CENTRAL ARIZONA SALINITY STUDY --- PHASE I

Technical Appendix C

HYDROLOGIC REPORT ON THE PHOENIX AMA

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1.0 INTRODUCTION

The Central Arizona Salinity Study (CASS) is a coalition of water and wastewater agencies evaluating salinity issues in Central Arizona. The mission of CASS is to provide its members with workable alternatives for a quality, cost effective, sustainable, and reliable water supply through partnerships and cooperative efforts in regional salinity planning and management. CASS was formed in November 2001. CASS is a study group and not a legal entity.

Salinity from local and imported sources is increasing the salinity of groundwater in localized areas and the salinity of reclaimed water in Central Arizona. The magnitude of the salinity issue is unclear and water providers in Central Arizona decided to work together to assess the problem and, if necessary, develop regional strategies for managing it. Central Arizona water providers must work together to protect, preserve, and develop these shared resources and to respond to issues of: increasing water quality and water supply regulation; increasing reclaimed water utilization; increasing levels of salinity into water reclamation facilities; developing brine disposal strategies; deteriorating groundwater quality in localized areas; and managing costs.

If no workable solution is implemented, salinity increases may result in greater water and wastewater treatment costs, decreased agricultural production, and some water sources may become unsuitable for their intended uses.

- Increasing salinity levels may reduce the ability of water providers to use groundwater and reclaimed water to meet customer water demands. Some communities may not have enough supply to meet demand. Growth and development in these communities may become limited.

- Water reclamation plants may have water quality permit compliance problems. High salinity levels in reclaimed water supplies may make this resource unsuitable for some of its intended uses. Retrofitting water reclamation plants to manage salinity and dispose of brine may significantly increase wastewater treatment costs.

- Water customer complaints may increase due to increasing salinity of the drinking water supply. Retrofitting potable water treatment plants to manage salinity and dispose of brine may significantly increase water treatment costs.

The following white paper describes hydrologic conditions in the Phoenix Active Management Area (AMA). This report is based on literature review of publicly available information. Much of the data utilized for the salt balance was obtained from a draft CASS report titled *Salt Balance Phoenix Metro Area Typical Year (2002).* Site-specific fieldwork was not conducted as part of this study. The purpose of the report is to provide a general framework of the physical, geologic, and hydrologic aspects of the Phoenix AMA with a primary focus on salinity.

2.0 PHYSICAL SETTING

The Phoenix AMA is located in central Arizona within the Sonoran Desert section of the Basin and Range physiographic province (Figure 1). There are seven defined sub-basins that comprise the Phoenix AMA: Hassayampa; West Salt River Valley (WSRV); East Salt River Valley (ESRV); Lake Pleasant; Carefree; Rainbow Valley; and Fountain Hills (Figure 2). The ESRV and WSRV sub-basins are collectively referred to as the Salt River Valley (SRV) and represent the primary areas of development within the Phoenix AMA. Due to a lack of available data for the Hassayampa and Rainbow Valley sub-basins, the ESRV, WSRV, Lake Pleasant, Carefree, and Fountain Hill sub-basins are referred to as the principal sub-basins in this report.

The Phoenix AMA comprises approximately 5,600 square miles. Land surface elevation ranges from 800 feet to 6,000 feet above mean sea level (amsl) and precipitation averages between approximately 7 and 8 inches per year (ADWR, 2000). The average daily mean temperature in the Phoenix Metro area is 73.3 degrees Fahrenheit (Western Regional Climate Center, 2003).

The principal surface drainage features in the Phoenix AMA include the Gila, Salt, Verde, Agua Fria, and Hassayampa Rivers and the Central Arizona Project (CAP) aqueduct. The Gila River represents the major natural drainage for surface water flowing out of the AMA. The Gila River enters the southern portion of the ESRV sub-basin between the Santan and Sacaton Mountains; flows northwest entering the WSRV sub-basin and continues west near the Sierra Estrella Mountains and Buckeye Hills. The Gila River exits the AMA at Gillespie Dam. The Salt River enters the ESRV sub-basin from the east and joins the Gila River in the southern portion of the WSRV sub-basin. The Verde River flows south through the Fountain Hills sub-basin and joins the Salt River between Stewart Mountain Dam and Granite Reef Dam. The Agua Fria River enters the AMA from the north, flows into Lake Pleasant, and joins the Gila River in the southern portion of the WSRV sub-basin. The Hassayampa River enters the Hassayampa sub-basin from the north and joins the Gila River upstream from Gillespie Dam. The CAP aqueduct flows through the northern and eastern portion of the Phoenix AMA and utilizes Lake Pleasant for storage.

