PROJECTED FUTURE UNMET DEMAND ANALYSIS

The **future water demand** (projected for 2035, 2060 and 2110) was compiled for each groundwater basin by adding the individual projected demands from the following sectors:

- Agriculture
- Municipal
- Tribal (in AMA only) Agriculture
- Tribal (in AMAs only) Industrial
- Industrial – hard rock mining (low and high demand)
- Industrial - rock products (low and high demand)
- Industrial - power plants (low and high demand)
- Industrial – turf (low and high demand)
- Industrial – dairy
- Industrial – feedlots
- Industrial – other

The future water supply (projected for 2035, 2060 and 2110) was compiled for each groundwater basin by adding the individual **currently developed and adjusted supplies** from the following sources:

- Groundwater
- Instate surface water
- Upper Basin Colorado River apportionment
- Lower Basin Colorado River apportionment
- Central Arizona Project
- Effluent

The projected future unmet water demand for each basin was calculated as the difference between the **future water demand** and the **currently available and adjusted supply** (Equation 1).

Unmet Demand = Future Water Demand – Currently Available and Adjusted Supply (Equation 1)

Multiple projected unmet demand scenarios were developed to account for the high and low range of industrial demand projections, normal supply and shortage conditions on the Colorado River and instate river systems due to potential drought and/or climate change and the two potential future population distributions (census split, and area split) for the year 2110.

Results of Projected Unmet Demand Analysis

The projected future unmet demand analyses for each basin for the years 2035, 2060 and 2110 are summarized in Appendix X. The results show that statewide unmet demand is projected to range from a low of -??????? in 2035 to a high of -??????? in 2110. The

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analysis indicates that approximately ?? % and ??% of the projected unmet demand for 2035 and 2110 would occur in AMAs with the remaining ??% and ??% of the projected unmet demand for those years occurring in non-AMA areas.

IDENTIFICATION OF POTENTIAL ADDITIONAL WATER SUPPLIES THAT MAY BE DEVELOPED TO OFFSET PROJECTED UNMET DEMANDS

The projections of future unmet demand were used to identify groundwater basins that will eventually require the development of additional water supplies to meet projected future water demands. Water supplies that were evaluated as potential sources of additional water to meet future unmet demands included: groundwater, surface water (instate rivers, Colorado River), CAP, effluent and other miscellaneous supplies. Groundwater management programs such as water conservation were also considered.

Potential Hydrologic, Technical, Legal and Other Issues Related to Developing Additional Water Supplies

Although additional sources of water supply are potentially available for any given groundwater basin, there are various hydrologic, technical, legal, environmental and economic issues related to developing such supplies that may limit their practical feasibility or actual development.

Groundwater

Based on available estimates of groundwater in storage, natural recharge and current rates of groundwater consumption it appears that pumping additional groundwater to supply part, or all of the projected unmet demand for many basins would be a potential option. However, estimates of groundwater basin storage and natural recharge vary significantly in reliability due to existing data limitations, methods of analysis and underlying assumptions. It should not be assumed that these estimates are alone sufficient to project the future long-term sustainability of groundwater supplies in any basin, or portion of a basin. The cost to develop additional groundwater supplies may also be prohibitive when determining if future long-term groundwater supplies are feasible.

During its review of currently available water supplies the WRDC Supply committee reviewed recent groundwater level change trends (from the late 1980s/mid 1990's to the mid/late 2000's) to make qualitative assessments of each basin's current overdraft status. Most basins showed predominant trends of either rising or falling water levels. For example, many of the predominantly agricultural basins of west-central and southeastern Arizona showed extensive water level declines over the last 15 to 20 years (see Spreadsheet and MAP). The observed water level declines in these basins are clear indicators that current levels of groundwater pumping are causing aquifer overdraft. In many parts of the Phoenix, Pinal and Tucson AMAs water levels have been rising over the last 15 to 20 years (see MAP). Water level rises in these areas are mainly attributed to overall reductions in groundwater pumping, and the introduction and use of large volumes of CAP water for direct use and recharge.

