expects residential water use in the golf community will be similar on a per unit basis to residential use at Forest Highlands, a mostly built-out private golf course community just south of Flagstaff. Flagstaff Ranch will have a similar clientele to Forest Highlands.

The developers project total water use of 250 acre-feet per year (81.5 MGY) at buildout for the entire 850 acres. However, the final figure will depend heavily on the types of commercial and industrial establishments that eventually occupy the business park. Some developable land exists around Flagstaff Ranch that could potentially be taken into the water company's service area.

Sources:

Dreiseszun, Herbert. Secretary/Treasurer, Flagstaff Ranch Water Company. Phone interview.

Flagstaff Ranch Golf Club. "Flagstaff Ranch Golf Club Residential Community Description."

Flagstaff Ranch Water Company. Annual report to the Utilities Division of the Arizona Corporations Commission, calendar year 2000.

Mehan, James. Manager, Flagstaff Ranch Golf Club. Personal interview.

FOREST HIGHLANDS

Service Area and Water System: Forest Highlands is a private golf course community located several miles south of Flagstaff, immediately east of Highway 89A, and immediately west and north of Kachina Village. The roughly 700 existing homes are predominantly used in the spring to fall golf season; only 10-15 percent are occupied year-round. Population data for Forest Highlands are not available.

The for-profit Forest Highlands Water Company (FHWC) manages water systems for domestic use and irrigation of the Canyon and Meadows golf courses, which have a total of 36 holes. It currently operates seven wells ranging in depth from 1,200 to 1,350 feet. Three of the wells are operated strictly for nonpotable use—golf course irrigation. The remaining wells provide potable quality water for domestic use. Well production ranges from 85 to 150 gallons per minute. FHWC has drilled two new wells and is currently awaiting certification of these wells for drinking water purposes. The company has one 500,000 gallon drinking water storage tank.

In total, the Forest Highlands wells have significant production capacity, but the heavy irrigation needs of the two 18-hole golf courses create a deficit in the FHWC water balance for May to July. This is managed by storing water pumped in winter months and by reusing wastewater effluent. The system includes 8 million gallons of open tank storage for mixing irrigation well water and treated wastewater effluent (two additional 8 million gallon facilities are approved by ADEQ but not built). FHWC also has an agreement to store 3 million gallons of treated wastewater effluent in the Kachina Village wetlands and pump back up to 80% of what is stored on an annual basis.

Wastewater services are provided by a separate community company operated by the same management team as FHWC. This system uses pressurized sewer lines and an activated sludge treatment plant.

In an emergency (e.g. for fire supply) the Kachina Village and Forest Highlands water systems can be connected with fire hoses. A piped linkage is planned.

Alternative Supplies: All wastewater from homes and buildings at Forest Highlands is reused for golf course irrigation. The wastewater treatment facility produces tertiary quality effluent that meets ADEQ A- ("A minus") effluent standards. Denitrification is not included in the treatment process because nitrate in the reclaimed water has nutrient value for the golf course turf. Treated effluent is released to the 8 million gallon storage tank, where it is mixed with groundwater prior to irrigation.

In addition to the 3 million gallon treated effluent storage agreement with Kachina Village, Forest Highlands also has an agreement in place to purchase up to 10 million gallons of Kachina Village's treated effluent as needed and available. The two utilities have cooperated to build a tertiary treatment wetland at the Kachina Village evaporation wetland complex to provide the treated effluent. (See the Kachina Village system profile for a description of this system.)

Forest Highlands may be able to obtain additional treated effluent if such transfers do not harm the Kachina Village wetlands habitat complex. It is not yet clear how often Forest Highlands will need the excess effluent, or how often Kachina Village will be able to provide it. In wet years purchases may not be necessary, and in dry years Kachina Village effluent may be needed to maintain the wetlands.

Rainwater collection is not practiced in Forest Highlands. Due to water rights concerns, runoff cannot be utilized as a supply. For example, developed areas of the new Unit 5 drain to a single catch basin. Water could be easily captured for onsite use, but instead is pumped to and distributed through nearby forest land to infiltrate and recharge groundwater and thereby avoid diversion of the natural water flow.

Water Metering and Rates: All homes and facilities at Forest Highlands are individually metered. Sewer charges are based on metered water use. Current water and sewer rates are:

TABLE A-13
FOREST HIGHLANDS WATER AND SEWER RATES

	Monthly Service Fee	*Rate Per 1,000 Gallons*
Water	$25.00	$2.00
Sewer	$30.00	$2.00

Prior to June of 2001, there was no volumetric charge for sewer service and the sewer service fee was $28.00 per month. A rate change to provide a base volume of sewer services within the service fee is currently under consideration.

Water Efficiency and Conservation: Domestic water conservation activities and results are somewhat limited. According to FHWC staff, "conservation" is not considered a favorable word with customers, so the term "Conscientious Water Management," is used instead. However, staff feel that customers are responsive to water use instructions. For instance, in the summer of 2000 the Arizona State Land Department put out a message that highly recommended supplemental watering of the trees around homes because of increased temperatures and two dry winter periods in a row. As a result of this recommendation, the amount of water used for home landscape irrigation almost doubled overnight. The FHWC conservation education program began just after the Land Department message was released. Homeowners responded to this program by cutting back their landscape irrigation to historical levels.

The water company monitors for meter read spikes, and calls seven to ten houses every month to alert the owners to dramatic increases in water use. Staff will assist customers in locating on-premise leaks. Leaks and breaks in landscape irrigation lines are a common problem.

Residents complained about adjustments that reduced flush volumes in clubhouse toilets, so those flushometer units were re-adjusted to standard flush volumes. Low-flush urinals have been more successful. Many houses in the community were built prior to the advent of functional 1.6 GPF toilets. It is likely that most such homes still use 3.5 GPF models.

Another unfortunate phenomenon is that most of the residential irrigation systems use automatic clock controllers. Many are not set for proper irrigation amounts and intervals, and few are adjusted for changes in plant evapotranspiration requirements as the irrigation season waxes and wanes. In 2002 FHWC has lowered the water distribution system pressure by 10 psi. This should reduce the amount of water that would otherwise be used by home landscape irrigation systems. Also, because of water conditions produced by the extremely dry winter of 2001-2002, FHWC has asked its customers to voluntarily comply with the City of Flagstaff's mandatory restrictions on home landscape irrigation. (Forest Highlands is completely independent from the City of Flagstaff.)

Irrigation-dependent landscaping is more common in Forest Highlands than in many other communities in the study area. However, the Covenants, Conditions, and Restrictions for newer portions of the development prohibit turf in house yards.

Water efficiency activities on the golf courses are more advanced. The computer-controlled irrigation system includes soil moisture monitors. The system is carefully designed to prevent surface runoff of irrigation water, because ADEQ does not permit unnatural runoff to tributaries to Oak Creek, a "Unique Water of Exceptional Significance." Also, sulphur burners are used with the irrigation wells to soften water and lower pH. This treatment increases the soil penetration of applied irrigation water, further reducing runoff.

FHWC endeavors to reduce or eliminate leakage from man-made lakes and streams on the golf courses. Over the last three years it has installed liners in three lakes and one stream that had obvious leaks, producing a decrease in the amount of make-up water required to keep these water features filled. The company has also completely abandoned one smaller water feature, after attempts to eliminate leakage there were unsuccessful. In 2002, the company will compare evaporation rates to the amount of water used in the lakes, to identify and quantify any remaining leaks.

Distribution system leakage is slight. The unaccounted-for water rate is reportedly less than five percent.

Water Use: In recent years ground water production at Forest Highlands has totaled 200–220 million gallons annually. Well production for 2000 was 200.7 MG, or 0.55 MGD. Metered domestic water use in 2000 totaled 110.3 MG, or 0.30 MGD. The large difference between production and metered use is due to irrigation of the golf courses from the nonpotable supply wells. Total water demand for the development also includes reclaimed water use on the golf course. On average, 44% of the annual metered use is indoor use that flows to the wastewater plant, where it is treated and sent to storage for irrigation. Using these figures, total water use in 2000 was as follows:

TABLE A-14
FOREST HIGHLANDS WATER USE IN 2000

Domestic uses (potable ground water)	110.3 million gallons
Golf course use (nonpotable)	
Ground water	90.4 million gallons
Treated wastewater effluent	48.5 million gallons
Total Water Use	249.2 million gallons

Note that treated effluent accounted for 35% of the golf course use, and 19% of total water use.

Water use per account in the residential accounts averages 191 gallons per day per account. Monthly variation in residential average use ranges from a low of 30.4 GPD per active account in February up to 395.6 GPD per active account in August. This extreme variation is due in part to the seasonal occupancy of homes and in part to summer residential irrigation. In the summertime, domestic wastewater flows average about 30–35 percent of domestic water sales, indicating that about 65–70 percent of summertime water use is for landscape irrigation.

The irrigation season for the golf courses typically runs from April to October. Staff noted that in some years the season is longer, and such years are becoming more frequent. November through March, excess well water is pumped into the 8 MG storage tank to be used during the summer irrigation period.

Growth and Water System Development: At buildout Forest Highlands will have just under 900 housing units, plus two clubhouses and a few other community facilities. At current building rates, buildout will occur by roughly 2008–2010.

Sources:

Forest Highlands Water Company. Annual report to the Utilities Division of the Arizona Corporations Commission, calendar year 2000. Data sheets on water production, consumption by class. Water rates. Consumer Confidence Reports, 2001.

Stephen, Dennis. Assistant Director of Public Works, Forest Highlands Water Company. Personal and phone interviews.

Strauss, Bill. Director of Public Works, Forest Highlands Water Company. Written communications.

FORT VALLEY

General description and status: Fort Valley is an unincorporated region northwest of the City of Flagstaff, along U.S. Highway 180. It includes a strip of private land immediately adjacent to the Flagstaff city limits, and a second, somewhat larger area of private land in the vicinity of Snowbowl Road and Bader Road, roughly three miles from the city limits. Widely scattered, mostly site-built homes on one-half to 2.5 acre lots and larger parcels characterize the development pattern of Fort Valley. As of 1988, the area had 253 residential buildings. A few commercial establishments exist in the area.

The *Fort Valley Area Plan*, approved by Coconino County in 1990, noted the rural character of the area and set forth policies to maintain that character. Due to its proximity to Flagstaff, the Fort Valley area has experienced continued growth. Development pressure is likely to increase, and proposals for urban/suburban density projects are not unlikely.

ADES includes Fort Valley among the designated named population places (NPPs) within Coconino County for which it prepares historic population data and population forecasts. Fort Valley's 1990 census population was 534; the 1997 population was 886. The 2000 Census populations for the NPPs are not yet complete.

Water supplies in the area are predominantly individual and shared wells that tap a shallow (approximately 200 feet deep) perched aquifer. Some residents haul water from City of Flagstaff standpipes. As in other remote areas, some utilize the services of a commercial water hauling company rather than hauling water themselves. Some rainwater collection probably occurs. The area plan indicates that many wells in the area suffer from water level fluctuations and fail in extended dry periods.

Standard septic and leach field wastewater systems serve most homes in the area. According to the area plan and the more recent *Flagstaff Are Regional Land Use and Transportation Plan* (July 2001 draft), standard onsite systems are not suitable for some portions of the area due to high water tables. Alternative onsite systems, such as above-grade mound systems, are required in these locations.

Sources:

Coconino County. 1990 (adopted February 20). *Fort Valley Area Plan.* Flagstaff, AZ: Coconino County Community Development Department.

Flagstaff Area Regional Land Use and Transportation Plan. 2001 (July). Draft obtained from City of Flagstaff Utilities Department.

Towler, Bill. Community Development Director, Coconino County. Personal interview.

GRAND CANYON VILLAGE

Service Area and Water System: Grand Canyon Village is the main visitor, administrative, and residential complex on the South Rim of Grand Canyon National Park. Park visitor facilities, and facilities and homes for park and concessions employees compose the village. Its 1990 year-round population was 1,499; the 2000 population was 1,460. Seasonal employees increase the summer residential population. The *Final Environmental Impact Statement for Tusayan Growth* (U.S. Forest Service 1999) estimated this increase at 40 percent in 1990. Total Park visitation, of which visitation to the South Rim is by far the largest part, has ranged between 4,500,000 and 5,000,000 persons per year since 1992. According to some staff this may be indicative of the "carrying capacity" of the park based on the quality of the visitor experience (i.e., more visitors may not come because of a sense of overcrowding). The average visit is about 2 to 4 hours. Thus, a very high percentage of visitors are day visitors who travel on to other sites and locations in the region.