3.0 GENERALIZED GEOLOGY

Basins within central Arizona are thought to have formed during the Tertiary Basin and Range Disturbance. During this disturbance, widespread extensional deformation in southern and western Arizona resulted in northwest trending mountain ranges separated by alluvium-filled troughs.

3.1 BEDROCK GEOLOGY

The principal sub-basins within the Phoenix AMA are generally bounded by the Vulture, Hieroglyphic and New River Mountains to the north; Mazatzal, Usery, Superstition, and Dripping Springs Mountains to the east; Santan, Sacaton, South, Sierra Estrella, Maricopa, and Gila Bend Mountains to the south; and Saddle and Belmont Mountains to the west (Figure 2). The mountain ranges bounding the principal sub-basins of the Phoenix AMA are predominantly comprised of Tertiary volcanic, granitoid, and metamorphic rocks and Precambrian granitoid and metamorphic rocks (Reynolds, 1988).

3.2 BASIN GEOLOGY

The sub-basins within the Phoenix AMA are primarily comprised of northwest trending structural troughs separated by low-lying mountains. The deepest basins are within the SRV sub-basins. Based on gravity modeling, the maximum depth to bedrock in the southern portion of the ESRV sub-basin and in the WSRV sub-basin is estimated at approximately 11,200 to 12,800 feet. The maximum depth to bedrock in the northern portion of the ESRV sub-basin is estimated at approximately 8,000 to 9,600 feet, and the Fountain Hills sub-basin between 4,800 and 6,400 feet (Oppenheimer and Sumner, 1980).

Three different agencies, the United States Bureau of Reclamation (USBR), the United States Geological Survey (USGS), and the Arizona Department of Water Resources (ADWR) have defined the alluvial deposits in the principal sub-basins. The USBR (1976) conducted an investigation for construction of the CAP canal and defined three units based on the dominant lithology. These units are designated as the Upper Alluvial Unit, the Middle Fine-Grained Unit, and the Lower Conglomerate Unit. The USGS also recognized three units in reports on the ESRV (Laney and Hahn, 1986) and the WSRV (Brown and Pool, 1989). These units include the Upper Unit, the Middle Unit, and the Lower Unit, which was further subdivided into an upper and lower part. The ADWR recognized and described three hydrogeologic units for the SRV; the Upper Alluvial Unit (UAU), the Middle Alluvial Unit (MAU), and the Lower Alluvial Unit (LAU) (Corkhill and others, 1993). The nomenclature and correlations for the basin-fill alluvial units described by each agency are presented in Table 3.1 below.

TABLE 3.1 CORRELATION BETWEEN THE ADWR HYDROGEOLOGICAL UNITS AND THE USGS AND USBR GEOLOGIC UNITS

ADWR (1993)	U.S. Geological Survey (1986 and 1989)	U.S. Bureau of Reclamation (1976)
Upper Alluvial Unit	Upper Unit	Upper Alluvial Unit
	Middle Unit	
Middle Alluvial Unit	Upper Part of the Lower Unit	Middle Fine-Grained Unit
Lower Alluvial Unit	Lower Part of the Lower Unit	Lower Conglomerate Unit

The UAU defined by ADWR is equivalent to the Upper and Middle Unit of the USGS, and the Upper Alluvial Unit of the USBR. The MAU defined by ADWR is equivalent to the upper part of the Lower Unit of the USGS and the Middle Fine-Grained Unit of the USBR. The LAU defined by ADWR is equivalent to the lower part of the Lower Unit of the USGS and the Lower Conglomerate Unit of the USBR.

The stratigraphic divisions defined by the ADWR are based on differences in the hydrologic and geologic characteristic of each unit while the divisions defined by the USGS and the USBR are based primarily on geologic variations of the lithology. The stratigraphic nomenclature defined by ADWR (Corkhill and others, 1993) is used for this report. A brief summary of each unit is presented below:

- ***Upper Alluvial Unit (UAU).*** The UAU was deposited in an open, integrated stream system and consists of channel, terrace, floodplain, and alluvial fan deposits. Principal material sources included the Salt and Gila River drainages. During the time the UAU was deposited, the Ancestral Salt River channel had migrated throughout the southern portions of the ESRV. Fine-grained deposits overlying coarse channel deposits were likely deposited by ephemeral streams and sheet flow associated with the migration of the Ancestral Salt River (Laney and Hahn, 1986). The UAU generally consists of silt and sand, except near principal drainages and the margins of the basins where the deposits are predominately sand and gravel.