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The evaluation of currently available groundwater supplies also included a comparison of the current rate of groundwater consumption in each basin to the basin's estimated natural recharge and groundwater storage. The estimates of groundwater storage and natural recharge were taken from data compiled in the Arizona Water Atlas that were originally presented in various hydrologic reports prepared by United States Geological Survey (USGS), the Arizona Department of Water Resources (ADWR) and other researchers. Low-end estimates were used for analysis when more than one storage or recharge estimate was available for a given basin. Original groundwater storage estimates for each basin were reduced (adjusted) by 20 percent to reflect hydrologic, practical and other limitations on the actual volume of groundwater that may be produced from a groundwater basin. For the most part, the estimates of groundwater in storage were available only to depths of 1,000 to 1,200 feet below land surface.

The results of the analysis indicated that, for most basins, the current rates of groundwater consumption are probably sustainable for at least 100 years (for the purposes of this report, 100 years is regarded as "long-term"). However, the analysis also revealed that some basins that are currently experiencing significant overdraft have relatively large groundwater consumption rates compared to estimated groundwater storage and natural recharge. The long-term sustainability of the groundwater supply for these basins is uncertain. Basins that have uncertain long-term groundwater sustainability, based on current rates of consumption, are listed in Table 1. A complete listing for all basins is provided in Appendix X. Based on the analysis it seems that plans to develop additional groundwater supplies in basins that already face long-term groundwater sustainability issues may be comparatively short-term solutions that will eventually fail to meet projected long-term water needs.

Basin	Sub-basin	2006 GW Demand (AF/Yr)	Estimated Natural Recharge (AF/Yr)	Adjusted GW Storage (AF)	Recent WL Neg. WL Change Rate (FT/Yr)
Butler Valley	none	14,500	1,000	2,000,000	-1.0
Douglas	Douglas	53,500	15,500	16,640,000	-1.2
	Douglas INA				-1.3
Gila Bend	none	295,300	10,000	13,600,000	-4.3
Harquahala	none	66,000	1,000	10,400,000	-1.1
Hualapai	none	8,800	2,000	2,400,000	-0.9
McMullen Valley	none	71,500	1,000	11,200,000	-2.2
Prescott AMA	Little Chino	20,300	8,200	2,400,000	-1.4
	Upper Agua Fria				-1.4
Ranegras Plain	none	29,350	1,000	7,200,000	-0.9
Willcox	none	175,000	15,000	33,600,000	-2.0

Table 1. Basins currently in overdraft that have long-term groundwater sustainability issues at baseline rates of consumption

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Physical Availability

Basins with a currently sustainable long-term groundwater supply still face other hydrologic and technical issues that may ultimately limit the actual volume of additional groundwater that can be produced. For example, in any basin groundwater production is directly related to aquifer transmissivity and storage properties. In many basins these properties vary substantially from location to location. Therefore, it isn't always possible to develop groundwater resources in the area where they may be needed to supply the current or projected water demand. Additionally, it is unrealistic to assume that sufficient wells could be drilled within a basin over any reasonable time-frame that would be capable of completely "draining" an aquifer, as some planned groundwater depletion scenarios might propose.

Groundwater Quality

Other hydrologic and technical issues related to the development of groundwater resources include degradation of water quality at increasing pumping depths. In many groundwater basins it is a well known fact that the quality of groundwater decreases with increasing depth in the aquifer. For most basins it is likely that increased treatment costs, particularly for municipal supplies, will be experienced as groundwater supplies are pumped from deeper depths in the aquifer system. Additionally, it is also known that some large areas in the state have comparatively shallow brackish groundwater that is unsuitable for certain types of use (Little Colorado River and Lower Gila basins).

Land Subsidence

Land subsidence and earth fissures are potential problems that often accompany groundwater development and aquifer overdraft. Wide-spread, damaging land subsidence and earth fissuring has occurred in many groundwater basins of central and southern Arizona where historic groundwater pumping has caused the water table to decline by several hundred feet and irreversible aquifer compaction has occurred. Land subsidence has caused significant damage to land, structures, wells, flood control and water/wastewater infrastructure and permanent reductions in aquifer storage capacity.