The village includes a school, library, bank, post-office, medical clinic, fire station, non-denominational church, a number of administration and maintenance buildings, a visitor center, and various visitor service establishments. A concessionaire, GCNP Lodges, operates all 907 hotel rooms (including 15 rooms at the bottom of the Grand Canyon at Phantom Ranch), as well as restaurants, gift shops and other establishments. The Village also has RV and camping spaces available. In 1998, retail space totaled 58,872 square feet and restaurant space totaled 63,121 square feet.

Water for Grand Canyon Village comes from Roaring Springs, located at 4,280 feet in Bright Angel Canyon, a Colorado River tributary draining from the North Rim of the Grand Canyon. The Trans-Canyon Pipeline brings a constant 700 GPM (about 1 MGD) down Bright Angel Canyon across the Colorado River, and up by gravity head siphoning to Indian Gardens, at 4,000 feet. From there water is pumped on an as-needed basis, typically about 12 hours per day, up a directional bore through canyon rock to storage tanks (totaling 14 MG) at 7,000 feet on the South Rim near the village. Water distribution lines run from the tanks to village buildings. Excess water from the pipeline at Indian Gardens overflows back into the Canyon and flows into the Colorado River. Water is chlorinated at Roaring Springs but does not require other treatment.

A 25-mile long 6-inch pipeline delivers a small amount of water to Desert View, a small visitor complex on the South Rim east of Grand Canyon Village. In addition, the Park Service trucks a small amount of water to a Forest Service ranger station just outside the park boundary, near Tusayan. The Park Service has also in the past allowed an Indian Nation, a private water hauler, and the Tusayan Water Development Association (TWDA) to haul water from the park. All three users have been cut off within the last few years. Legislation allowing TWDA to access up to four million gallons per year is still in place, but a dispute over Tusayan wells has caused the Park Service to cut off any deliveries.

The Trans-Canyon Pipeline suffers from periodic breaks due to floods and other natural hazards in the canyons it traverses. The Park Service must repair it regularly. While this water system does not affect Coconino Plateau ground water conditions and springs and seeps below the South Rim, it does have impacts on springs and other sites in Bright Angel Canyon considered sacred by local Indian tribes, and for which the Park Service has trust responsibilities. Alternative water sources and delivery systems are under study by the U.S. Bureau of Reclamation.

Water use within the Park is currently limited by wastewater treatment capacity. Wastewater treatment for Grand Canyon Village is provided by an activated sludge plant providing secondary treatment, followed by a sand filtration tertiary treatment system. The plant capacity is 750,000 GPD. Flows range from as low as 250,000 GPD in the winter, up to full capacity on peak summer days. Annual average inflow is about 400,000 GPD. Some wastewater is reused, the remainder is discharged to a dry wash behind the treatment plant.

Wastewater flows at Desert View average 10,000 GPD and are currently treated with facultative lagoons, soon to be replaced by a recirculating sand filter system.

Alternative Supplies: Treated wastewater effluent is an important water supply in Grand Canyon Village. The largest use is for irrigation of the village school's athletic field. The dormitory of the Albright Training Center is currently being retrofitted for reclaimed water toilet flushing.

The Bright Angel hotel uses reclaimed water for toilet flushing in the employee bathrooms, as does the new Park Service visitor center. Both the Bright Angel and El Tovar hotels are plumbed for wider use of reclaimed water for toilet flushing, but the systems are not currently in use. Reclaimed water is used on a small amount of turf at the El Tovar Lodge, the only irrigated landscape maintained by GCNP Lodges. The company also uses reclaimed water for washing down portions of the kennel it operates for the use of hotel guests.

Reclaimed water is also used by the railroad for its steam engine and reclaimed water was previously used by the Park generator plant when it was in operation. Some incidental irrigation, dust control, and revegetation efforts also use reclaimed water. The Park Service once considered using reclaimed water for vehicle washing, but state regulators rejected the proposal.

Park service staff report that coverage of the village with reclaimed water distribution lines is fairly thorough. but necessary on-site plumbing is not complete. Staff see potential to further expand reclaimed water use, but the funding to install service lines to buildings and dual-plumb buildings is not currently available. Reclaimed water lines could be provided to residential facilities, but permitting requirements are another hurdle. The required backflow prevention devices must be certified annually, a step that staff consider worthwhile for large facilities like hotels but not pragmatic for most residential buildings.

Water recycling is practiced in several facilities of the GCNP Lodges. The company's hotel laundry facility recycles a substantial portion of washing machine rinse water back to washing cycles. Also, boilers at the laundry and the Bright Angel and El Tovar hotels are essentially closed-loop systems, with some make-up water added periodically.

Rainwater harvesting is not currently practiced anywhere on the South Rim. A system was proposed for buildings associated with the light rail system proposed several years ago. Potable reuse has reportedly been considered.

Water Metering and Rates: Concessions in the park are metered. Many of the park facilities are not, including campgrounds and Park Service administrative and maintenance facilities. Current (2001) rates charged to park concessionaires are $14.43 per 1,000 gallons for water and $14.49 for sewer service, based on metered water use. These rates reflect actual costs for providing the services, village-wide.

Park housing users are charged on a different basis. They pay a fee for water as part of their rent. If an account's annual use exceeds average annual use, the account is assessed a surcharge; if less, a refund is given.

Water Efficiency and Conservation: The Park Service completed a retrofit program of its facilities in 1998. About 75 percent of all toilets in Grand Canyon Village are now believed to have been retrofitted. Most urinals are now 0.5 GPF models (1.0 GPF is the national standard). Waterless urinals are used in one restroom at Desert View. The retrofit program did not include faucet retrofits.

The Park Service cannot mandate retrofits in concession businesses. However, GCNP Lodges has steadily retrofitted hotel rooms as renovations are carried out. Company staff belief most of the rooms have by now been retrofitted with standard low-flow fixtures. The company has also replaced about 75 percent of its public restroom faucets with electronically activated valves. Further, the hotel guest linen policy is an advanced one. While most hotels automatically change linens unless multi-day guests put out a special card indicating they do not want linens changed, the GCNP Lodges' policy is to not change linens unless the card is put out. The company also makes water conservation education of employees a high priority. Notifying maintenance when leaks are found is especially emphasized. Additional water efficiency and conservation measures are now being planned as part of the company's new Environmental Management Plan.

The Park Service does not currently have in place a system-wide program to detect leaks in water distribution lines. Staff report their current focus is instead on improvements to the sewer system. Staff do not belief leaks are a significant problem, but they also note that leaks in the village rarely come to the surface—as leaks do in many communities—because of the fractured and permeable nature of the local subsoil and bedrock. Park-owned residential units are also not surveyed routinely for leaks, but staff report that occupants are usually vigilant about reporting leaking fixtures.

Reportedly, very few irrigated lawns exist in the residential areas. The Park Service and park concessionaires have water-recycling vehicle wash facilities. Residential car washing is not allowed during periods of water rationing, which last happened approximately seven years ago. No evaporative cooling systems are used on the South Rim.

Water Use: Because many park facilities are not metered, water consumption is not tightly tracked. Total water production, however, is metered, based on water pumped from Indian Gardens up to the South Rim storage tanks. Total production for the South Rim in recent years is presented in Table A-15.

TABLE A-15 GRAND CANYON NATIONAL PARK, SOUTH RIM HISTORICAL POTABLE WATER PRODUCTION	
1997	171.999 million gallons
1998	166.775 million gallons
1999	197.244 million gallons
2000	151.145 million gallons
2001	174.663 million gallons

Remarkably, the amount of wastewater reuse is not tracked nor well understood. Reuse ranges from a few percent of all treated effluent in the winter to perhaps 50% of all effluent in the summer, based on incidental observation by system operators of how often the reuse system pumps water. The utilities director roughly estimates that 30–35% of annual wastewater effluent production is reused. Thus, total reclaimed water use is approximately: 400,000 GPD annual average wastewater flow * 365 days per year * 0.30 = 43.8 million gallons.

Putting the above figures together yields the following estimate of total demand for the year 2000:

TABLE A-16 GRAND CANYON NATIONAL PARK, SOUTH RIM, TOTAL DEMAND IN 2000		
Potable Water Production	*Reclaimed Water Use*	*Total Demand*
151.1 MG	43.8 MG	194.9 MG

Staff indicate that approximately 80 percent of the billed water use occurs at park concessions, and 20 percent at Park Service facilities and residences. Very little irrigation occurs in Grand Canyon Village. Most, as indicated above, is done with reclaimed water. Seasonal water use increases by about 80% in the peak month (July or August) compared to the low month (February or December).

Growth and Water System Development: No expansions to park concessions are currently planned. Staff report that the park needs 250 additional housing units. Plans for these units were on hold pending an outcome on the Canyon Forest Village proposal, which would have included employee housing. Now that CFV has been rejected by Coconino County voters, expansion of park housing might proceed.

The key variable for further Grand Canyon Village development and future water demand is park visitation. Even without expansion of concessions, if visitation rises daily facility use and hotel occupancy rates would increase. Given current water fixtures and appliances, water demand would increase as well.

Sources:

Beshears, John. Park Engineer, Grand Canyon National Park. Personal interview.

Cross, Jeffrey. Director, Science Center, Grand Canyon National Park. Personal interview.

McNeilly, Lisa. Director of Environment, Health, and Safety; Grand Canyon National Park Lodges. Phone interview.

U.S. Forest Service. 1999 (July). *Final Environmental Impact Statement for Tusayan Growth, Coconino County, Arizona*. Williams, AZ: U.S. Department of Agriculture, Forest Service, Kaibab National Forest.

Welborn, David. Utilities Supervisor, Grand Canyon National Park. Personal and phone interviews and written communications.

KACHINA VILLAGE

Service Area and Water System: Kachina Village is an unincorporated community located just west of Interstate 17 several miles south of Flagstaff. The community was established through subdivisions in the late 1960s and early 1970s. The *Kachina Village Area Plan*, adopted by the County in 1997, encompasses roughly six sections, or close to 1,000 acres. All the area's population is in the Kachina Village development, all of which is within roughly one mile of the I-17 exit. Much of the remaining land in the area plan study area is part of the Coconino National Forest. The area plan does not encompass Forest Highlands, a private golf course community immediately west of Kachina Village.

The year 1990 census population of Kachina Village was 1,711. The 2000 population was 2,664. While the community was originally developed primarily as second homes, currently over 80 percent of the housing units are occupied year-round. The mix of housing types is quite diverse, including over 800 site-built and modular single-family homes, nearly 500 mobile homes, and a small number of duplexes. The development also includes a convenience store, a real estate office, a church, utility facilities, and two fire stations.

The Kachina Village Improvement District (KVID) provides water and wastewater services to the development. The KVID is a Water and Wastewater Division of the Coconino County Department of Public Works. It is currently the only utility in that division. The county took over management of the system in 1979 from a homeowner's association due to numerous problems tracing to substandard infrastructure installations when most of the development was constructed. The KVID has an ongoing program of capital improvements to replace and upgrade problematic water and sewer lines and treatment facilities, and has made considerable progress.

The water supply now comes from five wells, four of which may be run at any one time. The static water level of the wells ranges from 650 to 1100 feet below the surface. One of the wells apparently experiences a drop in water level when Forest Highlands' wells are pumping heavily to irrigate that development's golf course. Sand separation is required for water produced by one KVID well. The system includes 4 storage tanks with a total capacity of 910,000 gallons. The district currently has 88,000 feet of water distribution lines. In an emergency (e.g. for fire supply) the Kachina Village and Forest Highlands water systems can be connected with fire hoses. A piped linkage is planned. KVID provides a standpipe for water used for dust control during periodic grading of dirt roads within Kachina Village, but sells no water to residential or other water haulers.

