

The Water-Energy Nexus Dimension of the Central Arizona Project System Use Agreement

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Abstract

Water storage and exchanges are key components of water resources management in Arizona. Water utilities from two major Arizona cities, Phoenix and Tucson, have established Inter-Governmental Agreements to allow for storage of Phoenix's Central Arizona Project (CAP) allocations in Tucson. More recently, multiple agencies have been collaborating to implement a new and unprecedented agreement to enable policies allowing for the exchange of CAP water between the Active Management Areas within the state (AMAs, as defined by the 1980 Groundwater Management Act, as amended). These policies would help mitigate impacts on CAP customers in the event of future water shortages. This paper examines a water-energy nexus dimension to this unique agreement and the multi-agency legal framework for the agreement, known as the *CAP System Use Agreement*.

The Central Arizona Project transports Colorado River water across 336 miles and more than 2,000 feet uphill to supply drinking water to its large metropolitan cities in different AMAs, making it the biggest energy user in Arizona. Currently, there are no policies in place to facilitate the exchange of CAP allocations between AMAs. However, a formal agreement of this type could enable storage of hundreds of thousands of acre-feet of CAP water, which could be used in the event of a future shortage.

The framework for the agreement is being drafted by the United States Bureau of Reclamation, Arizona Department of Water Resources and Central Arizona Project. The *CAP System Use Agreement* will resolve legal, financial and obligatory issues related to wheeling, firming and exchanges of CAP water allocations. When implemented, this agreement will allow water utilities in Tucson to store portions of Phoenix's unused CAP allocation in the Tucson AMA recharge facilities, which can later be exchanged for CAP water ordered by Tucson but directed to Phoenix in times of shortage. The nexus approach will address limits and opportunities to firming, wheeling, and exchanges, specifically through energy use required in each of these areas.

Introduction

Arizona, located in the Southwestern United States, is one of the driest states in the country. In Southern Arizona, Tucson receives an average of only about 12 inches of rainfall annually. Forward-thinking water policy and management laws are the tools that have allowed the state's population and economy to boom. Without effective water management, there would not be sufficient water supplies for the population and thus, there would be no economic development. Yet, Arizona's cities are thriving with close to seven million residents which include a 6.8 percent rise in population between 2010 and 2015 (Quick Facts: Arizona).

Tucson and Phoenix are the most populated cities in Arizona. With no surface water bodies in the south and limited distribution of the Salt River Project system in Phoenix suburbs, these municipalities needed a reliable source of drinking water. As the communities' populations grew, groundwater supplies were rapidly being depleted. The Central Arizona Project (CAP) fills the water resource gap for Arizona's swiftly growing population.

CAP has been operating since 1993, ensuring that Arizona has full access to its Colorado River entitlement (See Appendix A for more background and history of CAP). Bringing 60% of Arizona's share of Colorado River Water to the thirsty cities of Southern Arizona, Municipal, Industrial, Agricultural and Indian customers all rely heavily on CAP for their water (Cooke, 2016). It is the single largest source of renewable water supplies in the state (CAP, 2015). Figure 1 shows the entirety of the CAP system along with all its components including pumping plants, recharge facilities, and its energy source, the Navajo Generating Station (NGS).

Figure 1

CAP System Map



Source: Liberti, Michael. "CAP System Map." Tucson Water. 19 May 2016.

CAP System Use Agreement

Cause for Agreement

The most current development with regard to CAP policy involves the movement of water on the canal. Recent discussions have occurred as to whether or not cities and utilities entitled to CAP allocations may exchange portions of their allocations with one another. For example, water utilities from Tucson and Phoenix would like to come to such an arrangement in the hopes of maintaining flexibility in securing water supplies in the face of a shortage. Discussions such as these become complex, primarily because the owner and operator of the canal which delivers the water is not the entity entitled to the water. Questions are being raised by various water institutions as to what is permitted and what is prohibited regarding movement of water on the CAP canal.

In response to these questions, an agreement is being drafted by Central Arizona Water Conservation District (CAWCD) and United States Bureau of Reclamation (USBOR) with input from Arizona Department of Water Resources (ADWR) and Arizona Water Banking Authority (AWBA) (CAP, 2015). This agreement will formally be known as the *CAP System Use Agreement* (Agreement). A suite of issues exists, which the Agreement attempts to address, including firming, wheeling, and exchanges of water on the canal (See Appendix B for definitions of these terms). The common attribute of these issues is water moving within the CAP system in a non-traditional way. The Agreement will serve as an overall framework essential to maximizing project benefits, fostering flexibility, and reducing potential conflict (Seasholes, workshop). More specifically, the Agreement will actually define the terms firming, wheeling, and

exchanges. In a guest opinion article in Arizona Capitol Times, Ted Cooke, General Manager of CAP, referred to drafting the agreement as a “process to enhance the flexibility of the CAP system and help ensure the reliability of the water on which we all depend” (Cooke, 2016). CAP hopes that the draft Agreement will be finalized by the end of 2016 (Block, 2016).

The Master Repayment Contract (MRC), originally written in 1972 and revised multiple times since, defines CAP’s repayment obligation to the federal government for its construction. The MRC addresses many potential conflicts on the canal, but according to Ken Seasholes of CAP, “Not all of the contractual language is perfectly clear and some things were not fully contemplated...in particular, certain aspects of Arizona’s recharge and recovery program. There is an urgent need to identify how to use the system for maximum project benefit; particularly, as we think about things like looming shortage and really, the need to take advantage of the investments we’ve made in water banking and the need for new supplies ultimately to come into the service area” (Seasholes, workshop).

Application of Agreement for Exchanges

Exchanges that do not involve wheeling are an important aspect of the *CAP System Use Agreement*. Currently, there are various types of exchanges, recognized in different frameworks including the MRC, the Basin Project Act, individual delivery contracts, and in Arizona State law. The exchanges proposed in the Agreement involve a Municipal and Industrial (M&I) subcontractor exchanging water with another subcontractor on the CAP system. For example, Tucson would store a portion of Phoenix’s allocation in its underground storage facilities. The

water, in times of shortage, would be exchanged with direct deliveries to Phoenix off of the canal.

This is a new variation on exchanges because it involves two subcontractors; it has never been done before. This new concept (also referred to as Inter-AMA Firming) was proposed by City of Phoenix, Tucson Water, and Metropolitan Domestic Water Improvement District (District), located in Marana. These three utilities created two separate Inter-Governmental Agreements (IGAs) that allowed for the first phase of the exchange process: storage. The second phase of the exchange (recovery and the exchange itself) cannot be completed without the implementation of the Agreement. These IGAs have since raised questions about system capacity issues related to downstream recharge.

The Agreement will facilitate Inter-AMA Firming, due to the fact that Project Water will be exchanged and firmed across different Active Management Areas (AMAs). Tucson Water and District are part of the Tucson AMA (TAMA), while the City of Phoenix is in the Phoenix AMA. Other municipalities and utilities may sign on to the Agreement in the future. The Inter-AMA Firming that the City of Phoenix, Tucson Water and District are looking to implement would work as follows:

Phoenix would have a portion of its CAP allocation delivered to District's and Tucson Water's facilities. TAMA utilities will recharge that water in their respective underground storage facilities. When Phoenix decides it wants its water back, the city will receive it via the canal; not from Tucson, but upstream of Phoenix. Instead of having Tucson utilities recover that portion and pump it back to Phoenix, these utilities will simply keep the water to recover as

they desire, while diverting the equivalent volume from their CAP allocations to Phoenix instead. The two CAP subcontractors (either City of Phoenix and Tucson Water, or City of Phoenix and District) are exchanging water, while also firming.

City of Phoenix would pay a fee for TAMA utilities to store its water. The current discussion for Tucson Water's fee is between \$35.00 and \$50.00 per acre-foot. District and Tucson Water are not required to charge the same amount. In the future, if more recharge basins are needed in Tucson to store even more of Phoenix's allocation, Phoenix would also pay for their construction. Phoenix is not looking to recharge its allocation in its own AMA due to the challenges associated with recharging water in that area, such as high salinity and the inability to recover the water. The cost of infrastructure for Phoenix to implement its own recovery system would be much higher than sending the water to Tucson for recharge.