Although land subsidence is generally regarded as a regional problem that is caused by the collective impacts of many wells, ADWR is charged with evaluating the potential for new, non-exempt wells that are proposed to pump in AMAs to cause unreasonable increasing damage to surrounding land and other water users due to projected water level decline and projected regional land subsidence. The potential for land subsidence or earth fissuring to endanger property or potential groundwater storage capacity is one of the three fundamental water management concerns that may be evaluated to determine if subsequent (new) active management areas are formed in the state. It is clear that land subsidence continues to be a major concern that could eventually impact groundwater development in certain areas of the state.

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Groundwater/Surface Water Interaction

The development of additional groundwater supplies may also be limited in areas where pumping may impact perennial or intermittent surface water features such as: rivers, streams, springs or lakes. In such areas groundwater in the aquifer may be in direct hydraulic connection with the surface water system, and additional pumping may cause reduction in surface water flows that could be legally limited or prohibited due to their detrimental impact to surface water right holders.

Along the main stem of the Colorado River any pumping that occurs within the area known as the Colorado River accounting surface may be regulated under Federal law or rules. For instate basins that have perennial or intermittent rivers, streams or springs; the existence of numerous surface water rights may practically limit the actual locations and volumes of any additional groundwater supplies that may be developed.

Environment

Since impacts to surface water resources often result in collateral impacts to environmental resources it is also possible than potential environmental impacts and concerns would be raised that could also limit the development of additional groundwater supplies in environmentally sensitive and/or protected areas.

Tribal Rights and Claims

Some of the Tribes have quantified rights for all or part of their communities. Those Tribes that have not yet quantified their rights through litigation or negotiation have pending claims. Groundwater is one source of water to meet Tribal entitlements.

Legal Limits

The development of additional groundwater resources and location of new wells in Active Management Areas (AMAs) and within some areas covered by various legal agreements or settlements also carries varying levels of regulation and potential restriction. In AMAs, applicable groundwater withdrawal permits or groundwater rights must be obtained to withdraw groundwater. Additionally, well spacing and impact rules must be followed to receive authority to drill non-exempt wells in specific locations in AMAs. Outside AMAs, restrictions on well drilling (other than well construction) are few, but prospective well owners are advised that the location and pumping of their wells may eventually be evaluated as part of future adjudications proceedings that could ultimately impact the future use of their well.

Inter-Basin Transfer

Legal restrictions prohibiting the transportation of groundwater from one groundwater basin to another, exist for most basins in the state. Except for a few limited situations,

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groundwater supplies that are developed in one basin cannot be transported to another basin.

Costs

The economic costs to drill and test wells and to pump, transport and potentially treat groundwater are significant considerations that may ultimately limit the uses and volume of additional groundwater that is produced in many groundwater basins. In 2008, the estimated cost to drill domestic wells in the Payson area was about $25,000 to $30,000 (ADWR, 2008). Recent costs to drill high capacity municipal wells in alluvial basins of central and southern Arizona were estimated at $600,000 to $800,000 (ADWR, 2008). Recent costs to drill four, 12-inch diameter municipal wells into deep, hard rock aquifers in the Flagstaff area were estimated to range from about $1.2 to $1.5 million per well (ADWR, 2008). Costs to drill 700-foot deep wells in the Showlow area that are capable of producing 300-500 gallons per minute (gpm) from the Coconino sandstone run from about $250,000 to $300,000 per well (ADWR, 2008). Costs to drill, case, develop and install pumping equipment in a 3,000 to 4,000 foot water production well for the City of Williams are reported to have run in the $2 to $3 million range. The reported costs to pump this well which has a depth to water that exceeds 3,000 feet below land surface (BLS) along with other City of Williams wells at peak rates that produce a combined volume of several hundred gallons per minute is in the $100,000 per month range (ADWR, 2008).

Pumping costs increase as the depth to water increases. Estimated pumping costs of groundwater are shown in Figure 1 for various pump (Ep) and pump motor (Em) efficiencies, and power rates currently available to groundwater pumpers in various areas throughout the state. For reference purposes, the current average statewide depth to water was about 200 feet BLS for the over 4,000 wells that are shown on Map A. Based on the current average depth to water for those wells, and assuming electrical costs will still be in the 4 to 10 cent per kilowatt-hour range (not necessarily a likely assumption), there would be about a 5-fold increase in pumping costs over today's costs when pumping depths approach 1,000 BLS.

