Arizona Department of Transportation: SR 89 Stormwater Recharge Pilot Project, Prescott AMA

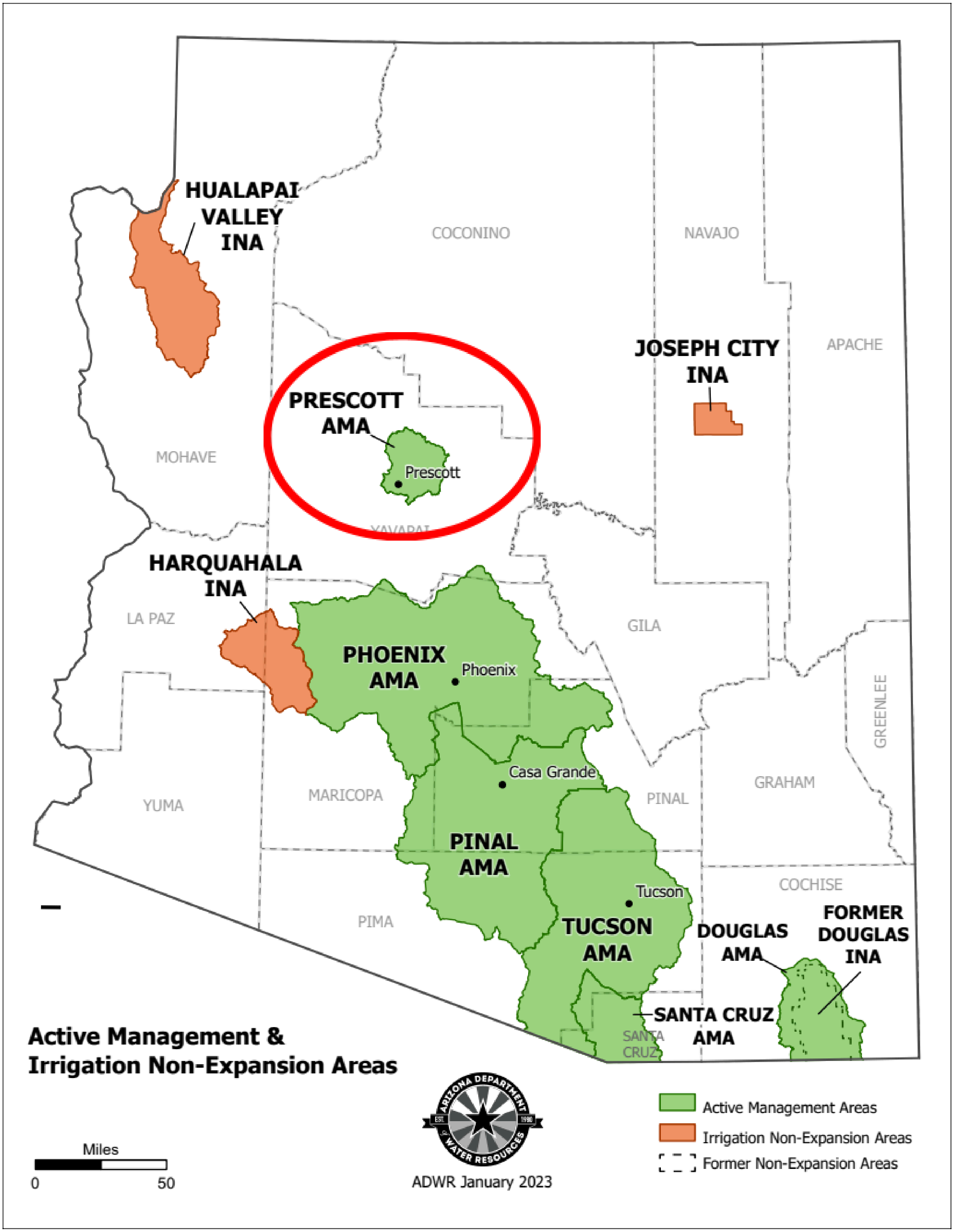
FINAL REPORT

September 2024

PREFACE:

The Arizona Department of Transportation would like to thank the Arizona Department of Water Resources and their supporters for the water conservation grant which provided the research funds to undertake this pilot research project, contract: ADWR DCP ADOT Contract 2020-3129. Without these funds this project would not have been possible

