F. Utilities

1. Sewer

The Property is located within the PCWRD sanitary sewer service area. According to PimaMaps, as shown on *Exhibit IV.F.1*, there is an existing 15-inch sewer line (G-85-053) located within the eastern portion of the Thornydale Road right-of-way, directly adjacent to the western boundary of the Property. This sewer will provide sewer service to the Property. No constraints have been identified that would preclude the use of gravity sewers to serve the Property.

2. Water

Metro Water District ("MWD") will provide water service to the Project. (Refer to *Exhibit II.F.2: MWD Will-Serve Letter* in Section II.) The Project will connect to existing water facilities located to the southeast of the Property in the Sumter Road/Scenic Park Drive intersection. Water easements will be provided if/as necessary for any public water installed to serve the Project. No constraints have been identified that would preclude water service for the Property. (See *Exhibit IV.F.2: Existing Water Facilities*.)

G. Recreation

There are no existing recreational facilities onsite.

Arthur Pack Regional Park, a 500-acre County-owned park, is located approximately ¼ mile southwest of the Property and wraps around the south and west sides of Mountain View High School at the corner of Thornydale Road and Linda Vista Boulevard. The park includes the Crooked Tree Golf Course, playground equipment, picnic areas, multiple sports fields and a 4.7-mile network of pedestrian, bike and equestrian trails through the Maeveen Behan Desert Sanctuary. Vehicular access into the park is provided at Thornydale Road and Overton Road.

See *Exhibit IV.G: Recreation Map*.

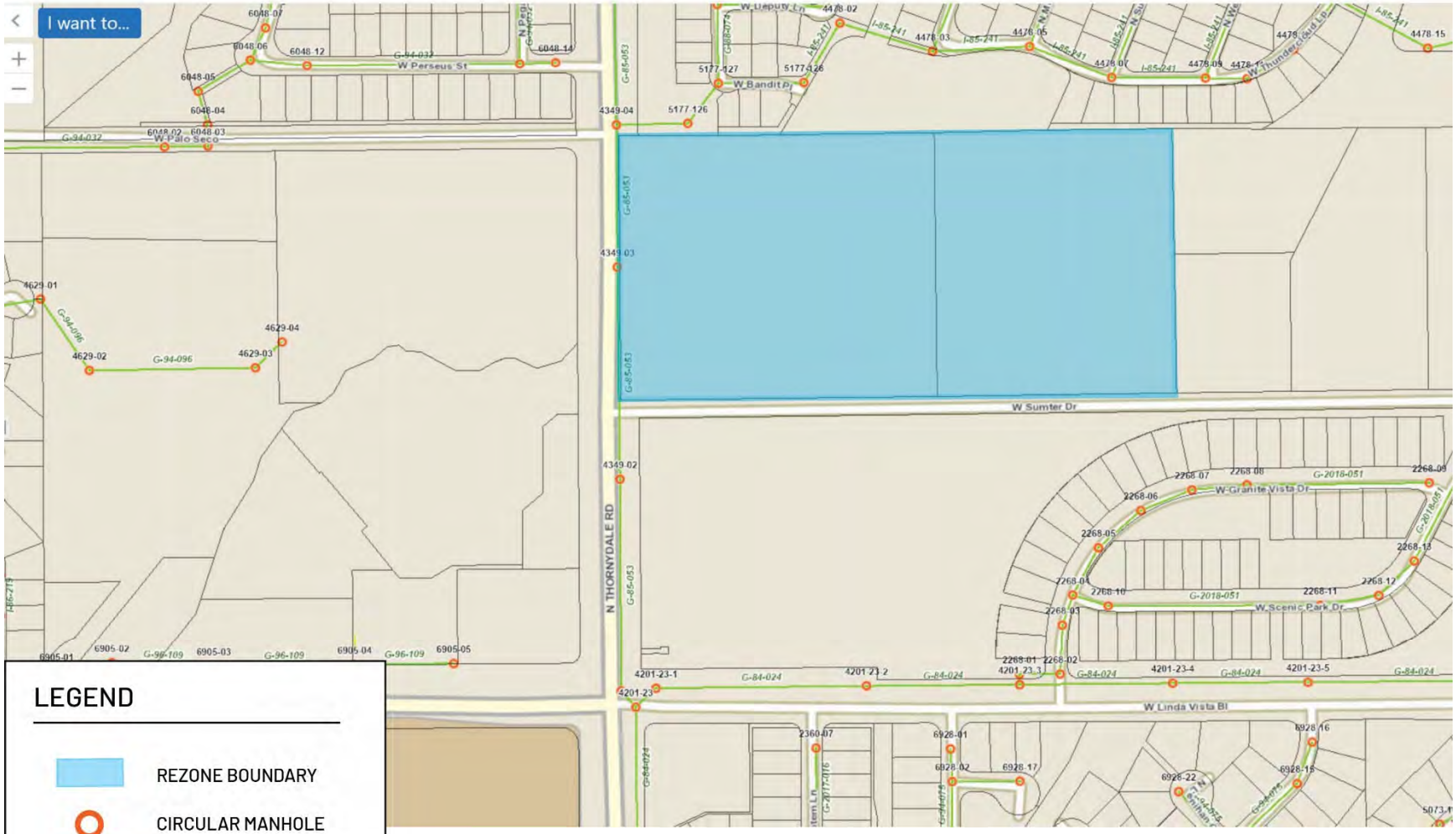


Exhibit IV.F.1: Existing Sewer Facilities

Exhibit IV.F.2: Existing Water Facilities

METRO WATER DISTRICT

THE INFORMATION CONTAINED IN THESE VALVE MAPS IS THE BEST CURRENTLY AVAILABLE. THE M.D.W.I.D. CANNOT GUARANTEE OR WARRANT THAT THE WATER LINE LOCATIONS AND OR DIMENSIONS SHOWN HEREIN ARE ACCURATELY DEPICTED ON THESE MAPS. THESE MAPS ARE ONLY A GRAPHICAL REPRESENTATION OF THE EXISTING METRO WATER FACILITIES AND SHOULD NOT BE USED AS A DESIGN TOOL. ALL FACILITIES SHOULD BE FIELD VERIFIED PRIOR TO CONSTRUCTION.