- ***Middle Alluvial Unit (MAU).*** MAU sediments were deposited in a closed, subsiding basin. Coarse-grained alluvial fans (generally consisting of sand and gravel) were developed near the margins of the basins. In the central portions of the basins, these fans graded into fluvial, playa, and evaporite deposits that are generally fine-grained. These deposits generally consist of silt and clay with some mudstones, however interbedded sand and gravel deposits are present.

- ***Lower Alluvial Unit (LAU).*** LAU sediments were derived from erosion of the mountains surrounding the sub-basins and were deposited in a closed, subsiding basin. The unit is coarse-grained near the margins of the basins (generally consisting of conglomerate and gravel) and fine-grained near the center, generally consisting of mudstones and anhydrite.

The Luke Salt Dome is a massive evaporite deposit located in the WSRV sub-basin. It is estimated to be more than 3,500 feet thick, however the total thickness of the body is unknown (Pay Dirt, 1984). The salt dome lies within the LAU and is considered a hydrogeologic barrier in the ADWR SRV model (Corkhill and others, 1993). The aerial extent of the Luke Salt Dome is presented on Figure 2. During the late Miocene, between ten and fifteen million years ago, the salt body was formed in a local structural basin as an evaporite deposit (Shafiquallah and others, 1980 and Peirce, 1976). The age of the salt dome is based on an overlying volcanic flow that was dated at 10 million years old (Shafiquallah and others, 1980).

4.0 HYDROGEOLOGIC CONDITIONS

4.1 GROUNDWATER OCCURRENCE

The present day groundwater system in the Phoenix AMA is dominated by regional pumping centers, and recharge supplied mainly by infiltration of excess irrigation water, canal leakage, and occasional flood events. The system is dynamic in that it responds to pumping stresses and recharge by adjusting the volume of groundwater in storage (Corkhill and others, 1993). Before the beginning of large-scale irrigation, infiltration from stream flow was the primary source of recharge. However, development of the surface water system greatly minimized the occurrence of surface flows within the AMA (USBR, 1976).

The estimated pre-development volume of water stored in the Phoenix AMA (to a depth of 1,200 feet) was approximately 136 million acre-feet (Freethey and Anderson, 1986). Between 1900 and 1982, approximately 81 million acre-feet of water had been withdrawn from the Phoenix AMA (Reeter and Remick, 1986). During that period, ADWR (1992b) estimated approximately 23 million acre-feet of groundwater was removed from storage. As a result, water levels declined between 2 and 8 feet per year (Laney and others, 1978), and as much as 400 feet of groundwater level decline occurred in some areas (ADWR, 2000). Near the Santan and Usery Mountains in the ESRV sub-basin, and between the Agua Fria River and the White Tank Mountains in the WSRV sub-basin, earth fissures formed near the basin margins due to land subsidence (Schumann, 1974; and Laney and others, 1978). However, between 1983 and 1992, with utilization of the CAP and fewer acres irrigated for agricultural purposes, water levels began to stabilize and are rising in some portions of the SRV (ADWR, 2000).

Groundwater in the Phoenix AMA occurs within the UAU, MAU, and LAU. In the past, the UAU represented the major water-bearing unit in the AMA (Reeter and Remick, 1986). However, the UAU has been significantly dewatered in many areas (Corkhill and others, 1993). Due to this groundwater withdrawal, vertical hydraulic gradients have developed in many locations. In the ESRV sub-basin, vertical head differences exceeding 100 feet have been measured between the UAU and the LAU where significant dewatering of the UAU has occurred and groundwater is pumped from the finer-grained sediments of the MAU and LAU (Corkhill and others, 1993).