The back end of the water transaction is where the actual exchange technically takes place; when Phoenix decides it wants the water back. This is one particular circumstance that helped spur the discussion of creating the Agreement. Without the Agreement, if there is an outage on the canal or a reduction in delivery due to a declared shortage on the Colorado River, Phoenix might be shorted, since it relies on surface water. Tucson, on the other hand, would not be in danger of an immediate water supply reduction because it could simply recover stored CAP water from its recharge facilities.

To date, City of Phoenix, Tucson Water and District have already begun a pilot project, or "proof of concept," to test the feasibility of the Project Water exchanges. In 2015, per an IGA, Tucson Water received 850 acre-feet of Phoenix's allocation to recharge in its Clearwater

Renewable Resources Facility (Clearwater). Clearwater actually consists of two facilities: Central Avra Valley Recharge Project (CAVSARP) and Southern Avra Valley Recharge Project (SAVSARP) (See Appendix B for more information on these facilities). In 2016, Tucson Water took another 4,000 acre-feet to recharge. Per a separate IGA, District took 150 acre-feet of Phoenix's allocation in 2015 to recharge in its Avra Valley Recharge Project (AVRP) and will take an additional 1,500 acre-feet in 2016 (Block, 2016). The actual exchange, or phase two, has not yet taken place; that is, the "return" of Phoenix water to Phoenix via the CAP canal, and the recovery of the equivalent amount at TAMA recharge facilities.

There are plans to complete phase two of this pilot project in the near future, though not until the Agreement is actually implemented. According to Water Resources Manager for District, Michael Block, a verbal agreement was made between District, Tucson Water, and City of Phoenix stating that "no exchange will take place until the *CAP System Use Agreement* and other agreements are finalized and executed." Block continued to state that it is not likely that those agreements will be executed in time for placing [CAP] orders by October 1, 2016 for 2017 deliveries (Block, 2016)).

If the Agreement is implemented, Tucson Water could receive up to 40,000 acre-feet per year of Phoenix's allocation, and District could receive up to 3,500 acre-feet per year. Expansions of current recharge facilities would be necessary in order to meet this projected capacity, all of which would be paid for by City of Phoenix. These expansions would benefit TAMA greatly. With continual recharge, the water table will continue to rise, saving on pumping costs for each utility. Tucson Water and District will have infrastructure to meet future recharge capacity demands without spending the capital. "If possible, you always want more capacity

than you need,” says Dick Thompson, Lead Hydrologist at Tucson Water. With an expansion, there would be more basins and equipment to maintain; the storage fees paid by Phoenix will cover expenses and help maintain these facilities. Without the expansion, only 5,000 to 10,000 acre-feet of Phoenix’s allocation could be stored at Tucson facilities.

Water-Energy Nexus

The concept of a water-energy nexus is growing in popularity and usage. It is no secret that the energy sector requires large amounts of water and that the water sector requires large amounts of energy; hence, the nexus. This approach is proving useful in water management and policy. It would be nearly impossible to successfully manage one sector without considering the other.

The Central Arizona Project is often cited as the largest energy user in the state of Arizona, supplying 80% of the state’s population with water. In 2014, CAP used 2.8 million megawatt-hours of energy to deliver 1.6 million acre-feet of Colorado River water (Basefsky, 25 April 2016). The end elevation of the 336-mile-long canal is 2,800 feet higher than the start of the canal, at Lake Havasu. The water is pumped uphill for almost the entirety of the canal, using 14 pumping stations, with the biggest lift of 800 feet at Lake Havasu (Seasholes, interview) “We are the energy-water nexus because of what we do,” says Seasholes, “We have direct responsibilities to manage the portfolio from NGS” (Seasholes, interview).

Navajo Generating Station

In order to understand the water-energy nexus, it is important to understand where CAP receives its energy from. There are many complexities associated with this power. Almost all (90-95%) of the power used to pump CAP water uphill comes from the Navajo Generating Station located on the LeChee Chapter of the Navajo Nation in Northeastern Arizona (See figure 1) (NGS, 2011-2016). NGS was constructed, primarily to provide power to CAP, under special permission from Congress (The 1968 Colorado River Basin Project Act), in order to avoid building more dams along the Colorado River, specifically near the Grand Canyon (Modeer, 2010). The plant began producing power in 1974 and has a “rated life-span” of 70 years, putting its closure in 2044 (Basefsky, 2 May 2016).

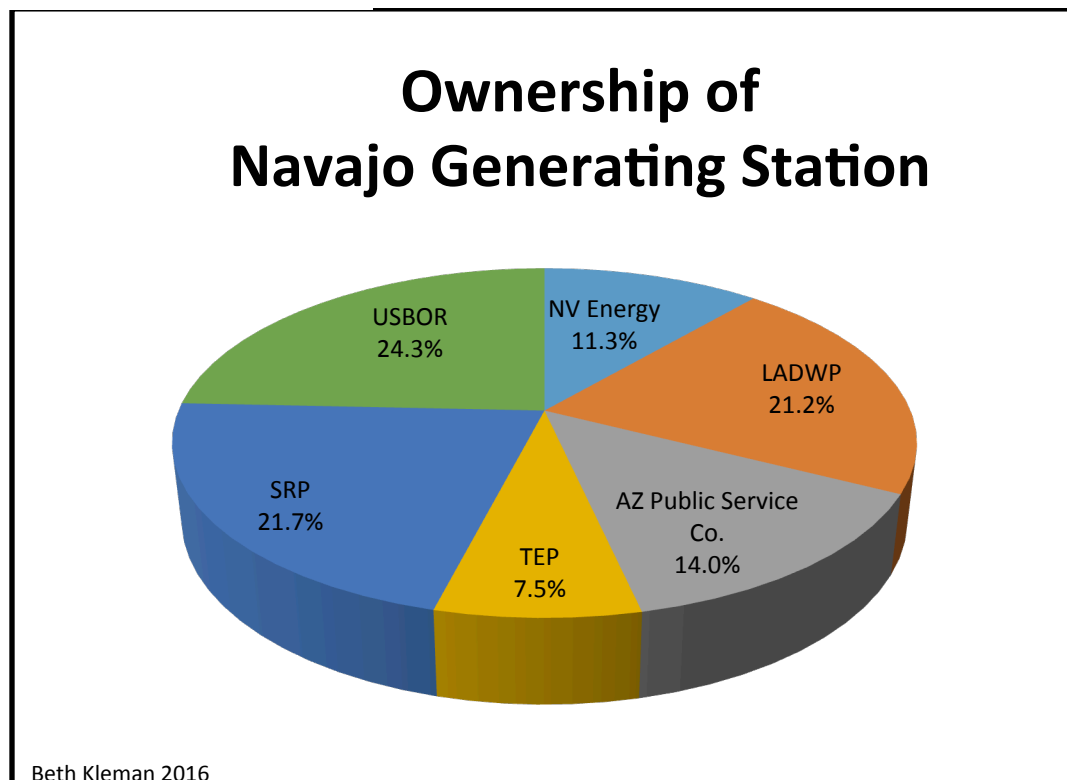
NGS is a coal-fired plant which receives its coal from nearby Kayenta Mine, located 78 miles to the southeast (see figure 1) (NGS, 2011-2016). The mine, owned by Peabody Energy Corp., transports the coal to the plant via a dedicated electric train. The power plant’s production capacity is 2,250 megawatts from three 750 megawatt units (NGS, 2011-2016). NGS employs nearly 500 people; the plant and mine combined employ approximately 900 people (Randazzo, 2015). Since both are located on the Navajo Nation, more than 90% of employees are Native American, making these facilities “critical sources of employment” for the Navajo Nation, adding labor and social-equity challenges to this water-energy nexus (NGS, 2011-2016).