Legend

Pipe

- 4" & Less Pipe
- 6" Pipe
- 8" Pipe
- 10" & 12" Pipe
- Larger Than 12" Pipe
- Tucson Water
- Oro Valley Water
- Private Water
- Abandoned Water

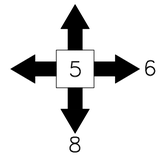
Boundaries

- MDWID-LB — Metro Legal
- MDWID-SB — Metro Service
- HUB-LB — Hub Legal
- HUB-SB — Hub Service
- CFIA — Cortaro Farms Impact
- LCIA — La Cholla Impact
- OVWC — Oro Valley Water
- TCL — Tucson City
- MTL — Marana Town
- OVTL — Oro Valley Town

Symbols

- Inline Valve
- Isolation Valve
- Check Valve
- Butterfly Valve
- Isolation Butterfly Valve
- Altitude Valve
- Air Release Valve
- Pressure Regulator Valve
- Fire Hydrant With Valve
- Fire Hydrant Without Valve
- Fire Hydrant With Blow-Off Valve
- Private Fire Hydrant With Valve
- Private Fire Hydrant Without Valve
- Reducer
- Stub Out
- Drain Valve Assembly
- Section Corner
- Dimension Number
- Other Water Providers
- M-YEAR-# As-Built Plan Number
- 3200-N Address Range Numbers
- ? Not Verified as Correct
- As-Built Waterline Beginning & End
- Water Service Meter W/ Single Hookup
- Water Service Meter W/ Double Hookup
- Irrigation Water Meter
- Corosion Test Station
- Active Well
- Abandoned Well
- Inactive Well
- Monitor Well
- Dry Well
- Private Well
- Sand Separator
- Surge Tank
- Active Booster Pump
- Inactive Booster Pump
- Reservoir
- Storage Tank and Size
- Pressure Tank
- Service Areas Outside Of Legal Limits
- Improvement Impact Areas
- 10'UE — Easements Sizes and Type
- 6"PVC — Water Line Type and Size

Map Reference



36	31	32	33	34	35	36	31
1	6	5	4	3	2	1	6
12	7	8	9	10	11	12	7
13	18	17	16	15	14	13	18
24	19	20	21	22	23	24	19
25	30	29	28	27	26	25	30
36	31	32	33	34	35	36	31
1	6	5	4	3	2	1	6

Drawing Name: MW121317_OR.DWG
Sheet Number: 5
Updated: MAY 2021
Setup By: TJD
Scale: 1"=200'

10400-N
9600-N
3800-W
2900-W
T.12 R.13 SEC.17
PROJECT
LAMBERT LANE
SHANNON ROAD
THORNYDALE ROAD
PECOS WAY
OASIS ROAD
APPALOOSA ROAD
GYMKHANA WAY
SUMTER DRIVE
LINDA VISTA BOULEVARD
CAMINO DE LA TIERRA
RANCHITOS PALOS VERDES LOTS 1-27 M.P. 23/22
NORTH RANCH LOTS 545-688 M.P. 42/55
NORTH RANCH LOTS 1-187 M.P. 39/58
NORTH RANCH LOTS 689-780 M.P. 42/62
NORTH RANCH LOTS 188-544 M.P. 41/68
NORTH RANCH LOTS 781-885 M.P. 45/32
TUCSON RESERVOIR
THE CHURCH OF JESUS CHRIST OF LATTER DAY SAINTS D.P. 7/95
HACIENDAS DE LA CAROLINA LOTS 1-8 M.P. 56/64
MOUNTAIN VISTA RIDGE, LOTS 1-201 SEQ #20183340400

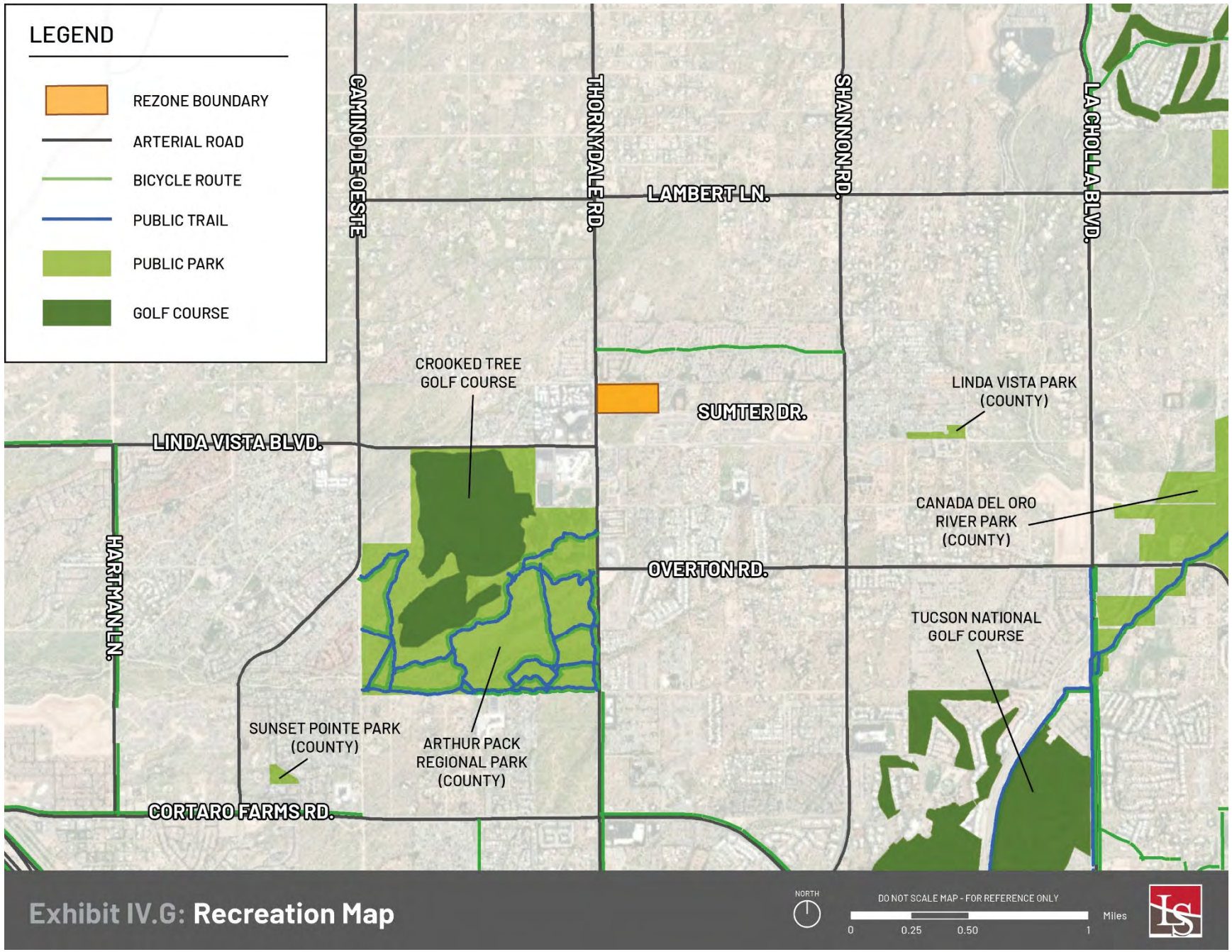


Exhibit IV.G: Recreation Map

H. Cultural Resources

Correspondence from the Arizona State Museum ("ASM") is included as *Exhibit IV.H*.

Per correspondence with the County's Office of Sustainability, Cultural Resources & Historic Preservation Division, previous archaeological surveys covered this area, so no new survey is required. Development of the Property is subject to ARS § 41-865 regarding State protection of human remains and funerary objects.