The Kachina Village Improvement District maintains roughly 95,000 feet of sewer collection lines serving all houses and other facilities in Kachina Village. Originally the district's wastewater plant discharged effluent to Pumphouse Wash, a tributary to Oak Creek. When Oak Creek was designated a "Unique Water of Exceptional Significance" by ADWR, the wastewater plant could not meet new standards. The KVID constructed a new plant in 1988. Now the wastewater system discharges secondary treated effluent from an extended aeration plant to a 140 acre complex of 8 evaporation/transpiration ponds. No surface discharge to local drainages occurs. The complex has been developed as a constructed wetland habitat area, in cooperation with the U.S. EPA, Arizona Game and Fish Department, Arizona State Land Department, NAU, Ducks Unlimited, and the Northern Arizona Audubon Society. The wetlands provide wildlife habitat and recreational, educational, and scientific opportunities for local residents and students.

Alternative Supplies: Excepting the important support it provides for wetland habitat, wastewater effluent is not reused within Kachina Village. However, KVID has recently completed an agreement to provide effluent to Forest Highlands for golf course irrigation. A portion of the pond complex was being reconstructed in the fall of 2001 as a wetland tertiary treatment zone. KVID will initially sell up to 8–10 million gallons per year to Forest Highlands, as available after the wetland support needs are met. Currently Kachina Village generates 50–60 MGY of wastewater, including some infiltration/inflow water. Additional treated effluent could be provided if doing so does not harm the wetlands complex. The area plan (p. 46) includes a policy stating: "The use of effluent for habitat purposes shall have priority over requests for irrigation purposes for neighboring golf course developments."

The Kachina Village Improvement District's manager believes few if any households in the district practice rainwater collection or graywater reuse.

Water Metering and Rates: Excepting 2 master meters for an 84-unit mobile home area, all households and businesses within KVID are individually metered. Water rates and sewer rates are as follows:

TABLE A-17
KACHINA VILLAGE WATER AND SEWER RATES

	Water	*Wastewater*
Monthly Base Rate	$14.05	$18.73
Gallons Used	*Water Rate per 1,000 Gallons*	*Wastewater Rate per 1,000 Gallons*
1-3,000	$1.04	$2.60
3,001-6,000	$1.56	$4.16
6,001-9,000	$3.12	No charge
9,001-12,000	$6.24	No charge
12,001-50,000	$10.40	No charge
Above 50,000	$16.64	No charge

The Kachina Village Improvement District instituted its conservation rate structure in 1995. It failed to generate adequate revenues, so rates were revised upward in 1997 to the levels above.

Water Efficiency and Conservation: The conservation rate structure is KVID's primary water efficiency and conservation tool. The district periodically distributes educational flyers and puts water conservation tips in the quarterly newsletter. It also notes meter read spikes and posts high use door hangars on roughly 30-40 households each month. District staff provide toilet leak detection dye tablets and will provide leak surveys when requested. Cold snap pipe breaks and leaking toilet flappers are the most frequent causes of meter spikes.

Most homes in Kachina Village were constructed before the advent of ULFTs, and the district manager believes that most homeowners have not replaced their older, high-flow toilets. He also stated that many residents do not have a strong water conservation orientation. The district has considered offering toilet rebates but could not afford to do so.

The 1997 *Kachina Village Area Plan* includes the following utility infrastructure policies:

> Water conservation measures shall be included in all development proposals requiring Commission or Board approval. Such measures may include, but are not limited to, the use of reclaimed water for nonpotable uses, low flow water fixtures, and xeriscape landscaping.
>
> Kachina Village Utilities and the Coconino County Building Division are encouraged to actively promote water conservation retrofits in existing buildings (i.e., low flow toilets, shower heads, faucets, dishwashers, and washing machines) through distribution of information, and, if possible, rebate and incentive programs. Existing dwelling retrofit potential and status shall be reviewed by the water rate review committee during each two year review period.

The Design Review Guidelines for site design in the Design Review Overlay of the area plan include these additional requirements for all development except single-family residential:

> Landscaping shall emphasize xeriscape techniques using indigenous plant species and similar species adapted to the local environment. (p. C-3)
>
> Landscaping plans shall include a mix of landscape materials such as crushed rock and boulders and a variety of plant types and sizes. . . . All landscape plantings shall be provided with a low-flow irrigation system sufficient to establish and maintain them in a healthy condition. (p. C-3)

The district has an ongoing program to replace substandard water distribution lines, and also fixes about 10 line breaks each year. In 1999 it undertook a leak survey, finding and fixing 13 leaks. Most leaks are on the residence side of the meter. The district cannot conduct an accurate assessment of unaccounted-for water because so many meters are old and inaccurate (the district is steadily changing out meters), and because of meter reading patterns for the system zones. The unaccounted-for rate is perhaps 15 to 18 percent. KVID’s manager believes the leakage rate is small, fire use is minimal, and meter slippage is probably responsible for most of the current unaccounted-for rate.

Water Use: Water production in 2000 totaled 79.0 MG, or 215,867 GPD. Monthly production pumpage in 2000 averaged 6.58 MG per month (216,577 GPD), or an average of 167 GPD per active account. Monthly production is relatively constant from October through April at about 5.9 MG per month (194,055 GPD), or 149 GPD per active account. May through September water production increases to the July peak and then decreases. July 2000 production of 8.59 MG (277,000 GPD) was an average 213 GPD per account. July 2000 production of 8.59 MG was 1.6 times the February production of 5.38 MG. As of 1997, according to information in the area plan, 385,000 GPD was the highest peak day use on record.

Total water use reportedly dropped in the years following implementation of the conservation rate structure. In recent years, total water use has slowly increased.

Growth and Water System Development: The Kachina Village development is approaching buildout. Based on the most current water and sewer assessment, 1,540 equivalent residential connections are available. A capacity study underway in the fall of 2001 is expected to show an additional 92 connections are possible. Currently there are about 1300 active accounts, and slightly more total connections. There is a very slight seasonality in the number of residential accounts. The residential accounts comprise 98 percent of the active accounts. There are a dozen duplex accounts, 6 commercial accounts, and 2 master meter accounts for the trailer park area.

The *Kachina Village Area Plan* (p. 8) describes 3 growth scenarios for the development, prepared in 1993 for a Capital Improvement Plan (CIP), as summarized here:

- The low growth alternative would max out the 1,540 connections without significant additional commercial development. The peak population would be 4,250.

- The moderate growth alternative is based on maximum buildout under current zoning. 160 additional connections would be required, and more intensive multiple-family, mobile home park, and commercial development would take place. The peak population would be 4,700.

- The high growth alternative is based on zoning changes to allow higher residential densities and greater commercial development in some areas. 220 additional connections over the moderate growth scenario would be required, and the peak population would be 5,300.

- Residents surveyed for the CIP strongly preferred the low growth scenario. A preference for current densities and limited commercial development is apparently still widespread. Further, physical limitations such as floodplains and steep slopes would probably preclude much of the potential development included in the moderate and high growth scenarios.

The 1997 ADES population projections for Kachina Village estimate a population of 4,397 in the year 2050, slightly higher than the low growth scenario.

There is some potential for expansion of the KVID system to private land north of Kachina Village. A developer would be required to pay for the necessary infrastructure. Over the long term, according to the area plan, land exchanges that privatize nearby national forest lands could also occur. The adequacy of the existing KVID water supplies to support additional growth was not addressed by the water demand study team. The wastewater treatment plant cannot accommodate much growth. Its capacity is 330,00 GPD. Current inflows average roughly 160,000 GPD, but the peak day inflow is about 300,000 GPD. At one time the peak inflows were considerably higher, but sewer line replacements and repairs have dramatically reduced infiltration/inflow to the system.

The July 2001 draft *Flagstaff Area Regional Land Use and Transportation Plan* states that average daily water demand is expected to increase 50 percent by 2020 (p. 153). The basis of this projection is not clear. It appears high, given that Kachina Village is approaching buildout.

Sources:

Coconino County. 1997 (adopted September 15). *Kachina Village Area Plan.* Flagstaff, AZ: Coconino County Community Development Department.

Flagstaff Area Regional Land Use and Transportation Plan. 2001 (July). Draft obtained from City of Flagstaff Utilities Department.

Kachina Village Improvement District. Data sheets on water pumpage, wastewater flows, numbers of accounts. Consumer Confidence Report. Water and sewer rates.

Lueder, Daniel. Operations Manager, Kachina Village Utilities, Coconino County Public Works Department. Personal and phone interviews.

MOUNTAINAIRE

Service Area and Water System: The *Mountainaire Area Plan*, adopted by the County in 1991, covers a 16 square mile area east of Interstate 17 several miles south of Flagstaff. Only 1095 acres in this area are private land. Most development is concentrated in the 140 acre Mountainaire subdivision. A few additional residences are scattered through the other private parcels. The 1990 census population for the Mountainaire area was 738; the 2000 population was 1,014.

The Mountainaire subdivision and homes in the Old Munds Highway area are served by the Ponderosa Utility Company (Ponderosa), a privately owned water system. Ponderosa operates two wells drilled 800 and 1,120 feet deep yielding 75 and 120 GPM, and seven storage tanks ranging in size from 7,500 to 125,000 gallons (338,000 gallons total capacity). Presently there are roughly 500 accounts on the system, all of which are single-family homes, excepting a local tavern.

Fifteen homes east of the Mountainaire subdivision haul water from a tap off the Ponderosa system to a separate collective distribution system. Ponderosa maintains a standpipe for construction water supply; no home water haulers currently use the standpipe.

Wastewater disposal for all properties in the area, including those within the large subdivision, is via individual onsite systems (septic). The area plan notes that poor soil conditions and small lot sizes in the subdivision have raised serious concerns about the adequacy of onsite wastewater systems. Further, the subdivision was initiated in the 1960s as a primarily seasonal home development, but now most homes are occupied year-round. Thus, soils are not "rested" as once occurred. In a number of cases, property owners have combined 2 lots to facilitate siting of an adequate septic tank and leaching field for a single house. A sewer system and community wastewater treatment facility was once proposed, but never built due to unaffordable costs. The Kachina Village Improvement District, which operates such a system across I-17 just west of Mountainaire, has considered buying out Ponderosa to manage the water system and provide sewerage services, but to date this has not occurred.

Alternative Supplies: No alternative water systems are formally implemented in this area. Ponderosa's owner does not know of any rainwater harvesting or graywater use within his service area.

Water Metering and Rates: All housing units served by Ponderosa are individually metered. Water rates include a monthly service fee of $21.00, and the following commodity charges:

TABLE A-18 PONDEROSA UTILITY COMPANY WATER RATES	
	Rate per 1,000 gallons
Connected accounts	$3.30
Standpipe rate	$5.70

The connected account rate has been in effect since April 1, 2000. The rate from August 1, 1997 until adoption of the current rate was $2.80 per 1,000 gallons. The standpipe rate has remained constant since 1992.

Water Efficiency and Conservation: Ponderosa has no significant water efficiency and conservation policies or programs. The area plan includes the following policies (p. 18):

> Commercial development shall be limited to low-volume water users.
>
> Use of water conserving plumbing fixtures shall be required for all commercial and multi-family development and encouraged for single family development.
>
> The use of drought tolerant/low water using plants shall be required for landscaping for all development other than single family dwellings and encouraged for single family development.

Some land in the area is zoned commercial, but to date these policies have had little meaning given the lack of development other than single family homes. The area plan includes this additional policy in its wastewater section (p. 21):

> In an effort to decrease the number and intensity of failures, the County shall work with residents within Mountainaire in providing information regarding proper maintenance of septic systems and information on low-flush toilets and low water using appliances.

The extent to which such information provision has occurred or has effected retrofits was not investigated by the water demand study team.

Irrigation-dependent landscaping is minimal to absent for most lots in the Mountainaire subdivision. Distribution systems are likely given the age of the system.

Water Use: In 2000 the Ponderosa water system pumped 26.9 MG and sold 23.2 MG. There were an average of 490 active accounts in 2000. Annual average metered water use in 2000 was 130 GPD per account. This water use ranged from 99 GPD per account in February up to 220 GPD per account in June.

Growth and Water System Development: Ponderosa's owner says that the system's two wells could support roughly 1,000 homes. Currently the 5 units of the Mountainaire subdivision have a total of 802 lots. Roughly 500 are currently occupied. Unless a sewer system is created, more lots may have to be combined to accommodate onsite wastewater systems.