The ownership of NGS is rather complex. Energy generated there is owned by electricity providers in three different states, with the largest share owned by USBOR (figure 6). The specific breakdown of owners is as follows: From Arizona, 14% is owned by Arizona Public Service Co., 7.5% is owned by Tucson Electric Power Co. (TEP), and 21.7% is owned by Salt River

Project (SRP). From California, the Los Angeles Department of Water and Power (LADWP) owns 21.2%. From Nevada, Nevada Energy (NV Energy) owns 11.3%. The remaining 24.3% is owned by USBOR (Randazzo, 2015). Though the plant has multiple owners it is operated by SRP, the “largest provider of electricity and water in the Greater Phoenix metropolitan area” (NGS, 2011-2016).

Figure 6

NGS Ownership Pie Chart



Source: Graph created by Beth Kleiman with information compiled from Mitch Basefsky and Randazzo, 14 May 2015.

Recent developments have occurred regarding the ownership shares of NGS. In May of 2015, SRP officials approved the \$10 million purchase of LADWP’s share of NGS. An additional \$2.88 million will be needed from SRP to prepay for coal expenses and to transfer LADWP

assets (Randazzo, 2015). According to External Communications Representative for CAP, Mitch Basefsky, LADWP wants out because California has a state law that prohibits power utilities from investing in fossil fuels. The implications of this law would mean LADWP would be unable to pay for any upgrades to NGS, causing them to be in default which could cause a lawsuit. In addition, by divesting from NGS, they automatically improve the percentage of renewable power in their portfolio (Basefsky, 2 May 2016).

Nevada Energy also plans to leave the plant and withdraw ownership, though not necessarily in the same manner as LADWP (sale of shares to another current owner). According to Basefsky, NV Energy most likely wants out of their ownership of NGS because they want to build new natural gas plants in Nevada, but the state legislature will not allow that unless they divest from other fossil fuel plants. NV Energy determined that NGS “would be a good trade-off for them, given the cost of coming coal plant regulations beyond CPP [Clean Power Plan],” (Basefsky, 2 May 2016).

Kayenta Mine

Peabody Energy, owner of Kayenta Mine, filed bankruptcy on April 13, 2016. The mine supplies NGS with the coal needed to run the plant. Peabody Energy Corp. is the nation’s largest coal miner, with ownership stakes in 26 mines in Australia and the U.S. (Randazzo, 2016). Despite the bankruptcy filing, officials are not expecting closure of Kayenta Mine.

The mine has a 35-day supply of coal on site, which can be used, and even increased, as a buffer in the case of a coal shortage. In addition, the contract between Kayenta Mine and NGS owners allows the owners to step in and operate the mine in the event that Peabody can’t

meet the contract (Randazzo, 2016). It is for these reasons that officials aren't predicting a closure of the mine. "Since the Kayenta mine is a money-maker for owner Peabody Energy, they are unlikely to close that operation in response to their recent bankruptcy filing," says Basefsky (Basefsky, 25 April 2016).

The Peabody bankruptcy filing is significant because it exposes a larger issue. Peabody makes most of its money by selling its coal to utility companies who then use the coal to generate electricity. Many utilities are shifting away from using coal, and moving toward natural gas. Natural gas costs less and produces much less pollution. If utilities stop using coal for energy, the coal plants will likely be forced to shut down. In the case of NGS, this would put hundreds of workers out of the job, crippling an entire community. If there is no coal to generate inexpensive power for CAP, there will be implications for all CAP customers.

If the mine were to close, Basefsky says that the multiple owners of NGS would need to evaluate whether an alternative source of coal was available and at what cost. "Depending on the results of that analysis, either the operating cost of NGS would rise or the plant would shut down" (Basefsky, 25 April 2016). The rise in operating cost for NGS would inevitably lead to a rise in cost for CAP, which would then lead to a rise in cost of water to all CAP customers. "Assuming that recent energy market price fluctuations reflect future market variability, this would require a 50 to 300 percent increase in CAP energy charges" (Impact, 2010).

Currently CAP pays NGS solely for the cost of the energy production. According to Basefsky, the CAP energy budget for 2016 is in the range of \$30.00 per megawatt hour (MWh).

CAP will pay for about 4.2 million MWh in a year, totaling about \$120 million (Basefsky, 28 June 2016). This is the largest expense category for CAP.

If NGS were to close, forcing CAP to find a new energy source, it would likely have to pay market value. It is impossible to predict what market value might be if and when the closure takes place. Regardless, the cost would most certainly be higher than it is currently. With the higher cost of energy to run CAP, water prices would rise; either in the form of increased service capital charges for M&I users, or increases in ad valorem tax rates, or both (Impact, 2010). Basefsky, states, “If NGS were to shut down, it would significantly impact what CAP pays for energy. CAP would have no choice but to purchase energy on the open market, at least initially” (Basefsky, 25 April 2016). The cost of power fluctuates with the cost of natural gas, which has a historically volatile market. The price for natural gas has been as high as \$14 per million British Thermal Units (MMBTU) in the late 2000s to less than \$2/MMBTU earlier this year. It is currently in the upper \$2/MMBTU (Basefsky, 28 June 2016).

A higher cost for power would have effects on how CAWCD is able to repay the federal government for the construction of CAP. The closure of NGS would cause CAP to lose at least \$50 million in annual revenues from the sale of surplus power (Impact, 2010). The surplus energy is sold at market value for that particular day/hour. “Power that is sold can vary widely from the low \$20/MWh range to as much as \$100/MWh” (Basefsky, 28 June 2016). In addition, the U.S. and Indian communities with water settlements would lose tens of millions of dollars in revenues each year (Impact, 2010).

Repayment

The Central Arizona Project cost approximately \$4 billion to construct. Pursuant to the Master Repayment Contract (MRC), \$1.65 billion must be repaid to the federal government (CAP, 2015). According to Ken Seasholes of CAP, the annual repayment of that sum by CAP is \$50 million with full repayment scheduled by 2044. The means by which CAP has been producing the funds to repay the federal government is through the sale of excess power generated by NGS.

CAP's share of power generated by NGS is about 4.3 million megawatt-hours, yet only 2.8 million megawatt-hours are used by CAP to deliver Colorado River water. This excess, unused power is then sold by Western Area Power Authority (WAPA) on CAP's behalf (Basefsky, 28 June 2016). In addition to repaying the government, that money is also used to help fund the Arizona Water Settlements Act with various tribes (Basefsky, April 25 2016).

Without NGS, the cost of CAP water would rise significantly, jeopardizing Indian water rights settlements and causing increased groundwater pumping (NGS, 2011-2016). "We shape our power so that we can sell as much as possible at peak season," says Seasholes (Seasholes, interview). Seasholes states that CAP has been on track to have the full amount of repayment paid by the sale of excess power; however, recently that "doesn't cover anywhere near as much of that \$50 million as it used to...[we] need to gradually increase capital charge to make up some of the difference" (Seasholes, interview).

Air Quality

Due to the fact that the generating station is in such close proximity to Grand Canyon National Park, air quality concerns play a role in the energy matters related to CAP and NGS. In 1999, the Environmental Protection Agency (EPA, 2016) issued the Regional Haze Rule, applied to 156 national parks and wilderness areas, for the purpose of improving “visual air quality” and visibility. States were imposed with developing long-term strategies to improve visibility in these national parks, primarily by reducing emissions of air pollutants (EPA, 2016). The Grand Canyon is one of these parks and NGS, a coal-fired plant, is located in very close proximity.

Nitrogen Oxide Emissions

In February of 2013, EPA proposed a method for any power plant violating the Regional Haze Rule to reduce emissions of nitrogen oxides (NO_x). This method (whatever it may be) is referred to as BART, Best Available Retrofit Technology. In order for NGS to comply with this rule, it would need to install a technology called Selective Catalytic Reduction (SCR). This technology would cost upwards of \$500 million, and possibly much more if additional air filters are also required to remove airborne particulates created by SCR. SCR would need to be installed and operational at NGS by 2023 (CAP, 2015).