I. Composite

A Composite Map is provided as *Exhibit IV.I*. This map indicates the Property's existing physical constraints, including structures, topography, hydrology, riparian habitat, significant vegetation, utilities and easements.

THE UNIVERSITY OF ARIZONA
ARIZONA STATE MUSEUM

Arizona State Museum
PO Box 210026
Tucson AZ 85721-0026
(520) 621-6281
www.statemuseum.arizona.edu

Robin Large
Lazarus & Silvyn, P.C.
5983 E. Grant Rd., Ste. 290
Tucson, AZ 85712

April 19, 2022

RE: Thornydale & Sumter Specific Plan
Parcels 224-44-0570 & 224-44-058A

Dear Robin,

The Arizona State Museum (ASM) has reviewed archaeological project and site records in support of the following project:

> Lazarus & Silvyn's Thornydale & Sumter Specific Plan project (Lazarus & Silvyn Project No. 2205-002; ASM Job No. 004560)

Correspondence indicates this project will involve the rezoning of privately-owned land with the intent of apartment development. The project area is located at 3620 W. Sumter Dr. within unincorporated Pima County, and encompasses parcels 224-44-0570 and 224-44-058A within Township 12 South, Range 13 East, Section 17.

I invite you to review the results of ASM's research, which are summarized below.

Search Results:

According to a search of the archaeological site records and reports held in ASM collections, 40 archaeological investigations were conducted within a one-mile radius of the project area between 1979 and 2020. Of these 40 archaeological investigations, three intersect the project area.

For the three archaeological investigations that intersect the project area, Table 1 summarizes their basic information and scope.

Additionally, four archaeological sites have been identified within a one-mile radius of the project area. Of these four archaeological sites, none intersect the project area.

ASM Reference Number (AZProj/Accession)	Report Author(s)	Year(s) Conducted	Scope of Project
1981-0174	Madsen et al.	1981-1986	Archaeological survey for research
1985-0089	Phillips	1985	Archaeological survey for development
2003-0022	Hesse	2003	Archaeological survey for transmission line

Table 1. ASM archaeological investigations that intersect the project area

Recommendations and Responsibilities:

1. Although the entire project area has been previously surveyed, the work was conducted 19 to 41 years ago. It is standard archaeological practice for a property to be re-surveyed if the previous survey was conducted 10 or more years ago, as there is a possibility for previously unidentified archaeological sites to have since been exposed. Therefore, ASM recommends—but does not require—that a qualified archaeological contractor be consulted before any ground-disturbing activity begins. A list of archaeological contractors is available on the ASM website at:
https://statemuseum.arizona.edu/crm/document/aaa-qualified-consultants

2. Pursuant to Arizona Revised Statute §41-865, if any human remains or funerary objects are discovered during project work, all work must stop within the area of the remains and the ASM Repatriation Office must be contacted at 520-626-0320.

3. City, county, or municipal governments may have their own requirements; therefore, ASM recommends that the relevant jurisdiction(s) be consulted.

If you have any questions about the results of this records search, please feel free to contact me at jknightonwisor@arizona.edu or 520-621-4011.

Sincerely,

Jonathan Knighton-Wisor
Research Specialist
Archaeological Records Office
Arizona State Museum
520-621-4011
jknightonwisor@arizona.edu

References:

Hesse, Jerome S.

2003 The Linda Vista Transmission Main Cultural Resource Survey, Pima County, Arizona. Cultural Resources Report No. 03-32. SWCA, Inc. Tucson.

Madsen, John, Paul Fish, and Suzanne Fish

1993 *The Northern Tucson Basin Survey: Research Directions and Background Studies*. Arizona State Museum Archaeological Series No. 182. Tucson, Arizona.

Phillips, David A.

1985 *Letter Report to Mr. Don Laidlow of Cella Barr Associates from David A. Phillips.* New World Research, Inc., Tucson, Arizona.

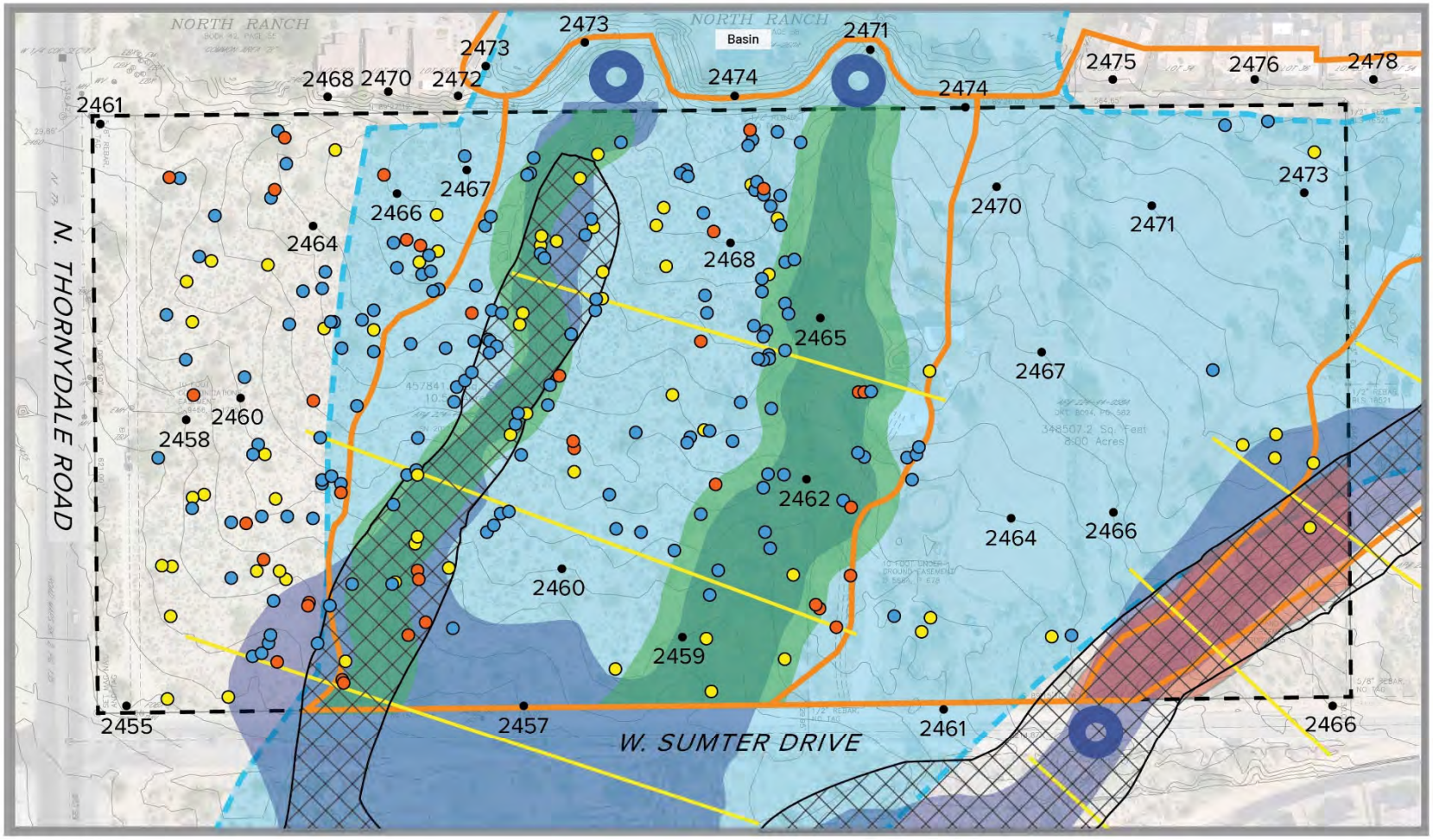


Exhibit IV.I: Composite Map

V. CONDITIONS OF APPROVAL

A. Purpose

B. Board of Supervisors Conditions of Approval

VI. REFERENCES

Pima County. "*PimaMaps*." Pima County, Arizona.