4.2 GROUNDWATER MOVEMENT

Based on predevelopment hydrologic conditions, groundwater in the Phoenix AMA generally flowed west in the southern portion of the ESRV sub-basin, southwest to south in the WSRV sub-basin, south in the northern portion of the ESRV sub-basin, and south in the Hassayampa, Lake Pleasant, Carefree, and Fountain Hills sub-basins (Freethey and Anderson, 1986). This groundwater flow regime roughly followed the flow directions of the surface drainages and was in dynamic equilibrium with total inflows equal to total outflows (Freethey and Anderson, 1986). Water levels in 1982 demonstrate post-development conditions in the Phoenix AMA (Reeter and Remick, 1986). Groundwater in the southern portion of the ESRV sub-basin generally flowed to the west similar to predevelopment conditions; however pumping centers flattened the regional gradient, created several cones of depression that altered local flow directions and created a groundwater divide in the western portion of the ESRV sub-basin (Laney and Hahn, 1986). In the northern portion of the ESRV sub-basin, groundwater flowed south, however a cone of depression east of the Phoenix Mountains significantly increased the gradient from predevelopment conditions. By 1983, a groundwater divide was identified between the ESRV and WSRV sub-basins (Corell and others, 1994). In the WSRV sub-basin, 1982 water levels show groundwater flowing toward cones of depressions; a small cone was located northwest of the Phoenix Mountains and a major cone of depression was located between the Agua Fria River and the White Tank Mountains (Brown and Pool, 1989).

Prior to development, basin-to-basin groundwater inflows and outflows were essentially equal (Freethey and Anderson, 1986). However, major groundwater development altered these conditions in the Phoenix AMA. For the purpose of this study, 37,000 acre-feet per year of groundwater flows into the Phoenix AMA, compared to 28,000 acre-feet per year of groundwater flowing out of the AMA (Poulson, 2003).

4.3 GROUNDWATER QUALITY

Water quality in the SRV is generally acceptable for agricultural purposes (Reeter and Remick, 1986). However, total dissolved solids (TDS) can be an issue for municipal use and some industrial purposes. In addition, in some areas of the Phoenix AMA, nitrate, fluoride, chromium, and arsenic concentrations in groundwater exceed drinking water standards. Also of concern are several organic chemicals derived from industrial sources including tetrachloroethylene (PCE), trichloroethylene (TCE), and perchlorate.

TDS concentrations are a general measure of water quality, and specific conductivity measurements can be related to TDS concentrations. TDS concentrations in milligrams per liter (mg/l) can be estimated by multiplying the specific conductivity measured in microsiemens per centimeter (μS/cm) by 0.60 (Reeter and Remick, 1986).

TDS concentrations in groundwater vary greatly in the SRV. In general, water quality is best near mountain-front recharge sources and poorest near the Salt and Gila Rivers. Specific conductivity values generally range between 300 and 600 μS/cm (approximately 180 to 360 mg/l TDS) in the northern portion of the ESRV sub-basin (between Union Hills, Phoenix, and McDowell Mountains), and in the northern portion of the WSRV sub-basin (between the White Tank Mountains, Hieroglyphic Mountains, and Union Hills) (Reeter and Remick, 1986). Specific conductivity values generally range between 700 and 2,000 μS/cm (approximately 420 to 1,200 mg/l TDS) in the eastern portion of the ESRV sub-basin, and between 1,500 and 5,000 μS/cm (approximately 900 to 3,000 mg/l TDS) in the western portion of the ESRV sub-basin.

Water quality generally degrades near the Salt and Gila Rivers. Specific conductivity values near the Salt River are generally between 1,500 and 2,500 μS/cm (approximately 900 to 1,500 mg/l TDS). Near the Gila River, specific conductivity values range between 2,500 and 7,000 μS/cm (approximately 1,500 to 4,200 mg/l TDS) (Reeter and Remick, 1986).

The quality of groundwater inflow and outflow for the Phoenix AMA has been evaluated and is based on ADWR reported flows (Corell and others, 1994) and available groundwater quality data in the area of the identified flow. For the purpose of this study, an average TDS concentration of 680 mg/l is used for all groundwater inflow; and an average TDS concentration of 1,100 mg/l is used for groundwater flowing out of the Phoenix AMA (CASS, 2002).

4.4 ADDITIONAL SALT SOURCES AND WASTEWATER TREATMENT PLANTS

Salt accumulates in the Phoenix AMA from sources other than surface water and groundwater. These sources include agricultural and turf practices, residential contributions, and industrial and commercial processes. In the year 2000, approximately 990,000 acre-feet of surface and groundwater were utilized for agriculture in the Phoenix Metro area. As a result, approximately 17,800 tons of salt was accumulated due to agricultural practices and 4,700 tons of salt was accumulated due to turf practices (Poulson, 2003).