Project Map


HUALAPAI VALLEY INA
COCONINO
NAVAJO
APACHE
JOSEPH CITY INA
PRESCOTT AMA
Prescott
MOHAVE
YAVAPAI
HARQUAHALA INA
LA PAZ
GILA
PHOENIX AMA
Phoenix
GREENLEE
Casa Grande
GRAHAM
YUMA
MARICOPA
PINAL
PINAL AMA
COCHISE
Tucson
PIMA
TUCSON AMA
DOUGLAS AMA
FORMER DOUGLAS INA
SANTA CRUZ AMA
SANTA CRUZ
Active Management & Irrigation Non-Expansion Areas
Active Management Areas
Irrigation Non-Expansion Areas
Former Non-Expansion Areas
Miles
0
50
ADWR January 2023

Purpose:

This project was a pilot project by ADOT and funded by an Arizona Department of Water Resources Water Conservation Grant Program with several objectives. The objectives include: stormwater recharge, log rain event data, measure recharged volume, flood mitigation on the adjacent highway to improve highway safety, to ensure the protection of groundwater quality, and to generate a best maintenance practices guidance document.

The project's location is within the Prescott Active Management Area (AMA) as indicated in the general area map (see map above) and is indicated w/ a red colored encircled area. The Prescott AMA is an area where significant groundwater mining is occurring in conjunction with a rapidly increasing population and a fast-paced rate of development taking place which will further strain groundwater resources. The potential for aquifer recharge through stormwater capture could prove to be a significant benefit in areas that are heavily dependent on groundwater extraction for a water supply.

This Final Report will provide an overview of project details as well as lessons learned throughout the process. There will be an accompanying Drywell Maintenance Guidance and Best Practices document included with this report. That document will have more detail on best practices and considerations for utilizing this type of recharge practice. There is some limitation on the guidance due to this being a pilot project in a single location. Therefore, the typical weather/precipitation patterns, and seasonal components are constrained by that location as well.

PROJECT LOCATION:

The drywell pilot project is located in Sections 27, Township 16 North, Range 2 West of the Gila and Salt River Meridian, within Yavapai County. The project extends along the SR 89 alignment from Mile Point (MP) 324.2 (Center St) to MP 327.0 (the southern town limits of Chino Valley).

LOCATION CONSIDERATIONS/LESSONS LEARNED:

There are considerations and criteria for a drywell recharge location that should be considered in determining the feasibility for this type of practice. Several locations were considered for this project and through an evaluation process of the criteria to be discussed below were narrowed to the chosen location. In addition, there were some lessons learned. Some of these criteria should be obvious but nevertheless warrant saying so as not to be ignored.

Land ownership: the installation requires not just a drywell but drainage structure such as a basin and conveyances to work properly. Therefore, enough property must be owned or controlled through some legal instrument to control what happens within close proximity for the long-term and room to mobilize for a drilling rig and staging of materials in the short-term.

Also, there should be an investigation as to the subsurface viability for this type of installation. This includes depth to groundwater to ensure enough space remains below the bottom of the drywell after installation to prevent direct to aquifer connection and enough space to provide pollutant treatment and attenuation prior to recharged water entering the aquifer in an effort to preserve groundwater quality and to avoid any chance of providing a direct conduit for a pollutant inadvertently introduced into the drywell directly or the pre-settling sediment chamber.

The subsurface must have enough hydraulic conductivity to avoid long-term (>36 hours) water sitting in the drywell. Water sitting longer than 36 hours will cause vector issues. Hydraulic conductivity is a measure of how easily water or other fluids can pass through porous materials like soil and rock. It's also known as the coefficient of permeability. Physically it is the rate of drainage of soil or rock. Hydraulic conductivity is a function of several factors, including: texture, grain size and distribution, density, and macrostructure. For example, a site that is expected to have a significant clay content or thick caliche layers may not be well suited for such an installation without significant modification to installation.

See photos below: Notice the tendency for the soil to form dirt balls up when squeezed by hand. The high clay content makes the soil very cohesive, and as such does not pass water easily as a soil with a lower clay content. This is not an optimal condition for a recharge location.

One lesson learned for this project is the importance of obtaining relevant literature and representative information (such as drill logs) with respect to subsurface site investigation to determine the efficacy of a location for recharge. In retrospect, it was discovered that the drywell installation contractor relied on information that should not have been considered representative of the project location.

The percolation test was completed after the installation was completed. This test is used to determine the hydraulic conductivity and to determine that installation is operable and if so to what measure of efficiency in passing and percolating water through the installation and into the ground.