Pima County. *"Pima Prospers."* Pima County, Arizona, adopted May 19, 2015.

Pima County. "*Title 18 – Zoning*." Pima County, Arizona, Municipal Code, http://library.amlegal.com/nxt/gateway.dll/Arizona/pimacounty_az/title18zoning?f=templates$fn=default.htm$3.0$vid=amlegal:pimacounty_az.

Appendix A

Property Survey

LEGEND

- FOUND MONUMENTATION AS NOTED
- FOUND BRASS CAP IN CONCRETE (BCSM) AS NOTED
- SET 1/2" DIAM. REBAR AND BRASS TAG, LS 11758
- NOTHING FOUND OR SET
- ( ) RECORD BEARING AND OR DISTANCE, NORTH RANCH BK. 39, PG. 58, AND BK. 42, PG. 55, MAPS AND PLATS
- < > RECORD BEARING AND OR DISTANCE, HACIENDAS DE LA CAROLINA BK. 56, PG. 64, MAPS AND PLATS
- [ ] UNRECORDED BEARING AND OR DISTANCE, RLS 4252, 08/1987
- | | RECORD BEARING AND OR DISTANCE, RLS 12537, SN 20173490069

NOTES

BASIS OF BEARING WAS N 00°32'01" W ALONG THE CENTER LINE MONUMENTATION OF N. THORNEYDALE ROAD.

BASIS OF ELEVATION WAS BASED ON NAVD88 PER NGS CORS NETWORK.

MONUMENTS FOUND WERE ACCEPTED BASED ON A PARTIAL RETRACEMENT AND BREAKDOWN FOR THE SW 1/4 OF SECTION 17.

REFERENCE IS MADE TO AN UNRECORDED OF SURVEY; BY LAWRENCE D. DADISMAN, RLS 4252, DATED 08/1987.

REFERENCE IS MADE TO RECORD OF SURVEY; BY FREDRICK J. STURNIOLO, RLS 12537, SEQUENCE NUMBER 20173490069, DATED 12/2017.

REFERENCE IS MADE TO MOUNTAIN VISTA RIDGE; BY PERRY ENGINEERING, SEQUENCE NUMBER 20183340400, MAPS AND PLATS, DATED 10/2018.

REFERENCE IS MADE TO NORTH RANCH LOTS 1 THROUGH 187, BY CELLA BARR ASSOCIATES, BOOK 39, PAGE 58, MAPS AND PLATS, DATED 10/1986.

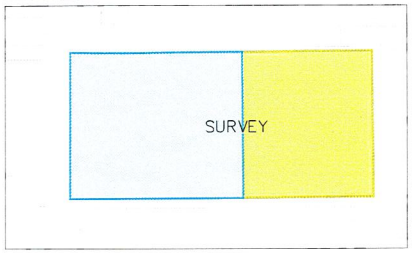
REFERENCE IS MADE TO NORTH RANCH LOTS 545 THROUGH 688; BY CELLA BARR ASSOCIATES, BOOK 42, PAGE 55, MAPS AND PLATS, DATED 10/1988.

REFERENCE IS MADE TO NORTH STAR ESTATES LOTS 1 THROUGH 98; BY RICK ENGINEERING COMPANY, BOOK 46, PAGE 82, MAPS AND PLATS, DATED 11/1994.

REFERENCE IS MADE TO HACIENDAS DE LA CAROLINA; BY ROGERS CIVIL ENGINEERING, BOOK 56, PAGE 64, MAPS AND PLATS, DATED 12/2002.

THIS SURVEY WAS PERFORMED FOR THE OWNER OF AP# 224-44-057D.

LOCATION MAP



SURVEYORS CERTIFICATE

I HEREBY CERTIFY THAT THIS SURVEY AND PLAT WAS MADE UNDER MY DIRECTION AND SUPERVISION DURING JANUARY 2022

RONALD E. STOLL, LS 11758

JOB NO. 3055

SHEET 1 OF 1

A PORTION OF THE

SW 1/4 OF S 17

T 12 S R 13 E G. & S.R.M.

PIMA COUNTY, ARIZONA

RECORD OF SURVEY

RES LAND SURVEYS, INC. 1910 E. 14TH STREET TUCSON, ARIZONA 85719

Appendix B

AGFD Best Management Practices for Saguaro Translocation and Replanting

BEST MANAGEMENT PRACTICES
FOR
SAGUARO TRANSLOCATION AND REPLANTING

Arizona Game and Fish Department

January 2019

The Arizona Game and Fish Department Mission:
To conserve Arizona's diverse wildlife resources and manage for safe, compatible outdoor recreation opportunities for current and future generations.

ABSTRACT
The *Best Management Practices for Saguaro Translocation and Replanting* (BMPs) provide information to help reduce impacts to saguaros from development in Arizona. They include recommendations on: 1) planning saguaro transplanting, 2) preparing saguaros for transplanting, 3) transplanting saguaros, 4) post-care of saguaros, and 5) research opportunities.

ACKNOWLEDGEMENTS
These BMPs were compiled by Arizona Game and Fish Department (AGFD) employees. The BMPs were developed from a detailed review of the literature and subsequent discussions with saguaro experts.

RECOMMENDED CITATION
Arizona Game and Fish Department. 2019. *Best Management Practices for Saguaro Translocation and Replanting.*

TABLE OF CONTENTS

EXECUTIVE SUMMARY

These Best Management Practices (BMPs) are recommendations and protocols to be used by developers and local permitting agencies in Arizona, and as a resource for other parties involved in the permitting process. Local governments are encouraged to integrate the BMPs described herein within their permitting process. The Arizona Game and Fish Department (AGFD), acting on behalf of the Arizona Game and Fish Commission, encourage the use of these BMPs to mitigate impacts to saguaros and wildlife species that depend on these cacti.