CAP’s portion of the costs for implementing SCR would be borne by its customers (CAP, 2015), adversely affecting CAP’s taxpayers, M&I subcontractors and Indian communities. The high cost could lead to CAP water rates two or three times higher than they would be otherwise. According to a 2010 CAP document, the installation of SCRs would require “an increase in CAP energy charges of at least \$9.85 per acre-foot, a 20 percent increase over the 2010 energy rate” (Impact, 2010). This would affect anyone who gets water from CAP, but the

“increase in energy costs would be especially harmful to CAP’s Indian and Non-Indian Agricultural water users” (Impact, 2010). In fact, the higher energy costs will hit almost everyone in the state (NGS, 2011-2016). In reality, installing SCR for all three units would be far too expensive for NGS to be able to implement, forcing the closure of the entire plant. “This would be an economic disaster for the Navajo and Hopi people” (NGS, 2011-2016).

The EPA did leave the option to consider alternative plans, should there be any, “in recognition of the importance of NGS to Arizona’s water sustainability and the major role the plant and associated coal mine play in the economies of the Navajo Nation and the Hopi Tribe” (CAP, 2015). In response, a new group was created to find that alternative. The Technical Work Group (TWG) consists of CAP, the Gila River Indian Community, the Navajo Nation, SRP, the Environmental Defense Fund, the US Department of Interior and Western Resource Advocates (CAP, 2015). TWG called its plan “Better than BART,” and offered two alternatives to SCR that would actually incur even greater reduction of NO_x emissions over the lifespan of the plant than the proposed EPA plan.

The EPA accepted TWG’s proposed alternative, making it the BART in the final Regional Haze Rule for NGS. The plan is to shut down one of the three generating units at NGS by 2020 and implement either SCR or another NO_x reduction technology on the other two units by 2030 (Basefsky, 3 May 2016). This will allow the plant to remain open, to continue to supply CAP’s energy, to continue to employ the Navajo Nation, and to meet all EPA guidelines. Despite this accomplishment, there are a number of lawsuits filed by environmental groups who want the EPA to reverse their decision in order to force NGS to close (Basefsky, 2 May 2016).

In addition to the lawsuits, there is an Environmental Impact Statement (EIS) process currently taking place over the lease of NGS on Navajo lands and the rights of way for water and electric transmission on the reservation. These leases expire in 2019 if not renewed before then. According to Mitch Basefsky of CAP, “Everyone expects the NEIS to pass, although there may be some mitigation that the NGS owners will have to fund” (Basefsky, 2 May 2016). Once the EIS process is complete, it must be approved and signed by the Secretary of the Interior. If the EIS does not pass, NGS will lose the lease for the land which the plant sits on, as well as the rights of way for the train that transports coal from Kayenta Mine to the plant. In other words, NGS will lose its right to operate on Navajo land (Basefsky, 2 May 2016). If this happens, there would be no need to implement BART because the plant would no longer operate. “That’s why the success or failure of the EIS and the subsequent lease and right of way agreements could impact the fate of NGS and the timing of the Regional Haze Rule implementation,” says Basefsky (Basefsky, 3 May 2016).

Carbon Dioxide Emissions

While the Regional Haze Rule aims to curb NO_x emissions, another of EPA’s plans aims to curb carbon emissions. The Clean Power Plan (CPP), finalized on August 3, 2015, aims to reduce the nation’s carbon emissions by 32% below 2005 carbon levels by the year 2030. More specifically, the CPP mandates carbon dioxide emission guidelines for existing fossil fuel-fired electric generating units (EGUs) (NGS, 2011-2016). The EPA issued a carbon rule specifically for existing fossil fuel-fired EGUs on tribal lands; NGS falls in this category. The target for EGUs on tribal lands is to reduce carbon emissions by 38% (Basefsky, 2 May 2016). Under the Clean Air

Act, the CPP sets a carbon emissions reduction goal for each state and gives states flexibility to meet their goals in the way that works best for them.

Despite everything, due to a request by 27 states to block the CPP, a stay was put on the plan on February 9, 2016. The CPP regulations will not be in effect while legal proceedings in regard to this challenge are taking place (NGS, 2011-2016). “The fate of the CPP is now in the hands of the DC Circuit Court,” says Basefsky, “They will rule on the merits of the states and other lawsuits opposing the CPP” (Basefsky, 2 May 2016). The circuit court is scheduled to review these merits in September of 2016. “Some form of CO₂ limits will likely be set eventually, but what and when are debatable,” Basefsky adds (Basefsky, 2 May 2016).

All of these federal guidelines to improve air quality and slow climate change, whether officially implemented yet or not, will have effects on energy production. As demonstrated by the information above, these guidelines will also have effects on water; specifically, on cost and delivery. More precisely, these air quality guidelines will determine the fate of the Navajo Generating Station, which will have great impacts on CAP and its customers.

Future Energy Sources

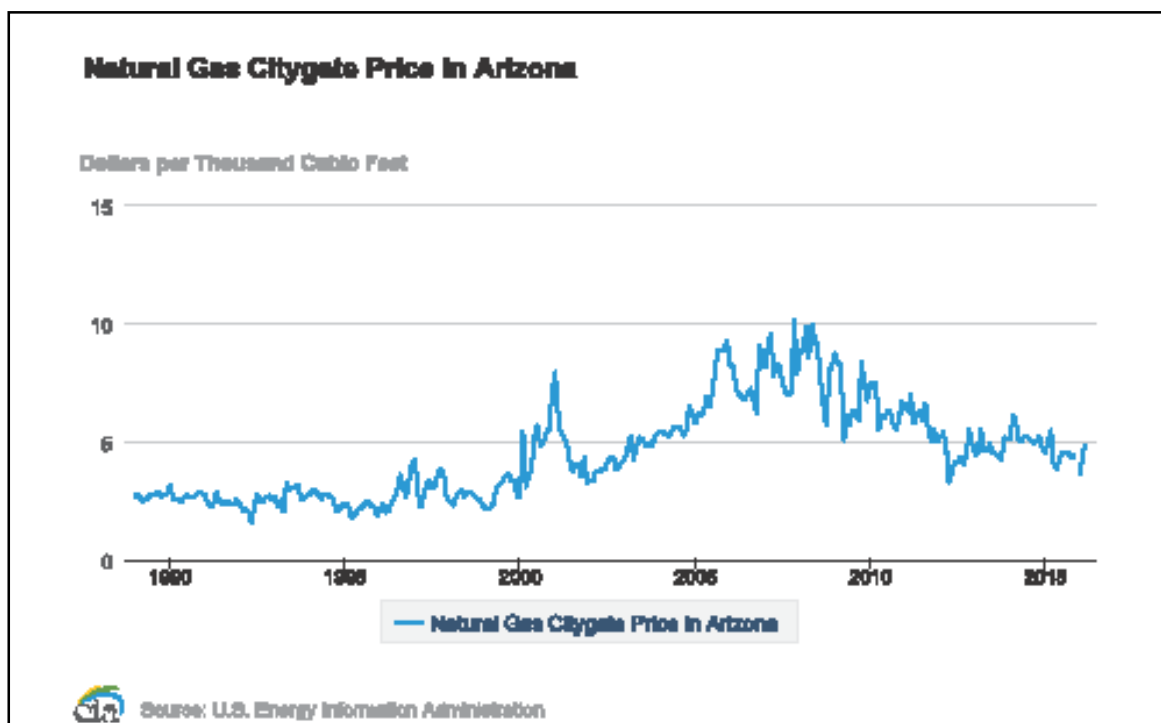
The entire U.S. is making its move away from fossil fuels, as evidenced by the recent CPP. Climate Change has taken the main stage in environmental discussions. Fossil fuels contribute to a warming climate, which scientists, activists, and politicians alike are trying to curb. The next decisions will be to choose what will replace coal to produce energy. Natural gas, nuclear power, and renewable energies such as wind and solar are all alternatives to coal. As states develop their plans to reduce carbon emissions, they will need to evaluate these options

and make key decisions that will affect their electricity generation and costs. “States must carefully evaluate the risks of substantially shifting toward natural gas against the benefits of ramping up renewable energy sources and energy efficiency” (The Clean Power Plan).