Based on the high costs to drill wells and to pump, transport and potentially treat groundwater it seems probable that economic considerations will have an increasing influence on the ultimate development of additional groundwater supplies in any basin, and potentially make groundwater too expensive for certain uses.

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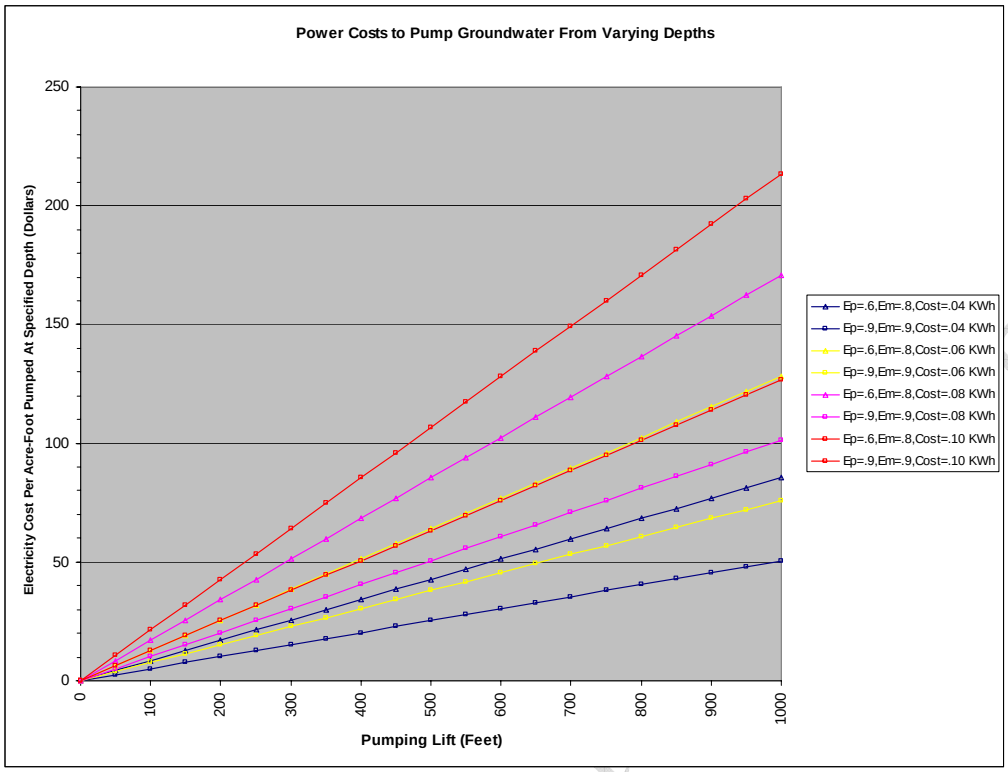

Figure 1. Estimated Cost to Pump Groundwater From Varying Depths

Surface Water (Instate)

Physical availability

The development of additional surface water supplies from the state's in-state river and stream systems is physically possible, but legally unlikely without the purchase and transfer of existing surface water rights. Perennial reaches of rivers and streams have been identified in many instate groundwater basins.

Surface Water Quality

Surface water quality is an important factor that must be considered when evaluating its potential use as an additional water supply. All surface water supplies that may be potentially developed for municipal use would require treatment to existing Federal and state drinking water standards.

Water Rights

There are existing surface water rights or claims to many of these flows, and it would generally be necessary to acquire existing rights in order to tap this potential source of supply.

Proposals to construct additional storage (new dams and/or reservoirs) have also been made. However, it is doubtful that many new dams could be built in the state, either due to the lack of suitable dam sites, or because the flow they might capture and divert would already be claimed by existing surface water right-holders.

Tribal Rights and Claims

Some of the Tribes have quantified rights for all or part of their communities. Those Tribes that have not yet quantified their rights through litigation or negotiation have pending claims. Surface water is one source of water to meet Tribal entitlements.