The document is organized around five basic project development steps:

1. Planning Saguaro Transplanting
2. Preparing Saguaros for Extraction
3. Transplanting Saguaros
4. Post-Planting Care of Saguaros
5. Research Opportunities

The BMPs do not duplicate or supersede any/or other legal requirements. This document does not mandate or limit the types of studies, mitigations, or alternatives an agency may decide to require.

INTRODUCTION

Transplanting a saguaro is a relatively simple mechanical process, but a more complicated biological process. Saguaros are long living cacti uniquely adapted to the Sonoran Desert's extreme environmental conditions. Saguaros have evolved thicker skins on their sides that are exposed to the most intense rays of the sun (Mazier & Schatt 1998, Mielke et. al. 2012). They have an extensive and mostly shallow root system that takes advantage of the infrequent and limited rainfall events in the desert and can store large quantities of water in their stems. Saguaros can weigh over 100 pounds per linear foot (Elliot 2003). These giant cacti are also more fragile than they appear. Their tremendous weight can actually crush and damage internal tissues if not moved with great care, and damage to their skin can leave openings for the entry of pathogens (Emming 2007, Mielke et. al. 2012). It is estimated that 80 percent of the roots are lost as the saguaro is extracted from the ground, and 30 to 50 percent of its stored water can be lost during the translocation process (Emming 2007).

Success of saguaro transplant survival is inversely related to size. Saguaros less than two feet almost always survive. Those over 25 feet rarely survive (Elliot 2003). Transplanting success is much higher with "spears" (saguaros without arms) less than 10 feet tall (Desert Botanical Garden 2010). There are two published studies that evaluate saguaro transplant survival over periods ranging from four to eleven years at five different sites (Harris et. al. 2004, Mielke et. al. 2012). Overall survival from these studies ranged from 66 to 78 percent. Survival rates and health were significantly affected by the height of the saguaro, whether or not it had arms, and the depth to which it was replanted as judged from the presence or absence of the stem's taper at its base. The results of these studies are summarized in Appendix 12.1.

Upon reviewing the extant literature, the Arizona Game and Fish Department (Department) recognized there was a lack of consensus on definitive guidelines for the translocation of saguaros. Therefore, the Department developed these Best Management Practices (BMPs) from a thorough review of the literature and subsequent discussions with several of the experts (see Appendix 12.2).

The main body of these guidelines presents the BMPs, the facts and discussion of how the BMP was derived, and the pertinent citations. At the very end of this document (Appendix 12.8) a summary version of the BMPs is included. This summary is designed to be printed and handed out to staff as needed for improved project implementation.

While some of the following recommendations are critical, the value of other recommendations may be less obvious and more incremental. The Department believes applying as many of these BMPs as possible will result in overall improvement in the survival of transplanted saguaros.

Although the primary purpose of these guidelines is to assist with the successful translocation of saguaro cacti, the Department recommends that all efforts should be made to avoid moving these cacti if at all possible. Mitigation by avoidance is the best method to minimize any negative impact (Thorton 2017). Careful planning and adjustments to the footprint of an activity or project might be able to avoid the necessity of removing the saguaro.

PLANNING THE SALVAGE/TRANSPORTATION

The relocation of a few dozen saguaros may require only a moderate amount of planning. The relocation of hundreds of saguaros, as might occur with large projects spanning many miles or acres, will require meticulous planning to ensure major logistical variables that impact time, costs, and desired results are considered. This section details the items that should be considered prior to translocation.

Permitting

In Arizona, the Department of Agriculture (AZDA) must be contacted whenever moving or destroying saguaros. Be sure to check with the local office for current rules and timelines to obtain the required permit.
More information is available at: https://agriculture.az.gov/plantsproduce/native-plants.

Survey, Marking, and Data Collection for each Saguaro

A thorough survey of the project area is recommended to identify and quantify the saguaros that will need to be moved. If monitoring or research activities are envisioned, saguaros that may not need to be moved should also be identified because some of these may be selected as control specimens. Those saguaros identified should be physically tagged, photographed (from all four cardinal directions), and the pertinent data recorded (Appendix 12.3a). Data collection apps and digital photography can be used to facilitate the recording process, and the multiple photographs may be useful for assessing future mortality causes. The required AZDA Native Plant Law (AZNPL) tag as well as the unique ID number tag should be affixed on the north side of the saguaro using long zip-lock plastic ties. The ties should be loose enough to allow growth, and can be cut and re-adjusted in the future if they threaten to cut into the stem. The zip-lock tie and tags should be placed 1 foot above the natural ground level. Although some workers use white correction fluid to mark cacti, these marks fade with time and are not recommended. Data recorded should include geo-coordinates, the unique ID number, height, number and length of arms, diameter-at-breast-height (DBH)[1], whether or not the saguaro has nurse tree shading, overall condition (see Appendix 12.3b), and any other special observations (e.g., stem cavities, notable damage, etc.) The multiple photographs will provide additional backup information.

Nearly every expert contacted thought it was important that saguaros be replanted to the same cardinal orientation (Byrd 2017, Desert Botanical Garden 2010, Elliot 2003, Emming 2017, Kelly 2005, Kelly and Grumbles 2009, Mielke et. al. 2012, NRCS 2009, Tucson Saguaro and

[1] DBH measurements are recommended after multiple BMPs (initial identification; after rehydration but prior to extraction; when the saguaro is actually removed from the ground; after the saguaro has been replanted; and 10 days after each supplemental watering or rainfall event that exceeds ¼ inch). A large sliding caliper is recommended to take the DBH measurement, and the measurement points can be marked with white correction fluid (this can be refreshed when necessary). These DBH measurements will be used to monitor the re-establishment of the saguaro, and in particular, to determine when the roots become functional again and can intake water and nutrients. This activity will cause the stem to swell (increase in diameter). This increase in stem diameter, when documented during the post-translocation monitoring phase, will be used to declare when a transplant has been initially successful. Because some of the shorter saguaros may not reach "breast" height, measurements should be taken at 4 feet 3 inches from the ground level, or 15 inches from the top, whichever is closest to the ground.

Succulent Society 2013). The north and east sides have more tender skin, and can easily sunburn if they end up facing the more radiant south and west directions after being replanted (Desert Botanical Garden 2004). Sunburn can scar the saguaro skin and cause permanent blemishes or even rot.

Studies (Harris et. al. 2004, Mielke et. al. 2012) also support the importance of the saguaro being replanted at the same depth at which it was growing. The recommendation to attach the tags on the north side of the saguaro at one foot above ground level is to facilitate the implementation of both of these BMPs: replant the saguaro facing the same direction, and to the same depth, at which it was growing.