The price of natural gas has been decreasing recently, making it a cost effective alternative to coal. Natural gas emits carbon, though considerably less than coal. However, due to the volatile price history of natural gas, some warn that reliance on this resource for energy could be dangerous. “Over-relying on it for electricity creates serious economic and public health risks for consumers and states and fails to provide a long-term solution to climate change” (The Clean Power Plan). Figure 7 shows Natural Gas price fluctuations since 1989.

Figure 7

Natural Gas Price Fluctuations over Time



NOTE: Citygate is a point or measuring station at which a distributing gas utility receives gas from a natural gas pipeline company or transmission system. The Citygate is not one specific, physical location, but a virtual trading point on the system. (EIA. 2015)

The use of renewable energy for power production would decrease carbon emissions drastically. One source notes that electricity generated from renewable energy sources would provide steady energy prices (The Clean Power Plan). This is due to the fact that once a facility is constructed, the only cost would be maintenance and operation, not the wind or sun itself.

Evaluating potential future energy sources is complex, particularly from a utility's point of view, making it extremely difficult to compare costs of utilizing different resources in order to determine which would be most favorable to implement. There are fixed costs and variable costs to consider, as well as constant market fluctuations. A utility must consider initial cost of implementation, on top of transmission requirements and costs associated with distribution, operation and maintenance. U.S. Energy Information Administration's 'Annual Energy Outlook 2016' explains various factors involved in projecting costs of different sources of electricity generation. Levelized Cost of Electricity (LCOE), for example, is used to summarize overall competitiveness of different generating technologies (EIA, Annual Energy Outlook, 2015).

According to CAP Power Programs Manager, Ronald Lunt, "If CAWCD were to build a natural gas fired combined cycle power plant, the costs are estimated to be in the \$60/MWh range" (Basefsky, 28 June 2016). This cost estimate is twice as high as what CAP is currently paying for power, mostly due to the capital costs associated with building an entire facility. Of course, the market price of natural gas at that time would also be a factor. Moreover, CAP would still have to continue to pay its share of repayment costs for NGS, if it were still running (Basefsky, 28 June 2016).

Water-Energy Nexus Dimension of CAP System Use Agreement

How will the proposed CAP System Use Agreement affect energy use and costs on the canal? As mentioned above, it is difficult to project what future energy costs for CAP might be, particularly if NGS were forced to shut down. As Basefsky points out, there are two basic variables involved in the Agreement's effect on energy use: 1) how many pumping plants lay between the water source and the delivery point, and 2) whether the deliveries are in addition to or in lieu of regular CAP deliveries.

If water, per the Agreement, is being transported on the canal in addition to the regular CAP Project Water delivery, then the volume of total water will be greater, requiring more energy. CAP system capacity is approximately 1.8 million acre-feet; under present conditions, 1.6 million acre-feet is delivered (Buschatzke, 2015). If a shortage is declared, there will be a reduction in regular CAP deliveries of Project Water. If Agreement water is carried on the canal along with a reduced regular delivery, then the total volume on the canal might not be any greater than when there were no reductions and no agreement. This would, in turn, require no additional energy.

Topography played a large role in the design of CAP. The canal is not perfectly straight because it follows geographic features to allow for the use of gravity to carry the water, wherever possible. The pumping stations were constructed where necessity dictated; in other words, when the water could not be gravity-fed. The pumping stations lift the water to the higher elevations along the canal and they are what require the energy. This is why Basefsky believes that the quantity of pumping stations between the source of water and the delivery

point will factor into effects on energy use caused by the Agreement. There are seven pumping plants between Phoenix and Tucson.

From a general perspective, the energy use could remain fairly balanced over time with the Agreement's implementation. Initially, more energy might be required to pump a higher volume of water from Phoenix AMA to Tucson AMA for the first phase of the exchange. Conversely, when implementing phase two of the exchange, a lower volume of water will flow south of Phoenix down the canal, requiring equally less energy. Considering the fact that energy prices will rise in the future, spending the required monies on more energy now could end up saving CAP money in the long run. As far as CAP customers are concerned, (particularly Tucson Water and District) they will not pay for this increase in energy use since CAP charges a "postage stamp rate" to deliver water; regardless of how far the water travels on the canal, or at what elevation of lift, all CAP customers pay the same rate. Of course, this rate is subject to change in the future.

Recovery of the recharged water also requires energy, and thus, money. In 2015 Tucson Water spent a total of \$ 7,205,883 on energy at CAVSARP and SAVSARP (table 2). A combination of Natural Gas and Electric power are used to operate the wells and boosters at these facilities. Figure 8 shows the ratio of natural gas to electric power paid for by Tucson Water. The lower the water table is, the higher it must be pumped in order to recover it. Likewise, the longer the distance that the water must be pumped, the more energy that is required. If Tucson Water and District are recharging thousands of acre-feet of Phoenix's allocation per year, the water table in TAMA will likely rise, requiring much less energy to eventually pump. Recharging the

water in the first place does not require any energy (once the water is in the recharge basins).

This theoretically amounts to energy savings during recovery for Tucson Water and District.

However, there are costs associated with re-equipping wells in order to pump from a higher water level. Every pump has a different pump curve which indicates at what water level each pump will operate most efficiently. In some cases, a higher water level might reduce the pump's efficiency, necessitating a replacement pump or raising the current pump. Both of these solutions incur additional costs.

Table 2

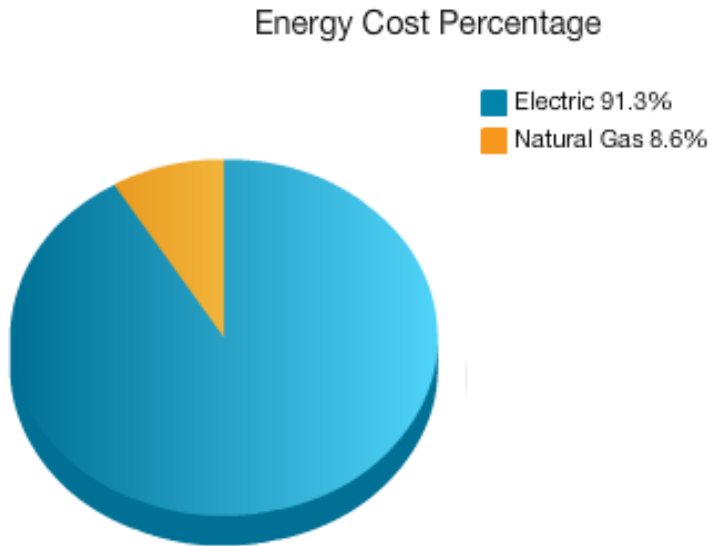
Tucson Water Energy Expenditures at Clearwater Recharge Facilities

	Electric	Gas	
CAVSARP	\$4,440,060	\$1,114,194	Total CAVSARP Energy Costs: \$5,554,254
SAVSARP	\$1,442,704	\$208,925	Total SAVSARP Energy Costs \$1,651,629
	Total Electric Costs: \$5,882,764	Total Gas Costs: \$1,323,119	

Source: Compiled by Beth Kleiman June 2016 with energy expenditure records from Tucson Water

Figure 8

Breakdown of Energy Source for Tucson Water Utility 2015



Source: EnergyCap

Note: Percentages are based on energy use for every aspect of the water utility, not solely recharge and recovery.

Conclusion

Undoubtedly, the use of energy is critical to the reliable delivery of CAP water to its customers. CAP and its customers must always be aware of new developments that could affect CAP's energy source (current as well as potential future sources). Changes to these electricity producers, whether it be ownership of, management of, or federal regulations, will inevitably have an effect on CAP. Since 80% of Arizona's population relies on CAP water, an outage on the canal could have tremendous consequences. A reduction in CAP supply delivery due to a declared shortage, however, would not have alarming affects on water users due to proactive water management policies, such as the Agreement.