Surface Water (Colorado River)

The development of additional Colorado River surface water supplies is physically possible, but would require the acquisition of existing Colorado River entitlements. The physical delivery of Colorado River surface water would currently be limited to potential users who are located along the main-stem of the Colorado River, and perhaps to potential in-state users who could acquire entitlements, and receive deliveries from the CAP canal.

CAP

The development of additional CAP supplies to supply projected unmet demands would be restricted to basins that currently receive CAP water, to basins that sometime in the future may be directly served by CAP canal extensions and to basins where water exchanges could be negotiated that would allow water users to use local in-state surface water in exchange for providing equal or greater volumes of CAP water to water users with actual physical access to the CAP canal. The likelihood of developing any additional CAP water is currently uncertain.

Effluent

The use of effluent to offset projected unmet demands is a very important option for many basins. Based on data developed from the Arizona Water Atlas and other sources there was about 503 KAF/yr of effluent generated in the state during the 2006 baseline period and about 212 KAF/yr of effluent that was directly used during that same time. Much of the difference between the volume of effluent generated and that which was directly used went to aquifer recharge, either in managed or constructed facilities. A substantial volume of effluent that is discharged into rivers and streams also helps support wildlife and riparian habitat.

In the future more effluent will be used directly to meet projected unmet demands. Additionally, in areas served by sewage systems, the volume of effluent generated will increase as populations grow. Therefore, basins with significant populations and

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sufficient sewage and wastewater treatment facilities will have significant additional effluent supplies available to help offset projected unmet demands.

Environment

Since impacts to surface water resources often result in collateral impacts to environmental resources it is possible than potential environmental impacts and concerns would be raised that could limit the development of additional surface water resources or the sever and transfer of existing surface water flows that may help maintain or support environmentally sensitive and/or protected areas.

Costs

The costs to acquire surface water rights, and to build infrastructure such as dams, diversion works, canals, pipelines, water treatment plants are very high. Some of these costs will be detailed in the WRDC Finance committee report.

Other Water Supplies

Many other sources of water may be potentially developed in the future to help meet projected unmet demands. Statewide, many of these potential sources of additional supply may be unavailable or insufficient in volume to significantly offset projected unmet demands. However, on the local and basin scale the potential supplies may be important.

Potential sources of additional water include, but are not limited to:

- Mine drainage
- Agricultural drainage
- Water harvesting
- Desalination of ocean water
- Weather modification

Mine Drainage

This potential source of supply could provide additional water in areas where hard rock mining operations, and possibly sand and gravel mining operations exist and require dewatering. This potential source of supply would likely be limited to the known copper mining areas of central and southern Arizona. And to areas along stream channels where sand and gravel operations exist and pit flooding occurs. Water quality issues and potential groundwater/surface water impact issues could also limit the volume and suitable uses of this potential source of supply.

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Agricultural Drainage

Significant agricultural drainage water is currently generated in the Lower Gila River and Yuma basins. In these areas much of the water is sent in drainage canals to Mexico and eventually reaches the wildlife habitat at the Cienega Santa Clara (in Mexico). Some agricultural drainage pumpage from the Lower Gila and Yuma basins has been identified to supply the Yuma Desalting plant, however the plant has only been operated for comparatively short periods since its construction. Significant drainage pumpage also occurs in the Buckeye Irrigation District in the Phoenix AMA, that water eventually reaches the channel of the Gila River and is diverted downstream at Gillespie Dam to farmers in the Gila Bend area. For those areas, and potentially other areas in the state, it is possible that agricultural drainage water could be used to supply some types of potential unmet demands.

Water Harvesting

Water harvesting is generally considered to have two potential scales of implementation. On the local level, rainwater may be harvested from roof tops and impermeable surfaces at homes and buildings and used to help supply the outdoor water needs of the properties. In some areas, rainwater harvesting may be capable of providing a significant percentage of these outdoor water needs.