The Ponderosa system could be extended to certain outlying areas, though some of the distribution lines are of insufficient size for this, and the cost of extending lines would be significant. Most private land outside the Mountainaire subdivision is zoned for 10 acre minimum lots, so the currently anticipated population potential of these lands is limited. It is possible that some public lands in the area plan study area could be privatized. The U.S. Forest Service has reportedly recently declared 320 acres near the Mountainaire subdivision as "surplus."

The ADES projects a population increase in this region of 30 percent from 2000 to 2020, and projects the 2050 population at 1,646 persons. The July 2001 draft *Flagstaff Area Regional Land Use and Transportation Plan* (p. 154) states that average daily water demand is expected to increase 62 percent by 2020. The basis of this water demand projection is not clear. It appears high, given that Mountainaire is approaching buildout, and given that ADES projects a population increase of only 30 percent in the same period.

Sources:

Brown, Walter. Owner, Ponderosa Utility Corporation. Personal interview.

Coconino County. 1991 (adopted December 16). *Mountainaire Area Plan.* Flagstaff, AZ: Coconino County Community Development Department.

Flagstaff Area Regional Land Use and Transportation Plan. 2001 (July). Draft obtained from City of Flagstaff Utilities Department.

Ponderosa Utility Corporation. Annual report to the Utilities Division of the Arizona Corporations Commission, calendar year 2000. Data sheets on water production and billings. Water tariff schedules.

PAGE

Service Area and Water System: The City of Page is located at the far northern tip of the study area, 136 miles north of Flagstaff on U.S. Highway 89. It is adjacent to Glen Canyon Dam and Lake Powell. A large expanse of the Navajo Reservation, which is not included in this Phase I water demand study, lies between Page and the bulk of the study area.

Established for the construction of Lake Powell, Page now attracts considerable summertime visitors to the Lake. Many homes in Page are used seasonally. Tourism, recreation, and hospitality services are the source of most of the local economy. Hotel rooms totaled 1600 in 1998. Restaurants, a 27 hole municipal golf course, and other tourist amenities and services are provided. Other important economic sectors include government, utilities (the nearby Navajo Generating Station), and retail and service businesses serving the city and the surrounding region. The 1990 census population of Page was 6,598; the 2000 population was 9,570.

The city provides all water services in Page. It also provides treated water to the adjacent LeChee Chapter of the Navajo Nation.

At the present time, Page obtains all its water from Lake Powell, under the terms of a 1975 contract with the U.S. Bureau of Reclamation. The contract originally limited withdrawals to 2,740 acre-feet (892.8 MG) per year. In 1993, the Bureau and the city agreed Page could increase its withdrawals by the amount of return flow to the Colorado River. While none of Page's wastewater plant effluent returns to the river, most of the water used at the local ice-making plant, system losses, and percolation through the soil of golf course and landscape irrigation water, do generate some return flows. The return flow credit effectively increases Page's water entitlement to about 3,300 acre-feet per year.

Page withdraws Lake Powell water via intakes located on the dam approximately 250 feet below the water's surface. Four pumps move the water 1,200 feet uphill via a single water line to the city's water filtration plant. Some raw water is shunted to the golf course before reaching the treatment plant. The capacity of the Lake Powell pumps is about 5.3 MGD, somewhat less than the drinking water plant capacity of roughly 6 MGD. The distribution system includes 4.5 MG of storage capacity for treated water.

According to Page staff and Page's water resources consultant, the city has two main concerns with its water system. The first is reliability. The pumping system was originally designed to run only three of the four pumps at any one time. Today, all four pumps run continuously in the summer. Further, any problem with the pipeline would shut off water delivery to the city until the line could be fixed. And finally, the storage capacity is considered inadequate.

Page plans to double its treated water storage capacity in the near future, and is investigating several additional options to improve the reliability of its system. One option is to build a redundant water line from the Salt River Project's Navajo Generating Station to draw water from a cooling water pump that taps Lake Powell. The Lake Powell Pipeline now under consideration to serve the western portion of the Navajo Reservation and possibly other portions of Coconino County could provide another option for redundant access to Lake Powell water, and possibly economies of scale in joint development. Groundwater wells are a third option. The city is currently studying development of two wells, both of which would be drilled approximately 1,200 feet deep. These wells could be put in service as early as April or May of 2002. If developed, the wells would be operated in conjunction with the existing Lake Powell system, to provide both a back-up and to allow periodic resting of some of the pumps on the main system.

The wells would also provide Page with some additional water supply, and thereby help address the second water system concern: adequacy of supply for future city development. This is addressed in the growth section below.

Most of the city is served by a wastewater collection system and a 2 MGD activated sludge wastewater treatment plant that provides secondary treatment. A very small residential and light industrial area is still served by onsite septic systems.

Alternative Supplies: All effluent from the city's wastewater treatment plant is chlorinated and sent to lined storage ponds, which have a total capacity of 82 million gallons. Some of the treated wastewater evaporates in the storage ponds; most is sent to the municipal golf course for irrigation use. ADEQ does not permit any direct return of treated wastewater effluent to the Colorado River. The golf course also uses some raw water from Lake Powell, but roughly two-thirds of its needs are met with treated effluent.

There is no known rainwater harvesting or graywater reuse in Page.

Water Metering and Rates: All single-family residential, commercial, and industrial water users in Page are individually metered. All or most multi-family residential complexes are served by master meters; units are not sub-metered. All users pay the same monthly water and sewer rates, as follows:

TABLE A-19
CITY OF PAGE WATER AND SEWER RATES

Type	*Cost*	*Description*
Water	$4.00	Base rate, 0-3,000 gallons
	$1.25	per thousand gallons; 3,000 gallons to winter consumption average[1]
	$1.35	per thousand gallons; consumption in excess of winter consumption average.[1]
Sewer	$2.52	per thousand gallons; applied to all metered water use

[1]Winter consumption average is average water used during the lowest three months between November and March. This figure is re-calibrated each year.

Significant increases in the commodity rates for both water and sewer have been considered, but have not gone to City Council.

Water Efficiency and Conservation: Water conservation and efficiency have not received significant attention in Page. The 1995 *Page General Plan Update* includes a goal of "adequate conservation" and an objective to "establish a water conservation program" (p. 5-4). No program has been established, and there are no special provisions for water conservation and efficiency within the building code or other city ordinances. City staff indicated the city is aware it should make more of an effort to advance water efficiency and conservation.

Differences in water pressure in portions of the city are a significant concerns. Some areas "off mesa" have pressures of 170 pounds per square inch (psi). Pressure this high can increase the amount of water used by faucets, showerheads, and some other fixtures. Thus, pressure equalization can be an important water conservation measure. The water department plans to move two pressure-reducing valves in early 2002; it believes this action will significantly reduce pressures in the problem areas.

Leaks in the water distribution system are not a substantial problem. The city conducted leak surveys one and three years ago, and fixed all identified leaks.

Water Use: Total water use in Page includes water production from the drinking water treatment plant, raw water used for the golf course, and reclaimed wastewater effluent used for the golf course. Some of the treated wastewater evaporates from seven storage ponds at the wastewater plant and two ponds at the golf course. Evaporation from the storage ponds could be considered a disposal method rather than a water use, while evaporation at the golf course ponds should be considered a water use, as the ponds are part of the landscaping of the course. For the purposes of this report, all evaporation, which averaged 59 million gallons per year from 1999 to 2001, is considered a water use. Thus, 100% of the wastewater plant effluent is here considered part of the city's water use. Total water demand in Page in 2000 was as follows:

TABLE A-20
WATER USE IN PAGE IN 2000, IN MILLIONS OF GALLONS

Potable Water	*Nonpotable water*		
Drinking Water Plant Production	*Raw water*	*Reclaimed wastewater*	*Total Demand*
786.081	148.727	260.403	1,195.211

Note that reclaimed wastewater amounts to 64 percent of nonpotable water use (golf course irrigation) and 22 percent of total water use in Page. This reduces the city's water withdrawals from Lake Powell accordingly.

Water use in Page in 2000 was slightly higher than in other recent years, as shown by drinking water production:

TABLE A-21
DRINKING WATER PRODUCTION, 1998–2001

1998	760.014 million gallons
1999	769.471 million gallons
2000	786.081 million gallons
2001	748.559 million gallons

Water use increases substantially in the summer months, due to landscaping use and tourist visits. Peak summer month drinking water production is over four times low winter month production.

Growth and Water System Development: While growth has been slow in Page in recent years, the city feels its needs could eventually exceed its contract entitlement. The 1995 *Page General Plan Update*, apparently using a historical city-wide per capita consumption rate of 280 GPCD and population projections available at the time, calculates that Page could exceed its annual contract allocation by 2015. According to the plan projections, water use could increase to 5,385 acre-feet per year by 2045 (exceeding the current use of 2,100 acre-feet per year by 2.5 times) if historic consumption rates continue and the population reaches 17,169. It is notable that the 1995 plan also provides projections based on reduced city-wide per capita consumption rates of 255 and 225 GPCD. However, no basis for those particular consumption rates is given.

Page is investigating new water sources. In addition to the wells mentioned above, the city is considering how it could obtain additional Colorado River water.

Much of the city's land area remains to be developed. As of 1995, roughly 4.86 square miles of the total 16.56 square mile total had been developed for urban uses. Because the city owns most of the land in Page, it has been able to keep most development contiguous to the city's downtown and its immediate vicinity. Most development is currently concentrated on or adjacent to Manson Mesa, in the north and western portion of the city. Some of the remaining land is topographically unsuited to building, but much is developable. Further, the city and the Navajo Nation have discussed possible land swaps to allow the city better access to some of its developable land, and to relocate the city's airport, which would provide further room for development near the city core.

Sources:

BRW, Inc. and Sunregion Associates, Inc. 1995. *Page General Plan Update.*

City of Page. Water and sewer rate tables. Consumer Confidence Report. Water and wastewater flow data tables.

Ladman, Fred. Land Surveyor and Assistant to the Engineer, City of Page. Phone interview.

Owens, Patrick. Lead Operator, City of Page Water and Wastewater Treatment Plants. Phone interview.

Plummer, Bill. Water Resources Consultant to the City of Page. Personal interview.

U.S. Forest Service. 1999 (July). *Final Environmental Impact Statement for Tusayan Growth, Coconino County, Arizona*. Williams, AZ: U.S. Department of Agriculture, Forest Service, Kaibab National Forest.

White, Steven. Planning and Zoning Director, City of Page. Phone interview.

PARKS

General description and status: The Parks area encompasses many private property in holdings of varying size in the Kaibab National Forest both north and south of Interstate 40 between Bellemont on the east (non-inclusive) and Pittman Valley on the west (inclusive). The study area of the *Parks Area Plan*, adopted by Coconino County in September of 2001, covers 265 square miles, of which roughly 30 square miles are privately owned.

The 1990 census population of the Parks area was 603; the 2000 population was 1,137. ADES includes Parks among the named places within Coconino County for which it prepares population forecasts. ADES 1997 population projections estimate the population of Parks to be 2,701 in 2050.

The area includes widely scattered single-family homes. There are a handful of commercial and public buildings, one mobile home park, and no industrial facilities or industrial zoned land. The area has a rural character that residents wish to maintain. Most subdivision activity occurred prior to 1975. The area has 1,069 platted lots. Most remaining land is subject to the 10 acre minimum lot size of the County's General Zone. The area has experienced steady individual lot development, which will likely continue. Most residents work in Flagstaff or Williams. Some of the housing, perhaps one-third, is seasonally used.

There are no community water or wastewater systems in the Parks area. The majority of residents haul water or buy from commercial haulers. A few residents are located above perched aquifers they can tap with shallow wells. Some of these wells are unreliable in dry years. Some rainwater collection probably occurs. Wastewater systems are primarily onsite septic and leach field systems; alternate systems are required in some areas with high water tables or poor soil percolation rates.

The area plan includes a substantial discussion of the pros and cons of developing an assured water supply for the Parks area. A deep well in the regional aquifer is one possible source. A deep well would be expensive, and there is no guarantee drilling would be successful. The Lake Powell regional water supply pipeline proposal is also mentioned. However, it should be noted that current alignments for the pipeline would not bring water to the Parks area.

In any case, a new water supply would only serve a limited area through a conventional distribution system. However, it could establish a reliable standpipe supply for Parks residents. The Bellemont Water Company standpipe, the primary source for most Parks residents, may become unavailable as the Bellemont area develops. Already, the City of Williams has cut off sales to commercial haulers in times of drought.