The *CAP System Use Agreement* does indeed have a nexus dimension to it, most simply, because it involves the use of the CAP canal to deliver water, which uses a vast amount of

energy derived from multiple sources. These sources face uncertain futures due to climate change and air quality regulations, in addition to local jobs and economic development for Native Nations. CAP would not be able to deliver water on the canal's inclined elevation without some form of energy. The Agreement may incur the use of less energy; however, it may not.

There are various factors involved in total energy use; most of whose futures cannot be predicted. Natural resource price fluctuation, unforeseen governmental regulations and changing technology will all have impacts on energy use and cost. It will be important for CAP and other Arizona water institutions to attempt to strike some sort of balance between current and future energy prices, the use of current and future energy sources, as well as the quantity of acre-feet recharged and recovered annually so as to maintain a groundwater level to effect maximum pumping efficiency. According to Ken Seasholes, one "could argue that there is an energy savings" but it would be "essentially energy neutral over time" (Seasholes, interview).

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Appendix A

CAP Background

It all began in 1922 when the Colorado River Compact was created by the seven Colorado River Basin States: Arizona, California, Colorado, New Mexico, Nevada, Utah, and Wyoming. The Compact divided the Colorado River Basin states into an Upper Basin and a Lower Basin. The Upper Basin included New Mexico, Colorado, Utah and Wyoming, while the Lower Basin consisted of Arizona, California and Nevada. Each basin was allotted 7.5 million acre-feet of Colorado River water to be divided among its states. In the Lower Basin, Arizona was given rights to 2.8 million acre-feet of Colorado River water annually and California became entitled to 4.4 million acre-feet, leaving Nevada with rights to only 300,000 acre-feet (CAP, 2015).

In 1946, the Central Arizona Project Association was formed for the purpose of educating the citizens of Arizona about the need for the Central Arizona Project, as well as to lobby Congress to authorize its construction (CAP, 2015). It wasn't until 1968 that a bill was signed by President Lyndon B. Johnson, authorizing the project. The Colorado River Basin Project Act of 1968 became the catalyst for the US Bureau of Reclamation (USBOR) to build the Central Arizona Project. In 1971, the Central Arizona Water Conservation District (CAWCD) was created to provide a means for Arizona to repay the federal government (USBOR) for the CAP system, in addition to managing and operating the CAP system. Construction finally began in 1973, at Lake Havasu and finished 20 years later, 14 miles south of Tucson.

Appendix B

CAP System Use Agreement Terms

In order to understand what is being proposed in the Agreement, it is essential to define the terms contained within it. Colorado River water on the CAP canal is otherwise referred to as **“Project Water.”** Project Water also includes certain Agua Fria inflows into Lake Pleasant (Figure 1). All other sources of water on the canal are referred to as **“Non-Project Water;”** the Agreement will distinguish between the two types. Some examples of Non-Project Water include imported groundwater and Colorado River water that was previously unavailable to CAP (Summary of Draft Agreement, 2016).

In addition to Project Water, the Agreement will authorize CAWCD to deliver other, even more specific types of water. **Recovery Exchange Water** is the water CAWCD delivers pursuant to a Recovery Exchange Agreement. **Replenishment Exchange Water** is the water CAWCD delivers when Central Arizona Groundwater Replenishment District’s (CAGRDR) sub-contract is exchanged for long-term storage credits used for replenishment. Non-Project Water for Firming and On-River Firming will also be addressed in the Agreement. Other Non-Project Water deliveries require a federal CAWCD wheeling agreement. The Agreement will approve a standard form of CAWCD Wheeling Agreement, which is to be attached as an exhibit to the Agreement (Summary of Draft Agreement, 2016). In short, the Agreement will allow CAP to offer contracts “for long-term reliable delivery of Non-Project Water, while protecting the rights of the US to have water transported under section 8.17 of MRC, and without interfering with Project Water deliveries” (CAP, 2015).

Wheeling

Wheeling provides reliable delivery of Non-Project Water through the CAP system.

Wheeling was authorized by the 1988 Master Repayment Contract between CAP and the USBOR. The MRC includes specific provisions related to the wheeling of Non-Project Water, including development of a standard form of wheeling contract (CAP, 2015). Articles 8.17 and 8.18 of the MRC address the Wheeling of Non-Project Water, both by the federal government (USBOR) and by CAP (CAWCD), respectively. Wheeling is an important use of the CAP canal. In fact, the first request for wheeling was made in 1983, long before the first CAP delivery in 1985 (Seasholes, workshop). A 1983 CAWCD Position Statement reads, "... [CAWCD] endorses the concept of transporting water surplus to outlying areas of the state into the District for use within its boundaries. Such transportation shall be limited to otherwise unused capacity of CAP works..." (Seasholes, workshop).

Article 8.17 of the MRC is titled, "Rights Reserved to the United States to Have Water Carried by Project Facilities;" In other words, wheeling by the U.S. Bureau of Reclamation. Article 8.18 is titled, more simply, "Wheeling Non-Project Water." It states, "Non-project water may be wheeled through project facilities pursuant to wheeling agreements between the Contractor and the entity desiring to use project facilities for wheeling purposes...The Contractor and the Contracting Officer shall jointly develop a standard form of wheeling agreement including the rate structure for wheeling non-project water" (MRC).

The "standard form of wheeling agreement" referred to in the MRC is what the CAP System Use Agreement will address. In other words, the MRC simply states that the wheeling of Non-

Project Water would be allowed, provided there is another formal agreement; the CAP System Use Agreement will be that formal agreement. CAP is trying to move away from the terminology of “Article 8.17” and “Article 8.18” and move instead towards “wheeling by the federal government,” and “wheeling by CAWCD” respectively (Seasholes, workshop).

As mentioned above, wheeling has been proposed since 1983, in the CAP Position Statement. It wasn’t until 2012 that CAP came out with a Staff Proposal for wheeling. This proposal would actually implement the proposed Standard Form Wheeling Contract from the MRC. The contracts would be issued on the basis of increased delivery and capacity, and would be open to all parties, including tribes (Seasholes, workshop).

Exchanges

Exchanges that do not involve wheeling are another important aspect of the *CAP System Use Agreement*. Currently, there are various types of exchanges, recognized in different frameworks including the MRC, the Basin Project Act, individual delivery contracts and in Arizona State law. The exchanges proposed in the Agreement involve a Municipal and Industrial (M&I) subcontractor exchanging water with another subcontractor on the CAP system. For example, Tucson would store a portion of Phoenix’s allocation in its underground storage facilities. The water, in times of shortage, would be exchanged with direct deliveries from Tucson to Phoenix off of the canal. This is a new variation on exchanges because it involves two subcontractors; it has never been done before. This new concept (also referred to as Inter-AMA Firming) was proposed by City of Phoenix, Tucson Water, and Metropolitan Domestic Water

Improvement District (District), located in Marana. It has since raised questions about system capacity issues related to downstream recharge.

Firming and Recharge

Recharge is a large component of Arizona's water management. Large quantities of water can be stored underground via recharge basins. Firming is the use of one water supply to increase reliability of another supply, primarily through recovery. In the case of the Agreement, Tucson will increase the reliability of its groundwater supply by recharging Phoenix's unused CAP allocation. Firming will satisfy the reduced portion of a CAP (sub)contract in the event of a shortage or an unplanned outage on the canal.

The benefits to firming and recharge are numerous; they include raising the water table, naturally improving the water quality through Soil Aquifer Treatment (SAT), diminishing impacts of groundwater overdraft such as subsidence, and preparing for shortage. SAT is a natural treatment which allows physical, chemical and biological processes to take place as the water percolates into the ground and mixes with groundwater, thereby improving water quality. In some cases, it can completely eliminate the need for costly water treatment plants. In addition, storing water underground eliminates the need for large reservoirs above ground which can be very costly, take up large land areas, and face water loss due to evaporation and leakage.