Large scale water harvesting projects are sometimes referred to as macro-scale rainwater harvesting or storm water harvesting projects. These types of projects involve the routing of runoff to collection or recharge areas and the potential treatment of land surfaces to render them semi-impermeable to infiltration. In Arizona, some proposed storm water harvesting projects and proposals have been met with opposition from surface water right holders and other parties who are concerned about potential impacts to existing surface water rights, potential impacts to land and wildlife habitat, potential impacts to aquifer water quality, etc.

At this time it is unclear to what extent storm water harvesting projects may eventually be implemented.

Desalination of Ocean Water

Desalination of ocean water is a possible method that may eventually bring additional water supplies to some Arizona basins. Possible locations for desalination plants include the Gulf of California and Pacific coast of California. In either situation it is unlikely that desalinated ocean water would actually be transported to instate Arizona groundwater basins. Instead, the desalinated water would be exchanged for Colorado River water that would have been used in California or Mexico. Suffice it to say, the costs of such activities would be high, the details complex and ultimate implementation may be far into the future. However, it is a potential long-term option to supplement water supplies that may eventually be available to some basins.

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Weather Modification

Cloud seeding projects have occurred in various areas of Arizona in the past. However, no comprehensive assessment of the results of such studies was made in the preparation of this report. Therefore, the potential for cloud seeding to appreciably increase precipitation and to ultimately increase available water supplies in any groundwater basin is uncertain.

Conservation

Conservation of water supplies is perhaps one of the most simple, yet potentially effective methods to help offset future unmet water demands. In AMAs conservation methods and goals exist for all major water use sectors, including the municipal, industrial and agricultural sectors. Outside AMAs many water providers and agricultural and industrial users practice conservation methods, both to conserve the available water supply and to gain the cost benefits that may be achieved by reducing water consumption. It is assumed that conservation in all water use sectors will be an ever-increasing practice in future years, and one capable of generating significant reductions in future water use for all groundwater basins in the state.

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Potential Source of Supply	Potential Issues	Potential Infrastructure Requirements
Groundwater (Within Basin)	Available GW in Storage Current GW Basin Overdraft Aquifer heterogeneity/productivity Water Quality Land Subsidence and Earth Fissures GW/SW Impacts Colorado River Accounting Surface Impacts Environmental Tribal Rights/Claims Groundwater Right and Well Drilling Rules Costs to Drill Wells and to Pump, Treat and Transport Groundwater	Wells Pipelines Storage Facilities Treatment Facilities
Groundwater (Import)	Same as Above Plus Inter-basin GW Transfer Restrictions	Same as Above
Surface water (In-state)	Physical Availability of SW Physical Availability of New Dam and Reservoir Sites Costs to Construct and Operate New SW Diversion and Transport Infrastructure Water Quality Environmental Costs to Treat SW SW Rights (Acquisition) Tribal Rights/Claims	Dams Diversion Works Pipelines Canals Treatment Facilities
Surface water (Colorado River)	Physical Availability of CR Water Water Quality Costs to Treat CR Water Environmental Tribal Rights/Claims Colorado River Entitlements (Acquisition)	Diversion Works Pipelines Canals Treatment Facilities
CAP	Physical Availability of CAP Water Proximity to CAP Canal Tribal Rights/Claims Costs to Treat CAP Water	Diversion Works Pipelines Canals Treatment Facilities
Effluent	Water Quality Treatment and transport costs	Pipelines WWTPs
Other Supplies:		
Mine Drainage	GW/SW Impacts Water Quality Treatment and transport costs	Same as for GW
Agricultural Drainage	GW/SW Impacts Water Quality Treatment and transport costs	Same as for GW
Water Harvesting	Technical Feasibility SW-Right Impacts and Other Legal Restrictions Construction, Operation and Maintenance Costs	Pipelines Recharge Facilities WQ Treatment
Desalination of Ocean Water	Technical Feasibility International and Interstate Water Transfer Issues Infrastructure and Treatment Costs	Desalination Plants Pipelines Brine Disposal Systems
Weather Modification	Technical Feasibility Cost	?
Conservation	Research, Outreach and Education costs Water Saving Equipment Costs	?

Table 2. Additional Water Supplies That May Potentially Be Developed
Summary/Conclusions:

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