The downside of a substantial and assured supply, according to the area plan, is increased pressure for higher density development, which most Parks residents find undesirable. This pressure would increase over time as the Flagstaff and Williams areas grow and experience increased land prices. The plan notes that the lack of water in the Parks area is a "serious constraint on future development" that could maintain the rural character of the area.

Sources:

Coconino County. 2001 (adopted September 17). *Parks Area Plan.* Flagstaff, AZ: Coconino County Community Development Department.

Towler, Bill. Community Development Director, Coconino County. Personal interview.

RED LAKE

General description and status: Red Lake is an unincorporated region north of the City of Williams extending several miles to both sides of State Highway 64. The *Red Lake Area Plan*, adopted by the County in 1992, encompasses a study area of 150 square miles. 40,000 acres—42 percent of the region—are privately owned. Much of the area is a sectional checkerboard of private and State Land Trust lands. The eastern and southern edges of the study area are predominantly Kaibab National Forest land.

The area includes widely scattered single-family homes and a few commercial establishments, primarily along Highway 64. Significant subdivision activity has occurred in this area, but few lots have been developed. The 1992 area plan lists 11 subdivisions that platted 5,380 acres into 2,119 lots. Only 188 lots were occupied at that time. Most of the remaining private land is zoned for large lots (10 acres per 1992 regulations, but proposed for change to 40 acres). Development in the area has picked up since 1992. However, ADES does not yet prepare population projections for the Red Lake area. Many Red Lake homes, perhaps 50 percent, are used seasonally rather than year-round.

Virtually all water used in this area is hauled from Williams, Valle, or Bellemont. Some rainwater collection probably occurs. While in theory deep wells or the Lake Powell pipeline could bring water to the Red Lake region, the cost of establishing water distribution systems would be extremely high. Substantial development of relatively small lot subdivisions would be required to support such systems. This type of development, including strip development along Highway 64, would also be contrary to the intent of the area plan. Alternatively, a pipeline could provide for a standpipe closer to Red Lake than currently available standpipes.

Sources:

Coconino County. 1992 (adopted September 21). *Red Lake Area Plan.* Flagstaff, AZ: Coconino County Community Development Department.

Towler, Bill. Community Development Director, Coconino County. Personal interview.

TUSAYAN

Service Area and Water System: Tusayan is a small-unincorporated community located along State Route 64 one mile south of the main South Rim entrance to GCNP. Private land totaling 144 acres forms the community core. Tusayan is completely surrounded by public land for many miles in every direction. Only a few private inholdings are scattered throughout the 70 square mile study area covered by the *Tusayan Area Plan* (Coconino County 1995). The 1990 census put the year-round population at 555; the 2000 population was 562.

Tusayan's economy is based largely on tourism. Roughly 75 percent of GCNP visitors pass through Tusayan. Summer population nearly doubles due to seasonal employees. As of 1998, there were 1,051 hotel rooms in the community. Moqui Lodge, located about 1 mile north of the business district and not on the local water system, has an additional 136 rooms. An airport, Imax Theater, restaurants, retailers, gas station and other visitor service establishments are located in Tusayan. Total retail space in 1998 was approximately 35,000 square feet, and restaurant space was approximately 25,000 square feet. Many community services—school, library, fire protection, medical clinic, worship center—are provided by Grand Canyon Village several miles north in the national park.

Two private water suppliers provide water to Tusayan homes and businesses. Hydro-Resources has two wells that were developed in 1989 and 1994. Anasazi Water has one well it developed in 1998. Each well is drilled roughly 3,000 feet deep, and each has a water level about 2,400 feet deep. Anasazi Water has one 300,000-gallon storage tank. Hydro Resources did not provide its storage capacity for this study. Both began to develop their systems prior to establishing the wells. They relied entirely on hauled water initially, and Anasazi still uses some hauled water to this day. This imported water comes from wells in Williams, Valle, or sometimes Bellemont, or from the water system in Grand Canyon Village until the Park Service cut off deliveries a few years ago. In 1995, 47 percent of Tusayan's water came from local wells, 30 percent from Williams and 23 percent from the national park. Since 1995, supplies have become more localized and diverse. Exact figures on hauling by Anasazi Water were not obtained, but the operator estimated the importation at roughly 0.6 to 1.2 MG in a normal year without extended periods of the system's well being down. This currently represents 1 to 2 percent of the community's water use. Much of the previously imported water has been replaced by a recently developed reclaimed wastewater system.

The distribution lines of the two private systems are interconnected to ensure service to the entire community in the event of a shutdown of either system. Both water suppliers wholesale their water to a non-profit water purveyor, the Tusayan Water Development Association (TWDA). The TWDA bills water customers but has no physical assets. It was set up in part to acquire water in times of need from GCNP, which can only sell water to a non-profit entity.

Hydro Resources reportedly maintains a standpipe for sales to water haulers. Further information on this system could not be obtained.

All indoor water uses in the Tusayan core, including the airport, utilize the wastewater treatment facility of the South Grand Canyon Sanitary District (SGCSD). Moqui Lodge and the Forest Service ranger station are served by their own wastewater stabilization ponds.

Alternative Supplies: Tusayan has several important systems that substantially reduce raw ground water withdrawals—a community-wide reclaimed water system and rainwater harvesting at the Grand Canyon airport.

The SGCSD uses extended aeration/denitrification, activated sludge basins to treat all received wastewater. All wastewater effluent is treated with ultraviolet disinfection. To produce reclaimed water, the district adds tertiary treatment using sand filters. Reclaimed effluent is stored in a 300,000-gallon tank prior to distribution back to the community. Gas chlorination maintains microbial kill in the reclaimed water distribution lines. The reclaimed water meets ADEQ A+ standards, which under recently revised regulations allow for toilet flushing and virtually all irrigation uses, including even home gardens. In 2001 46 percent of the wastewater received at the SGCSD plant was recycled back to community water uses. The reclaimed water system saved 22.4 million gallons per year, or 69 acre-feet per year of potable water in the period October 2000 to September 2001.

Reclaimed water use began approximately 10 years ago when the Best Western Squire Inn built its own onsite system. For many years now the county has required all commercial and multi-family facilities built in Tusayan to install dual plumbing. Thus, almost all commercial buildings were "ready to go" when the community-wide reclaimed water system began service in August of 2000. No building retrofits have occurred yet, though McDonald's is contemplating retrofitting its apartment complex. As of October of 2001, 11 commercial establishments are on the metered reclaimed water system. Notably, the primary use by volume is for toilet flushing. Eight establishments use reclaimed water for toilet flushing, 9 use it for irrigation. Except for some residential lawns and gardens, there is very little use of potable water for irrigation in Tusayan. All the significant commercial landscapes use reclaimed water for irrigation.

SCGSD also maintains a standpipe and temporary reuse permits to provide reclaimed water for hauling to local construction sites and elk and deer watering stations managed by the Arizona Game and Fish Department. Fire suppression use of reclaimed wastewater is also available to a limited degree.

Charges are $1.00 per 1,000 gallons of reclaimed water to connected accounts, which when compared to the water and sewer rates for potable water use creates a substantial incentive to maximize reclaimed water use.

The SGCSD staff and officials are justifiably proud of Tusayan's reclaimed water system. It is clearly a leading example in the U.S. of how wastewater can be recycled for indoor uses, as well as the more common use for landscape irrigation. Of the six hotels in town, four use reclaimed water for all of their toilets, and one uses it for most of its toilets. Only one hotel does not use reclaimed water for toilets, though it does do so for irrigation. Both fast food restaurants now use reclaimed water for all their toilet flushing. Reclaimed water use constitutes 30-50 percent of total water use at some of the hotels, and about 70-75 percent of water use at the local McDonald's restaurant. Another important innovation is use of reclaimed water in the residential sector. This was at first opposed by the ADEQ, but SGCSD lobbied the agency and such use is now permitted state-wide. A dormitory complex now uses reclaimed water for toilet flushing. No single-family homes currently use reclaimed water, but distribution lines to allow reclaimed water use for irrigation have been laid in virtually all parts of the town. Single-family hook-ups are expected in the future. To assist users of the reclaimed water system, the district periodically runs backflow and cross-connection prevention seminars.

The Grand Canyon airport, owned by the state and operated by the Arizona Department of Transportation, has a substantial rainwater collection system that provides potable water to the terminal and office, hangar facilities of several helicopter and fixed wing tour companies, and about a dozen homes. Water catchment, treatment and distribution is managed by A Quality Water Company. The system uses 5 acres of Hypalon plastic to collect rainwater and snowmelt. Roughly half of the catchment was built when the airport was created in the 1960s. The second half was added in 1997. Runoff from the runway is not collected, due to concern over possible contamination from fuel and other hydrocarbons. A 3 million gallon storage tank holds harvested water prior to treatment. The treatment system consists of an adsorption column, depth filtration, charcoal filtration, and chlorination. A 375,000-gallon tank holds finished water. The airport does have a connection to the main water system in the Tusayan core, but rarely buys water from the main system. Reclaimed water is also available at the airport and is used for irrigation. Some buildings at the airport are double-plumbed, but ADOT has not yet found funds to complete connection of the reclaimed water system to those buildings.

The *Tusayan Area Plan*, as adopted by Coconino County in 1995 and amended in 1997, requires use of reclaimed water for "nonpotable uses such as toilet flushing, landscape irrigation, and fire protection" for new commercial, industrial, and multiple family residential developments (p. 24). It further states that:

> The use of potable water as the primary irrigation source shall not be authorized. Irrigation systems shall be plumbed for the use of nonpotable water. The extension of reclaimed water lines shall be encouraged as soon as possible. If landscape plans suggest a permanent source of irrigation is necessary, a permanent on-site water system providing complete coverage shall be required. (p. 70)

From discussions with Tusayan stakeholders, it appears to the project team that the county rigorously enforces these policies. The plan also states that "Developers shall be encouraged to conserve and re-use drainage or runoff water but not to the extent of decreasing natural flows" (p. 49).

Water Metering and Rates: All commercial and most residential properties in Tusayan are separately metered. Some, like a roughly 50 unit trailer park served by Anasazi Water, have a master meter for billing by TWDA, but the landlord submeters and bills tenants individually. Rates per 1,000 gallons are shown in Table A-22. Sewer charges are based on metered potable water use. The current sewer rate reflects a 7.5 percent reduction implemented two years ago. Reclaimed water is metered separately. This table shows that the *minimum* combined rate for potable water use is $32.09 per 1,000 gallons.

TABLE A-22 TUSAYAN WATER AND SEWER RATES PER 1,000 GALLONS	
Location	*Cost*
Water–Airport system	$50.00
Water–Anasazi Water Company	$45.00
Water–Hydro Resources	$18.50
Reclaimed water–Connected accounts	$1.00
Reclaimed water–Standpipe	$4.00
Sewer rate	$13.59

Water Efficiency and Conservation: Persons interviewed believe local commercial establishments exclusively use ULFTs. The Seven Mile Lodge reportedly uses 1.0 GPF Swedish Ifo brand toilets. It is likely that the very high water and sewer rates in Tusayan provide a substantial incentive for water efficiency and water-conservative behaviors in both new and existing development.

The Anasazi Water Company monitors its customers' water use carefully from month to month, and contacts customers if water use rises substantially, in case this could indicate leaks. Because of the small number of customers on the system, it is very easy to closely monitor account usage. The system includes some older mains that have caused some leakage problems over the years. Portions are replaced from time to time. The operator estimates the overall unaccounted-for water rate at five percent, much of which may come from meter creep. The meters are being replaced. An unaccounted-for water rate estimated for Hydro Resources could not be obtained.

The *Tusayan Area Plan* requires that all major new developments include water conservation measures such as "low water using plumbing fixtures and drought tolerant landscaping" (p. 23). Whether plumbing fixtures must exceed current national plumbing standards is not noted. Landscaping standards are given marginally more definition: "Landscaping standards emphasizing preservation of native vegetation and materials and the use of indigenous and low water consuming plants shall be applied to all new developments other than single family homes" (p. 49). The extent to which the county further articulates and enforces these provisions was not determined in this Phase I study.