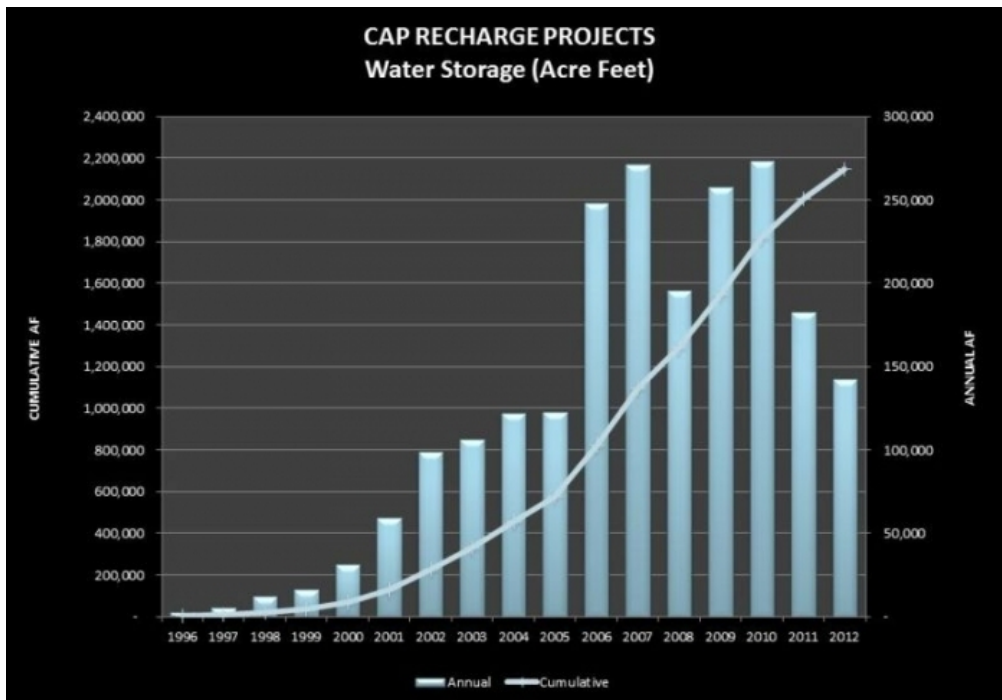
Recharge also allows for greater system flexibility; Tucson Water is not dependent on water coming down the canal in order to deliver to it to customers on the same day. Recharge enhances and reinforces Arizona's water supply, providing reserves in case of shortage or drought. "Recharge is a long-established and effective water management tool that allows

renewable surface water supplies, such as the Colorado River, to be stored underground now, for recovery later during periods of reduced water supply,” (CAP, 2015).

CAP operates six recharge projects: Pima Mine Road, Lower Santa Cruz, Agua Fria, Hieroglyphic Mountains, Tonopah Desert and Superstition Mountains. All but two are located in Phoenix AMA; Pima Mine Road and Lower Santa Cruz are located in Tucson AMA. Pima Mine Road recharge facility, located in the Santa Cruz River Flood Plain, was built in 1999 and is capable of storing 30,000 acre-feet per year. The Lower Santa Cruz recharge facility was built the following year, in 2000. This facility is capable of storing 50,000 acre-feet per year, spread over 3 basins covering nearly 30 acres. Agua Fria recharge project was built the following year, in 2001, and is capable of recharging a total of 100,000 acre-feet per year. The Hieroglyphic Mountains Project also consists of seven basins over 38 acres. Built in 2003, this project is permitted to recharge 35,000 acre-feet per year. Tonopah Desert Recharge Project was completed in 2006 and covers 207 acres using 19 basins to recharge up to 150,000 acre-feet per year. Superstition Mountains Recharge project began operation in 2011 and is designed to store 25,000 acre-feet per year (CAPH20, 2013). Figure 2 shows how much water has been collectively recharged at these sites.

Figure 2

Water Storage in CAP Recharge Projects



Source: <http://www.cap-az.com/departments/recharge-program>

In Avra Valley (West of Tucson), Tucson Water operates two main recharge facilities, together referred to as Clearwater Renewable Resources Facility. Central Avra Valley Storage and Recovery Project (CAVSARP) was built as a pilot study in 1997 and became fully operational in 2003 (Thompson, 2016). CAVSARP consists of 11 recharge basins covering 317 acres. The current permitted annual storage is 75,000 acre-feet. Southern Avra Valley Storage and Recovery Project (SAVSARP) began construction in 2008 and became fully operational in 2009. It consists of 9 basins, totaling 226 acres. The facility is currently permitted to recharge 75,000 acre-feet per year (Thompson, 2016).

The District operates one recharge facility consisting of four basins. The Avra Valley Recharge Project (AVRP), originally owned by CAWCD, became operational in 2006 and is permitted to store up to 11,000 acre-feet annually. In 2010, District assumed ownership and

operation of the facility, which is located just one mile southwest of another of CAWCD's recharge projects, the Lower Santa Cruz Replenishment Project (Tenney, 2014).

Table 1

Recharge Projects

Project Name	AMA	Year complete	Permitted capacity	Permitee	acreage	# of basins	Water Type
Avra Valley	Tucson	1996-97	11,000	District	11	4	CAP
SAVSARP	Tucson	2008	75,000	City of Tucson	226	9	CAP
CAVSARP	Tucson	2007	75,000	City of Tucson	317	11	CAP
PMR	Tucson	1998-99	30,000	CAWCD	37	5	CAP
Lower Santa Cruz	Tucson	2000	50,000	CAWCD	28	3	Effluent
Agua Fria	Phoenix	2001	100,000	CAWCD	102	7	CAP
Hieroglyphic Mountains	Phoenix	2002	35,000	CAWCD	38	7	CAP
Tonopah Desert	Phoenix	2006	150,000	CAWCD	207	19	CAP
Superstition Mountains	Phoenix	2011	25,000	CAWCD	39	2	CAP

Source: Table created by Beth Kleiman, compiled with information from CAP website and Dick Thompson

Recovery

On the other end of water recharge is recovery. It is essential to be able to recover the recharged water when and where it is needed. CAP is already responsible for recovering a portion of stored water in support of various subcontracts and agreements. These include M&I subcontracts when there is a shortage in Colorado River water supplies, in addition to the

Southern Nevada Water Authority Agreement and the Mohave County Water Authority Agreement (CAP, 2015).

As mentioned above, there are multiple storage and/or recovery entities in Arizona. Figures 3, 4, and 5 show all underground storage facilities in Tucson, Phoenix and Pinal AMAs, respectively. The Arizona Water Banking Authority (AWBA), created in 1996, stores excess CAP water in various Groundwater Savings Facilities (GSF) and Underground Storage Facilities (USF). There is also an Interagency Recovery Planning Group consisting of staff from CAP, AWBA, and ADWR. This group's focus is on drafting a recovery plan (CAP, 2015). Similarly, there is an Ad Hoc Recovery Planning Group consisting of individuals representing CAP, AWBA, ADWR, Arizona Municipal Water Users Association (AMWUA), Southern Arizona Water Users Association (SAWUA), Salt River Project (SRP) and Pinal water users. This group helps serve as a venue for stakeholder feedback and guidance (CAP, 2015).

On May 1, 2014, the CAP board voted to implement the Joint Recovery Plan. This plan advances the joint objective among CAWCD, AWBA and ADWR to “develop a coordinated and cooperative planning process that includes distribution and recovery of water stored by AWBA” (CAP, 2015).