Planning and Scheduling

Meticulous planning and scheduling of any sizeable salvage and transplant operation is critical. The Department recommends developing a detailed calendar indicating the order that each saguaro will be moved during each week and season; and whether the saguaro can be "once-moved" (i.e., extracted and loaded onto the cradle, transported to the new permanent site, and then directly re-planted from the cradle, NRCS 2009), or whether some/all saguaros will have to be placed in a temporary nursery storage setting. A uniquely important consideration in the overall implementation plan will be, based on the number of cacti to be moved, how many cradle/truck rigs will be needed. Beyond the numbers of saguaros to be moved and the timeline envisioned, there are other major logistical variables that impact time, costs, and final results. When developing your schedule/calendar, consider the following variables:

Seasonal Considerations

Saguaros can be successfully transplanted throughout the year. Spring is the most ideal season. The dry weather and soil conditions are less conducive to tissue rot, and the warmer temperatures promote active root growth and faster re-establishment (Kelly and Grumbles 2009, NRCS 2009). The 60°F night time temperature threshold can be used to define the startup of the optimal spring planting season (Kelly 2005). Many experts extend the planting season throughout the summer (Kelly and Grumbles 2009), but some caution that the extreme temperatures can be stressful, and the monsoons can result in excess soil moisture which promotes root rot (NRCS 2009). Planting can continue into the fall and winter months, with the understanding that new root growth might be delayed during these cooler months. Given that the saguaro can rely upon its stored water during these times, this is not viewed as detrimental (Emming 2017, Kelly and Grumbles 2009, NRCS 2009). Some advantages of winter planting include decreased chance of sunburn and less heat stress on both saguaros and human workers. However, transplanting should be avoided during fall and winter days when soils are saturated by rainfall, and saguaros should have a month in dry soil prior to any supplemental watering (see *Watering of Transplanted Saguaros*). If transplanting cannot be avoided during these more adverse, wet conditions, this should be noted in the record for any saguaros affected so it can be considered when assessing future survival rates.

Transplantation of Legacy Saguaros

If legacy saguaros (those over 15 feet tall and/or with multiple arms) are to be translocated, they should be given special consideration in the implementation plan. These giant saguaros should be

transplanted during the optimal spring months if at all possible. The methods used to extract saguaros (see Excavation of the Saguaro) tend to result in similar size root balls whether the cactus is 5, 10, 15 or even 20 feet tall. These large saguaros that have less roots per total mass should be moved during the most ideal transplant season so their roots have the longest growing season to re-establish. Survival rates can also be improved if the translocation is scheduled as a "once-move."

Although survival rates for these legacy saguaros are much lower and in some respects may not justify the cost of transplanting, the effort is sometimes still warranted to mitigate their outright destruction. When identifying legacy saguaros for translocation, it should be recognized that saguaros with arms longer than 7-8 feet, central stem lengths greater than 25 feet, and more than 7-8 arms are likely nearing the end of their lifespans. Those that are thinning and balding at the tops with spine loss, numerous bird holes, or other obvious damage and blemishes are also poor candidates (Emming 2017).

Allowing Sufficient Time for Handling Saguaros

When translocating saguaros, adequate time and care is important to achieve high survival rates. Salvage activities should allow ample time to handle saguaros, especially those that exceed ten feet in height. A minimum of an hour is required to remove a 10 foot saguaro, a minimum of one and a half hours is required if it has up to two short arms (NRCS 2009). Taller, multi-arm saguaros will require even more time.

Selection of Transplant Sites

Transplant sites should be as similar to the original site as possible: light exposure, freeze potential, soil type and texture, cardinal orientation and other abiotic factors (Kelly 2005). Select slightly raised (mounded) planting sites and avoid those where water can accumulate and keep the soil too wet (Emming 2017).

Elevational Concerns

Saguaros can grow at elevations to 4000 - 5000 feet in favorable microhabitats. When saguaros are transplanted at elevations above 2800 feet, aspect (the direction the slope is facing) becomes an important consideration. In these settings, care should be taken to place the plants on the warmer south- and west-facing slopes; north-facing slopes should be avoided. If planting on a north-facing slope is unavoidable, the plants should be placed near the top of the slope rather than near the base (Mielke et. al. 2012). The reason for the preferred selection of the upper slopes probably relates to the phenomenon of cold air drainage. This occurs on cold, still winter nights when the denser cold air flows off the slopes towards the valleys and mountain bases and can result in temperature differentials of 5-10°F within 100-200 feet of elevational change. These temperature changes can be the difference in survival of younger saguaros, or possible frost damage to mature saguaros (Emming 2017).

Acquisition/Scheduling of Equipment, Supplies, and Labor

An important consideration in the overall implementation plan will be acquiring and scheduling the equipment, supplies, and labor needed. This includes equipment such as special cradles and hydraulic lifts (saguaro "rigs") for moving saguaros; flat-bed trailers for moving the smaller spears; optional towable cherry-picker lift (for padding and securing arms prior to extraction,

measuring plumb and/or attaching guy wires to the taller saguaros for support after re-planting); water tank trucks and ATVs, as well as jet-spray and octopus hose systems for watering; hand tools (shovels, picks and digging bars, pneumatic diggers, various size pruners and pruning saws, etc.); calipers for measuring DBH; support stakes and guy wires; cutting tool disinfectant; and treatment chemicals and applicators (see Appendix 12.4). The number and availability of specialized cradle/truck rigs are expected to be a key limiting factor in the scheduling/implementation plan.

Pre-Extraction and Post-planting Watering

Identifying the watering methods to be used and the equipment needed, as well as acquiring and scheduling the use of the equipment, should be detailed in the implementation plan. Different methods might be required under different circumstances and available access to the translocated saguaros. This planning activity also includes locating historical rainfall data, designing the rain gauge network for the project(s) area, and determining trigger values (amount of rainfall) for supplemental watering if precipitation falls below the long-term average. Additional information is provided under the sections entitled HYDRATION OF SAGUAROS PRIOR TO EXTRACTION and *Watering of Transplanted Saguaros*.

Monitoring and/or Research Activities.

Monitoring the translocated saguaros should be conducted for a minimum of 5 years and preferably 10 or more. Saguaros are long living cacti and their ability to use their stored water can maintain an appearance of life even as they slowly die over an extended period of time. Specific data to be collected, the number to be monitored, and even identification of specific individuals should be determined prior to project implementation. Additionally, if research activities are planned, the protocols should be prepared and sample sizes determined prior to commencement of transplanting.

HYDRATION OF SAGUAROS PRIOR TO EXTRACTION

The saguaro's ability to store large quantities of water is an adaption that allows them to survive extended dry periods in the desert. Watering saguaros prior to transplantation seeks to maximize the benefits of this adaptation. Dehydrated saguaros do not fare well through the transplant process. The condition of the saguaro will determine if watering is necessary prior to extraction. Generally, if a saguaro appears fully hydrated and is in superb condition (i.e. appears full with its ribs apart and signs of growth such as new arms starting, new spines, or growth at the apex or tips (Saguarobylin_dot_com 2009, Desert Botanical Garden 2004, Harris et. al. 2004), then watering is not necessary. However, if the saguaro is dehydrated (shrunken ribs, pinched tips), and/or the hot season is approaching, then it should be well watered at least once prior to extraction. Even the healthiest saguaros lose 30 to 50 percent of their mass after a move (Emming 2007). Fully hydrating a saguaro before the move creates a reserve the plant can use while regenerating the 80 percent or more of the roots it will lose when excavated.