Water Use: Total water use in Tusayan can be composed from TWDA figures for potable water sold, SGCSD figures for nonpotable water sold, and estimates for water use at the Grand Canyon Airport.

Anasazi Water and Hydro Resources systems

Company specific data were not obtained for this study. The TWDA did provide some annual water-use data. It has handled billings for both companies since October of 2000. This is also the first month when the reclaimed water system was on-line with most commercial establishments in Tusayan. Thus, the year represented by October 1, 2000 to September 30, 2001, is a reasonably representative year for current Tusayan water use. During this period, TWDA billed customers for 31 MG of water use.

While little irrigation now occurs with potable water, tourism ebbs and flows produce marked seasonality of water use in Tusayan. Anasazi Water system's peak month is roughly three times use in its lowest month.

Airport system

According to the operator, water use at the airport averages about 9,000 GPD. Total annual use therefore amounts to about 3.3 MG. Winter use averages about 7,000 GPD. Peak summer day use is about 14,000-15,000 gallons.

Reclaimed water

Monthly-reclaimed water billing records provided by the SGCSD show that reclaimed water use from October 1, 2000 to September 30, 2001 totaled 22.361 MG. The low month was December, averaging 22,400 GPD. The peak month was July, with an average daily use of 111,600 gallons.

Tusayan totals

Measured and estimated water use in Tusayan for October 2000 through September 2001 totals as follows:

TABLE A-23
WATER USE IN TUSAYAN, OCTOBER 2000–SEPTEMBER 2001 TOTALS

Potable water–TWDA billings	31.0 MG
Potable water–Airport system	3.3 MG
Nonpotable water–SGCSD reclaimed wastewater	22.4 MG
Total water use	56.7 MG

Note that over 45 percent of Tusayan's water used is provided for by alternative supplies—almost 40 percent from reclaimed water, and almost 6 percent from rainwater harvesting.

These figures do not include unaccounted-for water due to leakage in the two potable water systems. This aspect of water use is probably small.

While water sources in Tusayan have changed substantially in recent years, total water use appears not to have changed markedly. Use in 1995 totaled 54.3 MG, according to the 1999 Tusayan Growth Environmental Impact Study (U.S. Forest Service 1999). It is not clear if this figure includes as comprehensive an accounting of water use as the 2000 figure estimated above; e.g., it may only be based on the main, in-town potable water systems, and may not include water use at the Grand Canyon airport or the reclaimed water use practiced by the Best Western Squire Inn in 1995.

Growth and Water System Development: The *Tusayan Area Plan* expresses a strong community desire for additional commercial development to reinforce Tusayan's importance as a staging and orientation stop for national park visitors. The plan further notes a need for additional housing for park and local workers and their families, and development of community services such as schools, churches, parks, etc.

This water demand study does not address the sufficiency of the existing wells to support growth. What is clear is that the wastewater plant can support substantial growth. The SGCSD facility now treats *peak* flows of 216,000 GPD. Connecting the existing Moqui Lodge and the Forest Service facility would add 50,000 GPD, bringing the peak inflow to 256,000 GPD. The plant's physical capacity is 750,000 GPD. Additional capacity would have to be added once peak flows reach 80 percent, or 600,000 GPD, per ADEQ regulations. The SGCSDs 20-year projections submitted to the Northern Arizona Council of Governments in its proposal seeking NACOG certification as the Designated Management Agency for the Tusayan area indicate that the current capacity is adequate for a growth scenario that includes 1,000 additional hotel rooms and a new national park transit center. The SGCSD has adequate space to support additional capacity expansions as well.

It is also clear that alternative supplies have additional potential in Tusayan. Presently only 46 percent of wastewater effluent is reused. The unused portion could in the future displace some potable water use for irrigation and toilet flushing at existing residences, and can and probably will be similarly used for any new commercial facilities. Also, the airport's potable water system has adequate treatment capacity to expand. Potential supplies could include an existing surface "tank" (a shallow damned surface wash) that collects water on the airport property, or construction of additional tarped rainwater catchments.

Growth within Tusayan's core is limited by the availability of private land, currently only 144 acres including existing development. While Tusayan is surrounded by the Kaibab National Forest, some developable private land exists nearby. The 158 acres Kotzin property is located approximately 1/2 mile northwest of the SGCSD plant and will be connected to its wastewater collection system. Two other significant properties—known as Apex and Ten X—lie several miles from Tusayan. The SGCSD reports it is impractical to tie these properties to the Tusayan wastewater gravity collection system due to local topography. However, potable or reclaimed water distribution lines, which are pressurized, could potentially be run to these properties. The Tusayan Growth Environmental Impact Study (U.S. Forest Service 1999) suggests that a 94-acre golf course proposal on the Ten-X property could be served by SGCSD reclaimed water. However, it is unlikely the town will produce enough excess wastewater effluent to be of significant service to a golf course.

Additional private inholdings are located further from Tusayan. Their development potential is uncertain.

The "wild card" of Tusayan growth is the potential for public/private land swaps that could allow significant development close in to Tusayan. Located at the doorstep of a World Heritage Site, it is clear that Tusayan and its vicinity is a prime development location. The Canyon Forest Village (CFV) proposal, extensively studied in the 1990s, approved by the U.S. Forest Service and the Coconino County Board of Supervisors, and rejected by Coconino County voters in the 2000 election, shows the lengths to which developers may go to build a gateway resort. The final proposal involved conveyance of 272 acres of National Forest land adjacent to the existing private land in Tusayan, in exchange for 2,118 acres of private inholdings with the national forest. Among the many environmental and other concessions made by the CFV developers, the final proposed water system would have hauled Colorado River water great distances by railroad car and pipeline at great expense. Major rainwater harvesting and wastewater reuse systems would also have been built.

Whether in future years CFV will re-surface in a modified form, or other large-scale developments will be proposed, whether such proposals will be successful, and the water demand and water source for any such developments are all highly uncertain. Consider the following development scenarios and water demand estimates. The 1999 Tusayan Growth FEIS estimated that total water demand (potable and nonpotable) for four Canyon Forest Village alternatives (B, C, G and H) would at buildout range from 91 MGY to 153 MGY. The range reflected different project sizes and different water efficiency and conservation assumptions. The figures do not count growth within the existing 144 acres of private land in the Tusayan core. These four alternatives would have acquired virtually all significant private lands in the Tusayan vicinity outside the Tusayan core, removing them from the potentially developable land base. The other action alternatives were estimated to generate from 29 MGY total demand (E and F) to 36 MGY potable demand plus unspecified nonpotable demand (D, which used existing private land in the Tusayan core to satisfy some of the development objectives). However, these alternatives did not involve Federal acquisition of developable private land and did not estimate the water demand that could be generated by development on those lands.

Coconino Plateau water stakeholders will need to decide whether land swaps and/or private land development outside the Tusayan core should be included in the Phase II water demand study. If they are, appropriate hypothetical development scenarios upon which the team can build water demand projections will have to be specified.

A key issue for Tusayan growth is growth in tourism. This depends largely on GCNP visitation increases and new hotel room construction. Average occupancy for the hotels was estimated in the *Final Environmental Impact Statement for Tusayan Growth* (U.S. Forest Service 1999) at 72 percent in 1994 and 60 percent in 1998; 550 rooms were added in the intervening period. Tourism, and local business, is also affected by world events such as the Japanese recession of the late 1990s and recent terrorist attacks in the United States.

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VALLE

Service Area and Water System: Valle is a very small unincorporated community located at the junction of SR 64 and US Highway 180, approximately 30 miles south of the GCNP entrance and 28 miles north of Williams. The 1990 census year-round population was 123; the 2000 population was 553 (these figures include a small subdivision 4 miles north, and some population in the surrounding rural area).

The community's economy relies on serving visitors passing through on their way to GCNP. Visitor services include a campground, the Grand Canyon Inn (74 rooms), several gift shops, a gas station/convenience store, a private airport, aircraft museum, and a small amusement park. Schools, medical services, and most other community services are currently provided in Williams or Grand Canyon Village.

The community is served by two water systems. Each system has its own well. Both wells were established in 1994. Each is drilled over 3,000 feet deep, and has a water level about 2,500 feet below the surface. Prior to establishment of the wells, all Valle residents and businesses hauled water from Williams or Bellemont.

The Grand Canyon Inn owns one water system. It provides water to the inn complex, which includes a 74-unit motel, restaurant, gas station/market, employee trailer park, and the owner's residence. A standpipe is also provided for water sales to commercial and individual water haulers. Two 36,000-gallon tanks provide storage. A package plant wastewater treatment system serves the complex.

The other system is based at the Grand Canyon Valle Airport and is run by Hydro-Resources Inc., which also operates 2 wells in Tusayan. This system has six 32,000-gallon storage tanks that serve the airport complex, and an additional six 32,000-gallon storage tanks that serve a 100-lot mobile home park (not all the lots are occupied). Two standpipes serve commercial and individual water haulers. Most of this water system's users are served by a 45,000 GPD wastewater treatment system. The plant has adequate capacity to serve future commercial development on the airport's property along SR 64 and to tie in nearby residences now served by individual septic systems.

Unlike Tusayan to the north, Valle is surrounded by large amounts of private land. Of the approximately 300 square mile study area for the *Valle Area Plan*, approved by the county in 1999, 63 percent is privately owned. The remainder is state-owned. Individual homes are scattered around the Valle area. All haul most or all of their water. As described in the growth section below, several very large subdivisions have been established, but none are extensively developed. Only one other community water system exists in the area. It serves the Sage Valley Mobile Home Park in the Woodland Ranches subdivision roughly four miles north of Valle. Water for the system is brought by a commercial hauler from standpipes in Valle or Belmont to two 60,000-gallon storage tanks. A community wastewater system that can serve up to 132 homes exists at this site. As of 1997, 45 lots were occupied.

Alternative Supplies: Presently, only the Grand Canyon Inn recycles wastewater. It draws water from an open 400,000-gallon storage pond for fire protection and to irrigate the hotel grounds. The inn owner reports that the system does not produce enough effluent for both landscape irrigation and toilet flushing.

The airport terminal is double-plumbed to allow for toilet flushing with effluent. However, the wastewater plant is located at some distance from the airport, so it is not currently economic to provide reclaimed wastewater for the small amount of water use at the terminal. With more development of the commercial strip by the terminal, reclaimed water use may become economically viable. At this time some wastewater is used for irrigation of a baseball field near the trailer park. The remainder is discharged to the nearby Blair Ranch property, where some of it is used for stock watering.

According to local sources, some rural households around Valle that haul water practice rainwater harvesting to provide for their gardens. Some may also reuse graywater.

Water Metering and Rates: Water rates for the Grand Canyon Inn system are as follows:

TABLE A-24
GRAND CANYON INN WATER RATES

	Per 1,000 gallons
Grand Canyon Inn—charge to users within the complex	$10.00
Standpipe rates:	
Commercial haulers	$12.50
Individual haulers (coin operated)	$20.00
Delivered water (hauled by Grand Canyon Inn truck; charge depends on distance traveled)	$30.00-60.00

Water rates for the Hydro Resources system could not be obtained.

Water Efficiency and Conservation: The Grand Canyon Inn owner reports that the inn uses low-flush toilets and fixtures.

Landscaping water use is very minimal in Valle. Besides the grounds of the Grand Canyon Inn, which are watered with reclaimed wastewater, the only other significant uses are reportedly some trees and a ball field in the mobile home park at the airport.

The *Valle Area Plan*, adopted by Coconino County in 1999, includes the following policies:

> Water conservation measures shall be included in all major development proposals requiring Commission or Board approval. Such measures may include the use of reclaimed water for nonpotable uses, low water using plumbing fixtures, and drought tolerant landscaping. (p. 14)
>
> The County shall investigate options for developing an incentive program for retrofitting plumbing fixtures to utilize low water consumptive fixtures. (p. 15)

The extent to which these policies are further articulated and enforced by the county is not clear.

Water Use: Neither the Grand Canyon Inn nor Hydro Resources would provide water use data for this study. Because water use from these systems includes highly varied components—connected residential accounts, connected commercial accounts, and standpipe users—estimating a current use figure is difficult, and not appropriate for this Phase I study. Current water use data will be sought again from the system owners for the Phase II study, or estimated if necessary using data derived from other study area locations for use per residence, use per hotel room, and other measures as needed

Growth and Water System Development: The *Valle Area Plan* sets out a vision of establishing a viable community that meets many of the needs of its residents and provides tourist-oriented facilities. These goals are to be achieved while maintaining the rural character of the area and allowing for a diversity of rural and neighborhood lifestyles.