Tucson AMA Underground Savings Facilities

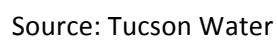
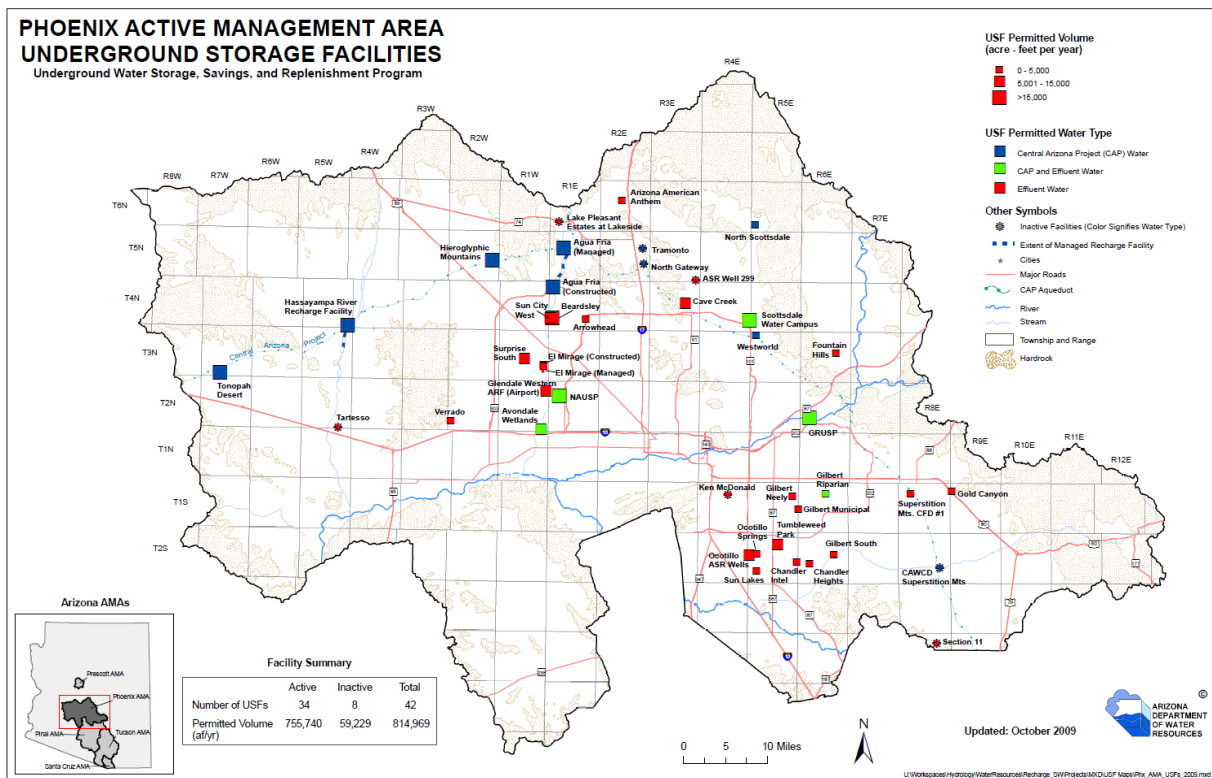


Figure 4

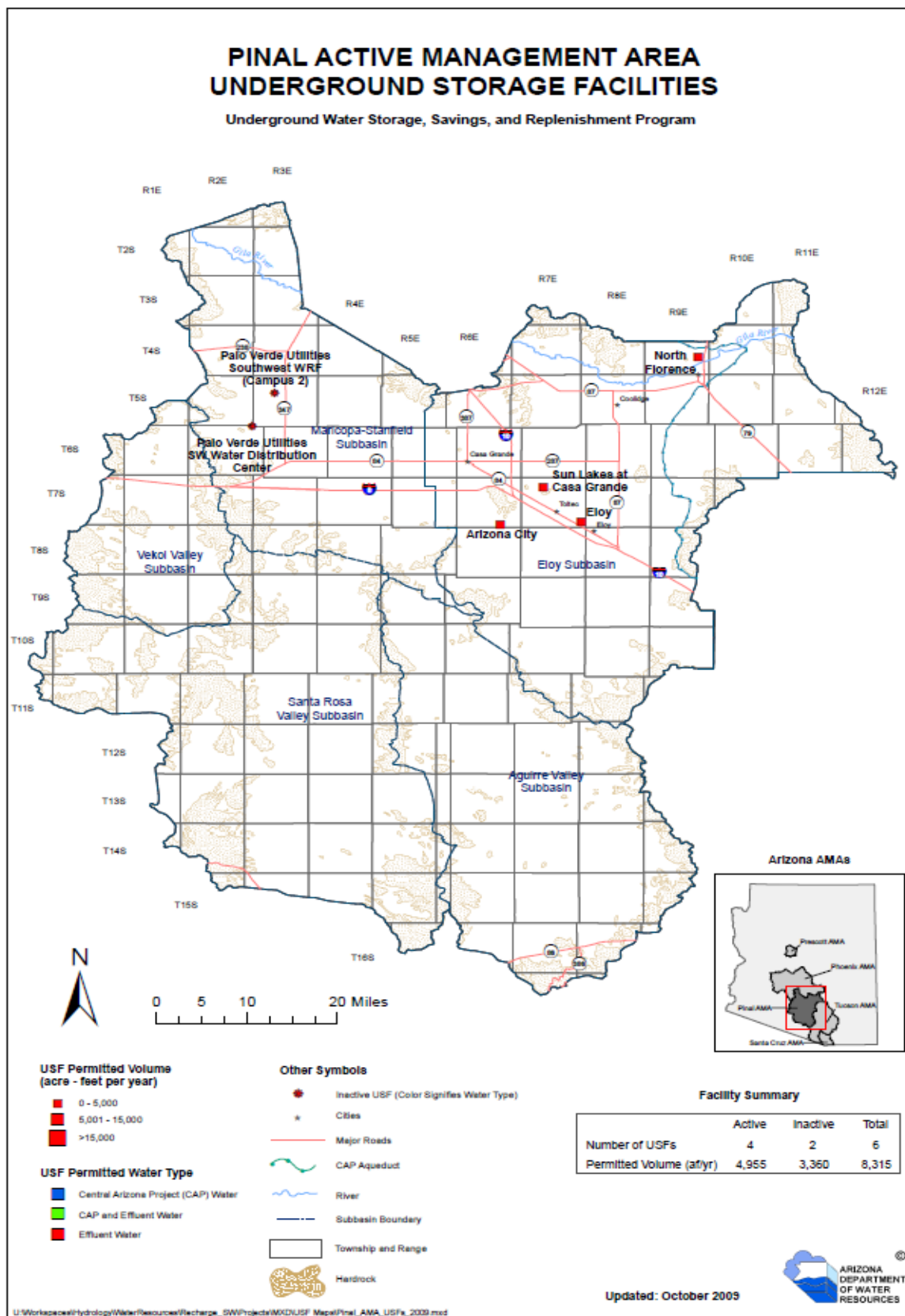
Phoenix AMA Underground Storage Facilities



Source: Tucson Water

Figure 5

Pinal AMA Underground Storage Facilities



Source: Tucson Water

Scheduling priority

In order to reconcile any conflicts over delivery capacity on the canal, a scheduling priority is enacted. With the authorization of the Agreement, potential delivery priority conflicts could arise. Under the Agreement, the scheduling priority will define how competition for monthly delivery capacity is resolved. During shortage, Firming Water carries the scheduling priority of the supply it replaces (Summary of Draft, 2016). The Annual Operating Plan (AOP) for the Agreement will use CAWCD's existing AOP process as the implementation mechanism for scheduling priorities.

Appendix C

Commonly Used Acronyms

ADWR- Arizona Department of Water Resources

AMA- Active Management Area

AMWUA- Arizona Municipal Water User's Association

AVRP- Avra Valley Recharge Project

AWBA- Arizona Water Banking Authority

BART- Best Available Retrofit Technology

CAVSARP- Central Avra Valley Storage and Recovery Project

CAWCD- Central Arizona Water Conservation District

CAGRD- Central Arizona Groundwater Replenishment District

CAP- Central Arizona Project

CPP- Clean Power Plan

CWAC- Citizen's Water Advisory Committee

EGU- Electric Generating Unit

EIS- Environmental Impact Statement

EPA- Environmental Protection Agency

GSF- Groundwater Savings Facility

IGA- Inter-Governmental Agreement

M&I- Municipal and Industrial

MRC- Master Repayment Contract

NGS- Navajo Generating Station

NOx- Nitrogen Oxides

SAT- Soil Aquifer Treatment

SAVSARP- Southern Avra Valley Storage and Recovery Project

SAWUA- Southern Arizona Water User's Association

SCR- Selective Catalytic Reduction

SRP- Salt River Project

USBOR- United States Bureau of Reclamation

USF- Underground Storage Facility

WAPA- Western Area Power Authority