Treatment plants process wastewater, but do not reduce the additional salt contributed by residential, industrial, and commercial users. These users add an estimated 300 mg/l of TDS to their discharge as a result of use of the water (CASS, 2002). Approximately 290,000 acre-feet of wastewater is treated annually in the Phoenix Metro area, resulting in an estimated 118,320 tons of additional salt loading to the effluent. This effluent (average TDS concentration of 890 mg/l) is utilized for agricultural, municipal, and industrial uses. In addition, a portion of this effluent is recharged and a portion is discharged to the Gila River (CASS, 2002).

5.0 SURFACE WATER CONDITIONS

5.1 SURFACE WATER OCCURRENCE

Surface water features in the Phoenix AMA include the Gila, Salt, Verde, Agua Fria, and Hassayampa Rivers, and the CAP aqueduct. The Gila River is the principal natural surface water drainage within the Phoenix AMA, and all rivers in the AMA eventually flow into the Gila River. The Salt and Verde Rivers are extensively dammed east of the Phoenix AMA and provide surface water to AMA users. The Agua Fria is dammed north of the Phoenix AMA forming Lake Pleasant. The CAP utilizes Lake Pleasant for storage and CAP/Agua Fria River water is distributed to users in the AMA. The Hassayampa River has not been developed and is ephemeral in the AMA.

The Gila River is generally dry in the eastern portion of the Phoenix AMA due to the Coolidge Dam (located in southern Gila County) and the Ashurst-Hayden Dam (a diversion dam east of Florence, Arizona) (Pinal County, 2003). The Gila River is perennial in the western portion of the AMA due to discharge from the City of Phoenix 91st Avenue wastewater treatment plant and from irrigation return flow and groundwater pumped for drainage by the Buckeye Irrigation District (ADWR, 2003). The Ashurst-Hayden Dam provides irrigation water for the San Carlos Irrigation Project, which delivers a portion of surface water to the Phoenix AMA.

The headwaters of the Salt River are in the White Mountains near an elevation of 11,400 feet above mean sea level. The Salt River generally flows toward the southwest and includes a series of four dams capable of storing over 2 million acre-feet of water (ADWR, 2003). The Salt River Project manages surface water and generates power from the Salt and Verde Rivers. This water is diverted to users from Granite Reef Dam.

The Verde River emanates from Sullivan Lake north of Prescott, Arizona, and flows to the Salt River. The Verde River is perennial and is regulated by two dams (Horseshoe and Bartlett) that are capable of storing approximately 310,000 acre-feet of water (ADWR, 2003).

The Agua Fria River has a median flow of approximately 39,000 acre-feet per year (ADWR, 2003b). However, the river is ephemeral in the Phoenix AMA due to the New Waddell Dam located at Lake Pleasant. The primary purpose of the New Waddell Dam is to store Colorado River water for CAP use, to store flow from the Agua Fria River, and provide flood protection (Bureau of Reclamation, 2003). Lake Pleasant has a storage capacity of approximately 820,000 acre-feet of water that is used for power generation and water delivery to customers in summer months (ADWR, 2003b).

The CAP aqueduct flows from Parker Dam at Lake Havasu on the Colorado River, through the Hassayampa sub-basin and northern portion of the WSRV sub-basin, then southeast through the ESRV sub-basin to Tucson. The CAP began providing water to the Phoenix AMA in 1986 and utilizes Lake Pleasant for storage. In 2000, approximately 800,000 acre-feet of water from the CAP (including CAP storage from Lake Pleasant) were utilized in the principal sub-basins of the Phoenix AMA (CASS, 2002).

The Hassayampa River originates in the Bradshaw Mountains and generally flows south where it joins the Gila River. Just north of the Phoenix AMA, where the river enters the Hassayampa Plain, the Hassayampa River crosses a major fault. Between 1983 and 1988, an average of approximately 11,000 acre-feet per year of surface water from the Hassayampa River flows into this fault and enters the Hassayampa sub-basin as groundwater inflow (Corell and others, 1994).