This drywell installation resulted in a subsurface conductivity that was less than optimal and on the low end of acceptable conductivity for operation. This is an excerpt from the installation contractors percolation (perc) test analysis, “The target is to encounter 10’ of permeable soils at the bottom of the excavation. When we experience these conditions we typically see rates ranging from a 0.40 cubic feet/second (cfs) to 0.80 cfs. In the case of this installation, we went to a depth of 100’ and the soils were nominal, so the performance wasn’t on the high range. Of course the system worked at *a rate of 0.20 cfs* and would drain 25,920 cubic feet of retained stormwater in 36 hours. In a typical application, a 2-hour duration of a 100 year event, each acre would generate about 6,000 cubic feet (cf) – 9,000 cf, so one drywell could mitigate a retention basin capturing runoff from 3-5 acres of contributory area in 36 hours."

Another way to state this is, yes, it will work but at 0.20 cfs it is not optimal for recharge rates, or it could be said that it is somewhere between 25% and 50% efficient as desired.

In addition, an investigation of the area's historical activity must be undertaken to avoid areas with potential old soil contamination issues. A current survey of the underlying groundwater quality in the form of baseline samples should be completed to know in advance of any water quality issues and for comparison in the future to show contamination is not being caused by the water recharged. Areas with significant industrial activity or a history of ground or groundwater contamination should not be considered for this type of control measure which can only be determined through a thorough land use investigation and/or sampling the appropriate media.

VEGETATION & LANDFORM:

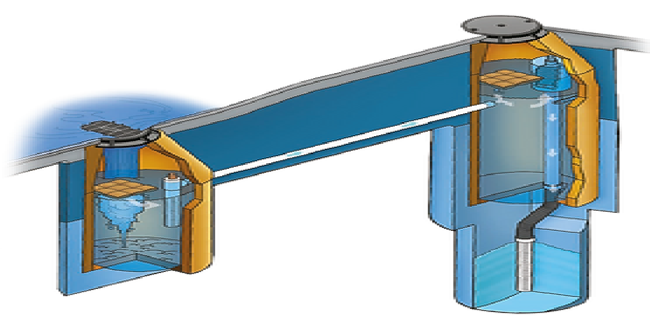
The contributing area is primarily composed of grasslands and is classified as upland prairie. Vegetative cover density is estimated at 30%.

The landform in the vicinity of the project is relatively flat and broad with the upper reaches of the contributing watershed located in mountainous terrain. Numerous small ill defined washes comprise most of the natural local drainage network along the corridor.

In this project, we utilized vegetation as a best management practice (BMP) for controlling pollutants to our drywell. Vegetation plays a crucial role in controlling pollution in runoff by slowing down water flow, increasing infiltration into the soil, and filtering pollutants through its root systems and leaves, effectively acting as a natural filter that can significantly reduce the amount of pollutants reaching the drywell. Therefore, it is important to keep the local vegetation intact and healthy. The main way to do this is to employ good mowing practices. This would include things like waiting until late in the growing season to mow, not mowing in excessively dry conditions, and maintaining a minimum height of six inches mowing height in areas with desirable plants and grasses. By maintaining a minimum of six inch height, it allows for a stronger root system, and maintains enough moisture to survive drought conditions which are a constant threat in Arizona. See image below for typical vegetation.

PROJECT INFRASTRUCTURE:

The project consists of one drywell, designed and installed by Torrent Resources, a CRH Company. The drywell type used is known as the MaxWell Plus Drainage System. This system is a dual-chambered infiltration BMP that pretreats stormwater twice for pollutant removal prior to infiltration. One additional feature in the main percolation chamber is a 1.5 inch diameter tube that extends from the top of the chamber to the bottom. This tube facilitates sampling the water being recharged through the use of a bailer. The bailer is basically a smaller diameter tube that can be inserted into the chambers tube, dropped to the bottom where a plug is actuated to collect a water sample and retrieved by an end connected cable. The diagram below depicts a typical MaxWell Plus drywell system. Reference: torrentresources.com/maxwell-plus/ 2024.



In addition, a Badger Model Recordall 4" Compound Flow Meter is installed in the connecting pipe located in an additional meter vault located between the two chambers as shown above in the diagram. The flow meter was intended to measure the flow in gallons as it passes through the connection pipe between the two chambers and prior to entering the percolation chamber (right hand side of the diagram above). The meter keeps a running tally of the volume of water passing through it and is recorded on the dials of the meter and read manually by accessing the meter vault during site visits. A mechanical flow meter was chosen for the site due to there being no electric power available for use at the site. See photo below.

The next piece of infrastructure is the rain gauge and data logging system consisting of rain gauge to measure and log stormwater precipitation events, a solar panel to charge the battery power data collection system, an enclosure cabinet that contains the data logger, power (see right hand photo below), and a telecommunication system so that data can be retrieved remotely that works off of a cell phone signal See photos below. The rain gauge is the white cylinder at the top of the left photo. The solar panel is mounted below the rain gauge in the left photo.