Two different methods are reported in the literature for rehydrating saguaros prior to extraction. One recommends watering two times, several weeks before extraction, and the other recommends a slow watering to a depth of 12 inches, two weeks before removal (Mielke et. al. 2012). Another method for watering saguaros (NRCS 2009) is to apply water over the shallow, widespread roots to a depth of 4-5 inches (see *Water Application Methods* for equipment needed). A soil moisture probe can be used to verify the water penetration depth. Given that the naturally growing saguaro prior to extraction still has its extensive, shallow root system intact, it would seem that application of water over this widespread root system (to the 4-5 inch depth) would be the most advantageous method. One watering would be the minimum application; two being preferable.

Although a baseline DBH[1] should have been collected when the saguaro was first inventoried, there may have been a considerable time lapse between then and this pre-extraction step. Accordingly, a new measurement should be taken just prior to this rehydration watering, with a follow-up DBH taken 10 days after the final watering (whether one or two are applied). An increase in DBH indicates that water uptake has occurred.

EXTRACTION OF THE SAGUARO

Handling Saguaros

Saguaros less than six feet tall can be moved relatively easily using a hand-cart (dolly) with never flat, pneumatic tires, a wheelbarrow depending on length of the saguaro, or slings if adequate workers are available. Depending on the height and girth, 5-6 foot saguaros can weigh between 300 to 600 pounds. Sufficient padding should be used so that no damage to the spines and trunk occur, and the saguaro should be well secured to the dolly. When placed on a transport vehicle or flatbed trailer, extra padding should be used to cushion the side and spines lying on the bed of the truck, and the spears should be secured so that they do not bounce. Saguaros can be stacked 2-3 high, depending on size, if sufficient padding is used (Byrd 2017). They should also be covered to prevent sunburn.

Saguaros taller than six feet are best handled with a special cradle for support and usually a hydraulic system for lifting and tilting (NRCS 2009). Prior to excavation, pad the trunk and arms generously with old carpeting, foam rubber, pillows, etc. and secure with cordage. A cherry-picker lift could be helpful for reaching the higher portions of the saguaros. It is important to support the entire stem length as well as any arms longer than three feet; the saguaro should be firmly attached to the cradle device for safety. Saguaros can break easily by tilting when unsupported, as well as the jarring from transport (Emming 2007, Mielke et. al. 2012). A dropped saguaro will likely die from internal damage, even if it can be erected again.

These special saguaro cactus "rigs" have been largely designed and constructed by the commercial nursery industry. A review of these designs is recommended. It is likely that many different ideas have been used and careful selection or even combining the various features might well yield a more "ideal" design and contribute to the survival of transported saguaros.

Excavation of the Saguaro

Prior to excavation, verify that the AZNPL and unique ID tag are attached one foot above ground level on the north side of the cactus. These will serve as reference marks for replanting. The DBH[1] should be re-measured and recorded. Some useful tools for extraction include shovel, railroad pick, digging bars, various types of saws with easily replaced blades (e.g., bow saw, pruning saw), various sizes of pruning shears, and sometimes power demolition hammers.

About two feet from the outside of the saguaro, begin digging a trench around the saguaro (Desert Botanical Garden 2010, Emming 2007, Kelly 2005, Mielke et. al. 2012). Whenever there is an opportunity to preserve a longer lateral root (i.e., it can be detected from the surface; the soil is particularly loose, or the root becomes exposed during the excavation), it should be taken. Lateral roots can also be found by starting a shallow excavation further from the stem (e.g., three feet) and then working back towards the stem to free the root prior to the deeper digging at the two foot radius to remove the tap root. For saguaros less than two feet tall, it is advised to remove the entire root mass, and to remove as much as possible for saguaros that range from 2 to 6 feet tall. Saguaro roots seem to be rather brittle; therefore considerable care is required during excavation (Peachey 2017).

Unlike other cacti, saguaros have a prominent tap root (Kelly 2005), although it rarely exceeds three feet in length, even on a 20 foot tall saguaro (Desert Botanical Garden 2004, Peachey 2017). If soil conditions allow for a deeper excavation and removal of more of the tap root, this should be done (Byrd 2017, Emming 2017). The minimum length for the excavated taproot is 18 inches.

Root Trimming and Treatments

After careful excavation, trimming and treatment of the roots is the second most important action for achieving a successful transplant. Not only does the saguaro lose the majority of its root system from the excavation process, but the saguaro also has a proclivity to suffer from root rot. The ability of the saguaro to regenerate new, healthy roots is critical for both moisture and nutrient absorption, and eventual stability of the cactus. Regrowth of roots is extremely slow, and likely mimics stem elongation. New root growth emerges along the trimmed remnants, not from the tips (Peachey 2017). Longer roots have more surface area from which to generate new feeder

roots, and longer roots may be better able to seal off any root rot from damaged ends well before the necrosis reaches the root base near the main trunk (Emming 2017).

After the saguaro has been lifted from the hole, any damaged parts of roots should be carefully trimmed away (Kelly 2005). Cuts should be above (stem side) the damage point, and should be clean and square (Cactusbylin_dot_com 2009, Kelly 2005). It is recommended that a minimum of 12-18 inches of solid, healthy lateral root, and as much of the tap root as possible, be retained (Emming 2017, Tucson Cactus and Succulent Society 2013). All tools such as knives, pruners and saws should be sharp and sterile. Use a 10 percent household bleach solution to clean tools between individual saguaros (Emming 2017).

The trimmed roots should be well dusted with a fungicide and bactericide (Desert Botanical Garden 2004, Elliot 2003, Kelly and Grumbles 2009, Mazier Undated, NRCS 2009). Agri-Mycin® 17 (an agricultural streptomycin, see Appendix 12.5) is the recommended bactericide Mazier and Schatt 1998). Bordeaux Mix has been suggested as a fungicide (Thorton 2017) as most of the previously used products have been removed from the market. Sulfur powder can be used as a last resort, but may not be very effective against white fungi (Peachey 2017, Thorton 2017). A photo of the roots, with a legible measuring stick, should be taken following excavation and treatment.

Air Drying Roots

Most experts recommend that the roots have time to air-dry (Desert Botanical Garden 2004, Harris et. al. 2004, Kelly 2005). One to two weeks is the general consensus, and the roots should be shaded during this period (Harris et. al. 2004). Shade cloth can be used if necessary (Emming 2017). Air-drying allows the recently traumatized and trimmed roots to form a protective callus, which prevents the entry of pathogens that cause root rot. This BMP can be readily accommodated for small projects where only a few saguaros are moved. However, when dozens or hundreds are being moved, this drying period is not always feasible as there may be a limited number of hydraulic cradles which cannot be left holding a saguaro for the extra days recommended for air-drying. In these situations, the Department recommends that the larger, more logistically challenging saguaros are transplanted using the "once-move" process (i.e., loaded onto the cradle, transported to the new site, and then directly re-planted from the cradle). Smaller saguaros, especially spears, can be stacked on flatbed trailers and left for the recommended time (under shade).