5.2 SURFACE WATER UTILIZATION AND GENERAL WATER QUALITY

Based on a study by Thomas and Poulson (2002), in a typical current year, a total of approximately 1.7 million acre-feet of surface water is utilized in the Phoenix AMA. It is estimated that 90,000 acre-feet of Gila River water is utilized annually in the Phoenix AMA, however 100,000 acre-feet of Gila River water flows out of the Phoenix AMA at Gillespie Dam. An estimated 810,000 acre-feet of Salt and Verde River water is utilized annually in the Phoenix Metro area. An estimated 50,000 acre-feet of Agua Fria River water augments the 752,000 acre-feet of CAP water that is utilized annually in the Phoenix AMA. These results are summarized in Table 5.1, and assumptions are listed below the table.

The general quality of surface water utilized in the Phoenix AMA during a typical modern year was evaluated by CASS (2002). Table 5.1 summarizes average flow and general quality of surface water entering the AMA. Assumptions utilized to determine average values are listed below the table.

TABLE 5.1 SURFACE WATER UTILIZATION AND GENERAL WATER QUALITY

DESCRIPTION	TYPICAL CURRENT YEAR
Average annual Gila River utilization (acre-feet)	90,000
Average TDS concentrations in the Gila River water (mg/l)	550
Average annual Gila River outflow (acre-feet)	100,000
Average TDS concentrations in the Gila River outflow (mg/l)	2,370
Average annual Salt and Verde River utilization (acre-feet)	810,000
Average TDS concentrations in the Salt and Verde River water (mg/l)	480
Average annual Agua Fria deliveries (acre-feet)	50,000
Average TDS concentrations of the Agua Fria River water (mg/l)	400
Average annual CAP deliveries (acre-feet)	752,000
Average TDS concentrations of the CAP water (mg/l)	650

- Gila River utilization and TDS concentrations based on average of available data for water diverted at Ashurst-Hayden Dam.

- Gila River outflow and TDS concentrations based on average of available data at Gillespie Dam.

- Salt and Verde River utilization based on 10-year median flow from Stewart Mountain Dam and Bartlett Dam. TDS concentrations are the weighted average based on flow and TDS data.

- Agua Fria deliveries based on year 2000 flow at New Waddell Dam. TDS concentrations based on 12-year average.

- CAP water deliveries based on year 2000 reported deliveries to Phoenix Metro CAP users, CAP recharge projects, the Gila River Indian Community, and Agua Fria River water users.

6.0 GENERALIZED SALT BALANCE

A flow-chart for the salt balance in the Phoenix Metro Area was developed by CASS (2002). This flow-chart and assumptions (Figure 3) is a major source of data for Sections 4.0 and 5.0. The assumptions for each item on the flow chart are referenced with circled numbers that correspond to the assumptions on the following pages. Table 6.1 summarizes the salt balance flow-chart and is presented below:

TABLE 6.1 GENERALIZED SALT BALANCE FOR THE PRINCIPAL SUB-BASINS IN THE PHOENIX AMA

SOURCE	SALT ACCUMULATION (Millions of tons per year)
Gila River Utilization	0.0673
Salt and Verde River Utilization	0.5288
Agua Fria River Utilization	0.0272
CAP Utilization	0.6648
Groundwater Inflow	0.0342
Additional Salt Sources	0.1408
Total Amount of Salt Entering the Phoenix AMA	**1.4631**
Gila River Outflow	0.3223
Groundwater Outflow	0.0419
Total Amount of Salt Leaving the Phoenix AMA	**0.3642**
Net Salt Accumulation in the Phoenix AMA	**1.0989**

Based on this general salt balance, approximately 1.5 million tons of salt enters the Phoenix AMA annually, and approximately 0.4 million tons of salt leaves the Phoenix AMA. In a typical current year, it is estimated that approximately 1.1 million tons of salt is accumulated in the Phoenix AMA.

The majority of the salt entering the Phoenix AMA is associated with CAP utilization (approximately 45 percent) and utilization of Salt and Verde River water (approximately 36 percent). Approximately 10 percent of the salt entering the AMA is associated with agricultural practices and from residential, industrial, and commercial users (additional salt sources). Utilization of water from the Gila and Agua Fria Rivers and groundwater inflow accounts for approximately 9 percent of the salt entering the AMA.

The primary source of salt outflow from the Phoenix AMA is the Gila River at Gillespie Dam (88 percent), and groundwater outflow accounts for the remaining 12 percent. It should be noted that approximately 25 percent of the salt entering the AMA leaves the AMA via Gila River surface flow and groundwater outflow.

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