Finally, there are solid cast iron covers on the percolation chamber and the meter vault. The pre-sediment chamber has a grate cover to allow stormwater runoff to enter and preclude waste like trash, roadway debris, and vegetation that would interfere with stormwater being recharged and pose a risk to groundwater quality. The covers are marked “Stormwater Only”. The two chambers and the meter vault are located at the north end of a drainage collection basin. The basin is approximately 120 feet long by 25 feet wide with an average depth of 2.5 feet and is connected to a roadside ditch drainage system at the south end of the basin. The basin and the roadside ditch system are connected by a 12 inch diameter corrugated metal pipe.

INFRASTRUCTURE DISCUSSION/LESSONS LEARNED:

One of the goals of this project was to measure the amount of recharged water. That goal turned out to be elusive and the data collected from the flow meter is problematic and unreliable leading to the measurements of gallons recharged to be under-reported based on the physical signs at the site upon several inspection visits.

The flow meter installed was a mechanical type and was designed to be used for measuring drinking water under a full pipe volume condition. The main reason this flow meter was chosen was because it did not require power. As it turns out, and another lesson learned, a very poor choice for collecting data under the conditions present at the site. It was constantly freezing up from silt entering the meter during water passages. This was not a problem for the recharged water, just for the meter that would freeze up due to dirt intrusion and fail to measure after a short time and/or not at all. In addition, a full flow pipe condition was rarely attained until a 90 degree standpipe was installed to the percolation chamber's inlet pipe from the connection pipe in January of 2024. Even in this case, the meter was still prone to being rendered inoperative by the smallest amount of grit building up inside the mechanism.

Had there been AC power available at the site, then there are a host of flow meters that could have been chosen. There are low-power battery operated flow meters available today for use that were not available when this project was designed that may be great choices today. These new flow meters could have easily been connected to the data logger that was employed for this project.

The only power available at the site is a small solar panel used to run the data logger, cell phone transmission, and the rain gauge which measures the storm precipitation over time in tenths of an inch. The rain gauge is a tipping-cup type and proved to be very reliable with no issues.

PROJECT SUMMARY:

Overall the project was a success for all purposes with one exception, accurately measuring the volume of stormwater recharged. As a recap, the goals of this project were 1. stormwater recharge, 2. log rain-event data, 3. Measure recharged volume, 4. Flood mitigation on the adjacent highway to improve highway safety, 5. To ensure the protection of groundwater quality, and 6. To generate a best maintenance practices guidance document.

The results of this research project are as follows:

1. Stormwater was recharged without issue as evidenced by reduced flooding of the adjacent highway;
2. The rain-event data was logged throughout the project's duration once "turned on". The total amount of rain logged was 29.87 inches from 10/04/2021 – 10/04/2024, and 19 events that measured at least 0.2";
3. Measure the recharged volume (gallons). In this case, the volume recharged was under-reported based on both the physical signs within the basin, and difficulty with the flow meter being found in a frozen and inoperative state on numerous occasions. In addition, the probable runoff generated from the drainage due to the storm precipitation

data far exceeded any measured volume the few times there was any flow recorded. The total flow in gallons measured for the recharged volume was 13,343. Also, the nature of the connecting pipe's flow made a full pipe flow condition impossible for 95% of the project's duration, or until the elbow was added to the outlet pipe.

4. The flood mitigation was a success based on no reports of local flooding within 3.0 miles of the project location during the project's operation;
5. The protection of groundwater quality was achieved based on the analysis of the drywell water samples, which revealed no risks to groundwater based on current groundwater quality standards (Arizona Administrative Code R18-11-406. Numeric Aquifer Water Quality Standards: Drinking Water Protected Use);
6. The generation of a Best Management Practices Guidance document that is being submitted with this report.

FUTURE RESEARCH DIRECTIONS:

As with all research projects the goal is to inform on the focus subject, in this case, stormwater recharge for the benefit of reducing groundwater mining in an arid area. I believe this project has been successful in that endeavor. However, there lies the question of where to go next and expand on this subject in the quest of building a better and more informed framework of the subject area. In this case, there are a few ways that I can see that pursued. The first, and most important, would be the quest for an accurate methodology to employ for the collection of water volume recharged and the best practices for that. Another line of investigation could be, the best practices for a baseline investigation when installing these systems. Finally, there are many variations that could be employed on the design of these systems which could be based on the environmental variations encountered from criteria like land uses, difficult soil conditions, or seasonal influences and weather patterns.