Given Valle's location along at the junction of the two main highways leading to the south entrance to GCNP, additional commercial development is likely. A number of lots at and near the highway intersections, plus portions of the airport's planned community, are zoned for commercial and light industrial uses. Significant growth has not occurred in recent years, perhaps because tourist numbers have not increased as expected. A motel complex with a restaurant, gas station, and convenience market was approved over five years ago but not built.

As for residential growth, significant subdivision activity has occurred both close to Valle and in the surrounding area. Close in, significant subdivisions include Grand Canyon Subdivision, with 7,827 mostly one-acre lots on 12,160 acres, and Grand Canyon Ranches, with 42 mostly 40-acre lots on 1,560 acres. Clear Air Estates lies over 4 miles southwest of Valle, with roughly 500 2 to 5 acre lots on 2,880 acres. Over four miles north is Woodland Ranches, with mostly 40-acre lots, plus a mobile home park, on 7,680 acres. The Howard Mesa Ranch, located far south of Valle, was purchased in 1998 and was being subdivided when the *Valle Area Plan* was developed. Homes in Howard Mesa are reportedly used mostly if not exclusively for seasonal occupation.

With the exception of the mobile home park in Woodland Ranches, none of these subdivisions currently has any utilities installed. Large-scale development of existing subdivisions—especially the Grand Canyon Subdivision, with its large number of small lots—will be difficult given the problem of assembling multiple lot owners to collectively install utilities.

Most land in the *Valle Area Plan* study area is zoned for 10 acre minimum lot sizes. The "individualist development pattern" (*Valle Area Plan*, p. 47) of scattered home development is likely to continue. Such homes would almost surely haul their water, given the high costs of drilling to the deep aquifer. However, higher density development in Valle or the surrounding area is possible if imported pipeline water become available or a developer emerges who is willing to assume the costs and risks of deep well drilling. Further, some observers have noted the potential for sale and development of some of the thousands of acres of state trust lands in the Valle area, should new circumstances such as continued population growth or availability of pipeline water emerge (Heffernon and Muro 2001).

Arizona Department of Economic Security does not prepare population projections for the Valle area.

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WILLIAMS

Service Area and Water System: The City of Williams is located in roughly the southwest corner of the study area. It is 32 miles west of Flagstaff on Interstate 40, and 59 miles south of GCNP on State Route 64.

The city is sometimes called “the Gateway to the Grand Canyon,” and tourism is an important part of the local economy. An important tourist facility is the Grand Canyon railway that runs from Williams to Grand Canyon Village. Williams also attracts stops from travelers along I-40. Visitor services include 1,350 hotel rooms (1998), restaurants, gift shops, gas stations, convenience stores, etc. The economy additionally includes agriculture, rock quarrying, ranching, government services (including the Kaibab National Forest headquarters), and limited industry.

Williams has experienced relatively slow growth in recent decades. Its population actually declined from 3,599 in 1960 to 2,266 in 1980. Its 1990 census population was 2,532; its 2000 population was 2,905.

The city limits of Williams currently encompass 46 square miles. Eighty-nine percent of this land is in the Kaibab National Forest. The city water system serves most of the remaining five square miles.

Until recently, Williams was completely reliant on surfaces water sources. The city has five reservoirs, constructed between 1892 and 1952. Current storage capacities are:

TABLE A-25
CURRENT STORAGE CAPACITIES

Reservoirs	*Storage Capacity*	
Cataract Lake	135 MG	414 acre-feet
City Dam	36 MG	110 acre-feet
Dogtown Reservoir	360 MG	1,105 acre-feet
Kaibab Lake	293 MG	899 acre-feet
Sante Fe Dam	70 MG	215 acre-feet
Total	894 MG	2,743 acre-feet

Inflows to the reservoirs occur during spring snowmelt, and vary substantially from year to year. Evaporation and seepage from the reservoirs is substantial every year—these losses amount to more than the city’s current annual water use. When the reservoirs are full, they provide about a 2.5 year water supply given current average rates of water use. Two dry years in a row result in significant stress on the surface water supply system. This occurred in 1996/97, and again in 1999/2000.

Since the 1996/97 drought, Williams has vigorously pursued development of reliable groundwater supplies. This program illustrates the risks and costs of well development in the region. The first boring targeted a presumed perched aquifer at 500-600 feet deep west of the city. The well was dry. A second attempt, below the Sante Fe Dam, ran into technical difficulties at 2,000 feet and was abandoned. A third attempt nearby struck water at 1,400 feet. This well is now producing at a peak rate of 110-120 GPM, but only 20-25 GPM if pumped hard for 12 or more hours. A fourth boring on National Forest Land in the vicinity of Dogtown Reservoir was successful and now produces 220-240 GPM. Drilling of a second Dogtown well was essentially a failure, though rehabilitation may be attempted in the future. The most recently developed well was drilled on the city's rodeo grounds, and produces 220-230 GPM. The Dogtown and rodeo grounds wells are over 3,000 feet deep. To date, Williams has spent roughly seven million dollars for three producing wells and three dry wells.

Together, the three successful wells produce about 500 GPM, perhaps a bit more when pushed hard. Williams intends to develop more wells in coming years, as discussed in the growth section below.

The city's water treatment plant has a capacity of one MGD. Treated water storage capacity is 3 MG.

Williams maintains a metered standpipe for the use of commercial and individual water haulers. The city replaced its coin-operated system for individuals with a pre-paid debit card system in 1999. Because of concerns about its water supply status, William restricts issue of new cards. Outside of the city limits, only residents of houses built by June of 2000 may obtain a card. Most eligible households have done so by now. These accounts are now therefore a valuable commodity in the region, and an important property appurtenance when remote homes are sold. As of 2000, Williams had 495 registered non-commercial water hauling customers. The city has restricted use by commercial haulers in drought periods. In 1999 commercial haulers were only allowed to obtain water for delivery to residential customers. Delivery to the Tusayan water system, for example, was not allowed.

Wastewater treatment plant capacity is 540,000 GPD. The plant uses aerated lagoons. The collection system has historically experienced significant inflow and infiltration problems. However, over the last five years the city has replaced 75 percent of the collection lines, at a cost of five million dollars.

Alternative Supplies: Williams has built a pumping station and 4.5 miles of pipeline to provide treated wastewater effluent to the municipal golf course west of downtown. The city developed the system when it expanded the golf course from nine to 18 holes in 1998. Raw water from Cataract Lake supplements the reclaimed water use. Reclaimed water fills three ponds on the course, displaces some of the raw water use for the original course and provides for the course expansion's irrigation needs. The course uses 100 percent of the city's wastewater production in the summer. In the winter, wastewater is discharged from the treatment plant to Cataract Creek. The city plans to develop an I-40 construction borrow pit—"Lake Ellen"—into a treated effluent storage reservoir, perhaps as soon as the next five to ten years. With this facility on-line, all raw water use for the golf course will be replaced with reclaimed water, and reclaimed water will be available for other uses.

Water Metering and Rates: With the exception of a small percentage of multi-family units, all non-municipal water users in Williams are individually metered or sub-metered. Eleven city-owned facilities and municipal landscapes are not metered. Current water and sewer rates, billed monthly, are as follows:

TABLE A-26
WILLIAMS WATER AND SEWER RATES

Water	$6.72; flat rate for first 0 to 1,000 gallons $3.37/1,000 gallons; 1,001 to 10,000 gallons $3.54/1,000 gallons; 10,001 to 20,000 gallons $3.72/1,000 gallons; 20,001+ gallons
Sewer Residential Commercial	 $13.00 flat rate 65% of water charge
Standpipe water Non-commercial haulers Commercial haulers	 $8.83/1,000 gallons $12.52; flat rate for first 0 to 1,000 gallons $7.33/1,000 gallons; 1,001+ gallons

Water Efficiency and Conservation: Williams has made water conservation education efforts that include water bill inserts and school presentations. More importantly, the city has an ordinance in place that includes the following water efficiency and water conservation measures:

- *Plumbing regulations for new construction, remodeling, and fixture replacement.* The code echoes but does not go beyond national plumbing standards for toilets, urinals, and showerheads. For faucets, it goes slightly beyond national standards in requiring that lavatory faucets use no more than 2.0 GPM. Two other notable provisions are included. Public restroom faucets must use metering or self-closing faucets. Pressure reducing valves are required in all new construction and remodeling where line pressure exceeds 50 psi.

- *Water waste prohibition.* Flow onto public streets for longer than 10 minutes of raw or potable water used for irrigation is unlawful. If such flows are the result of an antiquated irrigation system, the responsible individual must within 60 days develop a plan to repair, upgrade, or modernize the system, and implement the plan within 12 months.

- *Retrofit incentive program.* Credits on the water bill are given for retrofits of plumbing fixtures meeting the plumbing regulations and for drought resistant landscaping shown in Table A-27.

- *Water shortage restrictions.* This part of the ordinance establishes levels of mandatory conservation practices to be put in places during water shortages. It defines four levels of resource status, and four corresponding action levels with increasingly stringent advisories, restrictions, and prohibitions on specific water uses (e.g., landscape irrigation, car washing, pavement washing, pool filling, etc.). It also allows or requires the cessation of all commercial water hauling outside the city limits and all commercial water hauling for non-residential uses within the city limits.

TABLE A-27 WILLIAMS CONSERVATION MEASURE REBATES	
Ultra-low flush toilet	$50
Ultra-low flush urinal	$40
Showerhead	$10
Kitchen faucet	$20
Lavatory faucet	$15
Irrigation timer for existing turf	$25
Turf conversion to inorganic ground cover on at least 75% of the total landscape* – $0.25/sq. ft.	up to $350
Drip irrigation for existing turf – 50% of the cost	up to $50

*Also, a minimum of 75% of any new plantings must be drought-resistant shrubs and trees or acceptable xeriscape.

Williams' billing system automatically produces each month a list of accounts for which water use has increased by a certain percentage over the previous month. For these accounts—typically 20-30 each month—meters are re-read. If staff determine the use spikes are correct, they notify the customer of the spike and discuss the possibility of a leak on the customer side of the meter.

Since 1995, the city has replaced over 90 percent of customer water meters. While a number of city facilities are not metered, their irrigation water use is accounted for. The distribution system leakage rate is believed to be low. A leak detection firm carried out a survey of 21 miles of city lines in April of 2000 and found two leaks, which were subsequently repaired.

Water Use: Total water demand in Williams, Table A-28, consists of water production from the treatment plant, which includes billed water, unmetered water used at 11 city-owned facilities and landscapes, and unaccounted-for water; process water used at the drinking water treatment plant; raw water used for the golf course; and reclaimed water used for the golf course. Process water is nonpotable raw water used for filter backwash, sediment removal, and chemical feed. It amounts to about four percent additional water above total production. It is considered a water use here because Williams does not recycle this water back into the water supply system.

TABLE A-28
WILLIAMS WATER USE, 2000, IN MILLIONS OF GALLONS

Potable	*Nonpotable*			*Total Demand*
Drinking Water Plant Production	*Treatment Plant Process Water*	*Raw Water for Golf Course*	*Reclaimed Wastewater for Golf Course*	
202.198	8.088	0.000	48.480	258.766

Reclaimed wastewater provided for 19% of total water demand in 2000. Williams did not use raw water on the golf course in 2000. Ordinarily the city does supplement reclaimed water with raw water for golf course irrigation. In 2001, for instance, the city provided 33.297 million gallons of raw water and 40.099 million gallons of reclaimed wastewater to the golf course.

Williams tracks water use for four customer classes. Total water billings in millions of gallons for recent years are shown in Table A-29. This table shows that billed water use has been fairly steady over this time period. Water use might have been higher in some years but for restrictions and conservation behaviors during periods of drought.

TABLE A-29
WILLIAMS METERED WATER USE, 1995–2000, IN MILLIONS OF GALLONS

	1995	*1996*	*1997*	*1998*	*1999*	*2000*
Residential	50.683	52.342	52.440	53.442	51.036	51.173
Commercial	68.901	70.614	75.277	75.315	78.546	74.995
Water haulers, commercial	20.779	9.904	8.790	8.362	6.777	3.333
Water haulers, non-commercial	5.534	5.611	6.249	8.531	9.089	10.994
Total	145.897	138.471	142.756	145.630	145.448	140.495

In the last 2 years reported, residential use amounts to 35-36 percent of total use, commercial use is 53-54 percent, and water hauling is 10-11 percent. The city's 10 largest water users are all hotels. There are no very large industrial water users.

Twenty-five of the 495 non-commercial water haulers are located within the city limits; the remainders are from outside of the city. It is not known how many of the registered non-commercial haulers use the standpipe each month. The monthly count of commercial hauling users is known. The low monthly use in 2000 was 7 haulers; the high was 10 haulers. Probably 80 percent of the users are located in the Red Lake area north of Williams; the remainder are located mostly south and west of the city. The city believes residential water haulers use on average about 3,000 gallons per household per month, compared to the in-city usage of about 4,000 gallons per household per month.

Seasonal water demand variation is substantial. Total billed water use in the peak summer months is over twice the use in winter months.

Growth and Water System Development: According to the finance director, the city would like to grow from its current population of roughly 3,000 to about 5,000 or 6,000. City officials feel this population level would achieve economic benefits such as new retail stores and business services that would keep dollars circulating in the local economy substantially longer than at present. The current ADES 2050 population projection for Williams is 4,825. While there are some infrastructure constraints to growth in Williams, these are steadily being addressed. Williams is likely to grow as land and housing become more expensive in the Flagstaff area.

Because of its precarious water situation in recent years, Williams has established a policy to inform subdivision developers that the city may have to halt issuance of building permits in some years. To date it has not had to do so, and staff do not believe the policy has not prevented initiation of any development projects.

Williams intends to continue developing groundwater supplies. It reportedly needs 600 GPM in well capacity to avoid supply problems on peak summer days. (600 gpm produces 864,000 gallons per day. During a few peak summer days the demand reaches 1,000,000 gallons per day. By managing its water in storage (3,000,000) gallons, Williams can meet demand with entirely with well water. However, the city prefers to use surface water whenever possible, due to its lower cost.) Current well production is about 500 GPM. The city's goal is to have 1,000 GPM on-line by 2010 to accommodate expected growth through that year (up to 4,500 people based on current rates of water use) and to allow for one well to be down for maintenance or repair at any given time. Williams will probably have sufficient funds to drill its next well within the next three to five years. The local geohydrology is now better understood, and the chances for successful well development are considered good.

Some regional water stakeholders, especially the Havasupai Tribe, have raised concerns about impacts of the city's well development on springs and seeps in the Grand Canyon area. The city and the tribe have entered into an agreement regarding regional ground water management and water conservation efforts by the city of Williams. The agreement document includes several pages of recitals on tribal sovereignty, the significance of the Coconino Plateau to the tribe, the importance of water on the Coconino Plateau, the importance of water conservation, and the affect of drought on the water resources of the city. The specific agreement clauses address conditions under which the tribe will not oppose or may oppose well permits from the U.S. Forest Service and the city's right to respond to opposition, monitoring of well levels and production, restrictions on provision of water by the city to residents outside the city and city opposition to the County allowing home development in areas without water supply, mutual support for development of other water supplies, mutual opposition to large-scale development proposals that rely on groundwater development, continuation of water conservation efforts by the city, and the city's support in principle for the tribe's position that any decrease to the natural flow of Havasu Creek cannot be tolerated.

Williams intends to continue promoting water efficiency and conservation as part of its supply/demand equation. As mentioned earlier, it also expects to displace some current and future raw or potable water use with reclaimed water.

The city is currently considering an expansion/replacement of its drinking water plant. Water system hook-up fees for new development would finance this. The existing wastewater plant will need to be replaced and perhaps expanded in the not-too-distant future. This project is not yet scheduled, and new well development and the city library have priority for capital funding over the next several years. As noted above, it also plans to eventually develop more storage capacity for treated wastewater effluent.

Williams may in the future expand its treated water storage capacity. It could also develop additional reservoir capacity by bringing Gonzales Lake (an I-40 construction borrow pit) on-line with the city water supply system. Saginaw Dam is another potential reservoir site.

Wildcat subdivisions outside of the city are a significant concern to the city. Development in unincorporated areas impacts Williams in many ways: standpipe water use, delivery of septic tank septage to the city wastewater plant, provision of school capacity and other needs not provided by remote development.

Sources:

City of Williams. 1998 (December). "Water Resource Study," Powerpoint presentation notes. 17 pages, obtained from City Finance Director

City of Williams. Monthly water billings by customer class. Water and sewer rate sheet. Consumer Confidence Report, 2000. Water conservation ordinance.

Duffy, Joe. Acting City Manager/Director of Finance, City of Williams. Personal and phone interviews and written communications.

Gillett, Thomas. Public Services Group Leader, Kaibab National Forest, U.S. Forest Service. Personal interview and written communications.

Memorandum of Agreement Between the City of Williams and the Havasupai Tribe. 1997 (August 7).

U.S. Forest Service. 1997 (February 24 draft). *Environmental Assessment: Nugent Land Exchange*. Williams, AZ: U.S. Department of Agriculture, Forest Service, Kaibab National Forest.

U.S. Forest Service. 1999 (July). *Final Environmental Impact Statement for Tusayan Growth, Coconino County, Arizona*. Williams, AZ: U.S. Department of Agriculture, Forest Service, Kaibab National Forest.

APPENDIX B

INTERVIEWS

APPENDIX B: INTERVIEWS

The following individuals were interviewed for this study. Most interviews took place October 2001 through January 2002, with some interviews at later dates. While some of the individuals listed below represent more than one group, each person is listed only for the group most appropriate to the topics of this study.

TABLE B-1
LIST OF PERSONS INTERVIEWED

Entity	*Name*	*Position*
A Quality Water Company (Tusayan)	Chris Williamson	Partner
Anasazi Water Company (Tusayan)	Pam Hoffman	President
Arizona Department of Water Resources	Herb Dishlip	Assistant Director
Bellemont Travel Center	Lonnie McCleve	General Partner
Bellemont Water Company	Nona McClain	Manager
Center for Business Research, ASU	Tom Rex	Research Manager
Coconino County	Paul Babbitt	Chair, Board of Supervisors
Coconino County	Bill Towler	Community Development Director
Doney Park Water Company	Bill Linville	General Manager
Flagstaff	Ron Doba	Utilities Director
Flagstaff Ranch Golf Club	Jim Mehan	Manager
Flagstaff Ranch Water Company	Herbert Dreiseszun	Secretary/Treasurer
Forest Highlands	Dennis Stephens	Assistant Director of Public Works
Grand Canyon National Park	John Beshears	Park Engineer
Grand Canyon National Park	Jeffrey Cross	Science Center Director
Grand Canyon National Park	Dave Welborn	Utilities Supervisor
Grand Canyon National Park Lodges	Lisa McNeilly	Director of Environment, Health, and Safety
Grand Canyon Trust	Nikolai Ramsey	Program Officer
Grand Canyon Trust	Brad Ack	Program Director
Hydro Resources Inc. (Tusayan and Valle)	John Rueter	President
Kachina Village Utilities	Daniel Lueder	Operations Manager
Morrison Institute, ASU	Rick Heffernon	Senior Research Analyst
Navajo Army Depot, Arizona National Guard	Cullen Hollister	Director of Engineering
Northern Arizona University Department of Civil and Environmental Engineering	Charlie Schlinger	Professor
Page	Fred Ladman	Land Surveyor and Assistant to the Engineer

Page	Patrick Owens	Lead Operator, Water and Wastewater Treatment Plants
Page	Bill Plummer	Water Consultant to City of Page
Page	Steven White	Planning and Zoning Director
Ponderosa Utility Corporation (Mountainaire)	Walter Brown	Owner
South Grand Canyon Sanitary District (Tusayan)	Robert Petzoldt	General Manager
South Grand Canyon Sanitary District (Tusayan)	Peter Shear	Chairman, Board of Directors
Tusayan	Chris Brainard	Accountant for Tusayan Water Development Association and South Grand Canyon Sanitary District
U.S. Geological Survey	Don Bills	Hydrologist
Valle	Norm Gobeil	Chair, Area Planning Committee
Valle	Willy and Lorraine Collins	Owners, Grand Canyon Inn
Valle	Patch Karr	Barbie Drilling, Inc.
Williams	Joe Duffy	Director of Finance
U.S. Bureau of Reclamation	Kevin Black	Program Manager
U.S. Forest Service, Kaibab National Forest	Thomas Gillett	Public Services Group Leader

APPENDIX C

PROJECT TEAM

APPENDIX C: PROJECT TEAM

Rocky Mountain Institute's (RMI's) mission is to foster the efficient and restorative use of resources to create a more secure, prosperous and life-sustaining world. RMI works with communities, corporations, individuals and governments to help them create more wealth and employment, protect and enhance natural and human capital, increase profit and competitive advantage and enjoy many other benefits of creative, integrative solutions to problems. The Institute's approach is independent, non-adversarial and trans-ideological, with a strong emphasis on market-based solutions.

Rocky Mountain Institute was established in 1982 by resource analysts Hunter and Amory Lovins. What began as a small group of colleagues focusing on energy policy has since grown into a broad-based institution with more than 45 full-time staff, an annual budget of nearly $5 million (much of it earned through programmatic enterprise) and a global reach. Areas of influence include water, energy, climate protection, transportation, community economic development, business practices and environmentally responsive real estate development.

The Institute brings to the project nearly 20 years of cutting-edge research and consulting in the water management field. RMI helped pioneer end-use/least cost approaches to water resource planning, and is well-known in the field for documenting the results and costs of progressive water conservation programs. RMI staff has evaluated the benefits of water demand management for the U.S. Environmental Protection Agency, the Metropolitan Water District of Southern California, the California Institute for Energy Efficiency, the Governor's office of the State of Colorado, and many others. RMI water staff participates in the Natural Capitalism Practice, the Institute's consulting group, which emphasizes the economic opportunities created by more efficient use of resources and the implementation of profitable new business models.

Planning and Management Consultants, Ltd., (PMCL) of Carbondale, Illinois, was founded in 1976 and is a qualified small business enterprise (SBE) that is 100 percent employee-owned. Its 35-person multidisciplinary team of nationally and internationally recognized researchers and planners continues to maintain recognition among federal, state and municipal agencies and institutions for expertise in providing a wide range of resource planning and management services. Areas of expertise include public involvement, flood planning and management, federal infrastructure planning, risk planning, environmental valuation, recreation planning, noise management and water demand forecasting. PMCL is known for developing innovative methods and practical solutions regarding water resources planning and management for water utilities and other water agencies.

Planning and Management Consultants, Ltd. not only has great depth of knowledge and experience in these subject areas, but also has the necessary technical skills, such as survey research, economic analysis, database management and statistical analysis techniques, to assure the validity of study results. The key to PMCL's continued success has been its aggressive approach to problem solving by utilizing state-of-the-art analyses and multidisciplinary approaches and by providing effective solutions that meet the needs of clients. PMCL's clients include: the American Water Works Association, the U.S. Army Corps of Engineers and other federal agencies and dozens of water providers and local governments across the country, including southwestern entities such as the Phoenix Water Services Department, the Southern Nevada Water Authority, the Metropolitan Water District of Southern California, the City of Albuquerque and others.

The RMI/PMCL team collaborates closely on the North Central Arizona Water Demand Study, with each organization taking the lead in certain areas according to its strengths. The primary personnel for the project are Adjunct Research Scholar *Richard Pinkham* for Rocky Mountain Institute and Senior Analyst *Bill Davis* for PMCL. Mr. Pinkham has over 12 years of research and project management experience in a variety of water management fields, including water efficiency implementation and policy, water system infrastructure and planning, decentralized wastewater management, water reuse, stormwater management, stream restoration and water marketing. Mr. Davis has conducted water demand analyses, water-use forecasts, water conservation program evaluations and economic studies of water management activities for over 13 years. Senior Advisors to the project, providing project oversight and assistance as needed, include Amory Lovins, Robert Wilkinson and Karl Rábago for RMI, and Eva Opitz, Jack Kiefer and Benedyt Dziegielewski for PMCL.