When scheduling conflicts preclude the recommended air-drying time, some techniques that may help mitigate this insufficient time are:

(1) use of fungicide and/or sulfur powder;
(2) utilizing weekend time (or other non-work days) for extra drying time as much as possible;
(3) recognize that the moving wind around the open air roots during transport could facilitate drying; and
(4) consider the use of blowers to hasten drying time (Note: this method has not been documented and would best be employed under an experimental protocol.) If this technique is used, it will be important to record how long the blowers were used on each

cactus so the data can be analyzed to determine if this technique is beneficial or detrimental to the survival of saguaros.

Because the recommended air-drying time will not always be possible, it is imperative that records kept for each saguaro note the actual air-drying time as precisely as possible (time in hours are best, but time in quarter-day increments might also suffice). If chemical treatments or forced air blowers are used, this too should be noted. With these data and continued monitoring, it should be possible to better correlate air-drying time with survival rates and to determine the best techniques and ideal time frames.

There is some suggestion (based on a dissertation study by Caldwell completed in 1966), that the callus process might happen much quicker that commonly assumed[2]. However, there has been no further investigation of this phenomenon since the time of that study, so the BMP remains at 1-2 weeks.

Cover Saguaros during Transport

Once the saguaro has been removed from the ground, it is important to protect it from sunburn. Unprotected saguaros can burn under a hot sun in minutes or hours (Elliot 2003). Whether reclined in the cradle, loaded onto a transport vehicle or trailer, or actually being transported, all parts of the saguaro, including the roots, should be covered with carpet, 30 percent shade cloth, or some other protective cover, such as a tarp. The coverage must also be well secured so that it does not blow open during highway travel and expose any part of the cactus to possible sunburn.

[2] The dissertation research identified groups of complex organic molecules that combined to produce protective compounds that could kill or inhibit invading organisms. These compounds also rapidly built physical barriers to seal off the damaged areas. This process appears to be an evolved mechanism to protect the fluids stored within a succulent saguaro from a sudden breach, and to do this quickly. While the complete process and the specific contributions of various identified chemicals have not been determined, rapid color changes indicate that these responses occur within hours, even if the final lignification takes additional time. It seems that the response to trauma is first the chemical formation of "biocides" to combat foreign elements, quickly followed by the formation of physical barriers, and the eventual creation of lignified structural layers that permanently wall off the damaged parts (Peachey 2017).

TEMPORARY STORAGE

Storing saguaros should only be done when absolutely necessary. Immediate transfer of these cacti to their permanent location reduces the amount of mechanical handling and probability of damage to the plant, and ensures the best survival rate (NRCS 2009). This "once-move" approach is especially important when transplanting the larger and/or multi-arm saguaros. The need for temporary storage, locations, and durations are key factors that should be addressed during the planning stage of a transplanting project.

Locations selected for temporary storage areas should be open to allow good air circulation. The saguaros should be both properly oriented using the tags placed on the north side and covered with 30 percent shade cloth to prevent sunburn. The saguaros must remain in an upright position. Pea-gravel is the recommended backfill (see Backfill and Backfilling). If the pea-gravel is well packed, saguaros up to 12 feet tall (with or without arms) and spears (saguaros without arms) up to 15 should not require additional support. Saguaros over 12 feet tall with arms, and any saguaros over 15 feet tall should be supported with guy wires and stakes. The Pima County Native Plant Nursery has maintained saguaros in a storage setting for two years (Byrd 2017).

RE-PLANTING THE SAGUARO

The ideal time period to transplant saguaros is the spring. The dry weather and soil conditions are not conducive to tissue rot, and the warmer temperatures promote active root growth and faster establishment (Kelly and Grumbles 2009, NRCS 2009). The 60°F night time temperature threshold can be used to define the startup of this optimal planting season (Kelly 2005). Many experts extend this planting season throughout the summer (Kelly and Grumbles 2009), while some caution that the extreme temperatures can be stressful, and the monsoons can result in excess soil moisture which promotes root rot (NRCS 2009). Most knowledgeable persons also concur that saguaros can be planted essentially throughout the year, although the days when the soils are saturated by rains (summer or winter) might best be avoided. It is acknowledged that during late fall, winter and early spring periods, unless the weather is unseasonably warm, the newly transplanted saguaros might remain dormant, without any new root growth, for several months. Given that the saguaro can rely on its stored water during these times, this is not viewed as detrimental (Emming 2017, Kelly and Grumbles 2009, NRCS 2009).

Hole Preparation

Excavate the new hole to a width twice as wide as the extant root ball (Desert Botanical Garden 2004, Mazier & Schatt 1998). If longer lengths of lateral roots were successfully excavated without excessive damage, those longer than 18-24 inches can be buried in a trench dug to accommodate them (i.e., like laying pipe), rather than expanding the diameter of the entire hole (Emming 2017). It is highly recommended that saguaros are replanted no deeper (or within 1-2 inches) than their original level in the ground (Byrd 2017, Saguarobylin_dot_com 2009, Desert Botanical Garden 2004, Desert Botanical Garden 2010, Emming 2007, Kelly 2005, Mazier & Schatt 1998, Mazier Undated, NRCS 2009). Although there are some commercial planters that plant the stem deeper for added stability, this results in roots being significantly deeper in the ground and beyond the penetration range of most desert rains (Elliot 2003, Mazier & Schatt 1998). In addition, the stems are not designed to be in contact with the soil above the natural growth level, and have a tendency to develop rot. The most compelling reason, however, to replant at the original ground level, is the transplant success documented in a study of ADOT saguaro translocations (Mielke et. al. 2012)[3].

The translocated saguaros should have a zip-lock tie near the base that is one foot above the original ground level (this tie should also hold the AZNPL tag and the unique ID tag that mark

[3] Based on this study that evaluated the transplant success of saguaros moved during four ADOT highway projects, there was a significant survival and health benefit to saguaros that were planted at or near to their original ground level as judged by the presence or absence of a taper at the base of the stem. At one of the study sites (SR86), saguaros that showed a taper were judged to be in good condition 3x more than those without. Combining the data from the three other study sites (which rated saguaros health as good, fair and poor), there is additional evidence that replanting to the original ground level depth is beneficial. When both good and fair condition percentages are considered at the other three sites, there was a consistent 12+% improvement for the saguaros that exhibited a taper. The benefits were more pronounced when looking at the average percent results across the three sites for each individual category:

	Good Condition	Fair Condition	Poor Condition
With taper (planted near original depth)	78%	15%	9%
Without taper (deeper than original depth)	48%	33%	45%

the north side of the saguaro). This one-foot distance marker, along with the vertical length of the extant root mass, including the tap root, can be used to measure precisely how deep the hole should be (after subtracting the extra foot). Soil at the bottom of the hole should be able to promote good drainage (i.e., a sandy type soil). If it's too hard and compact (i.e., a clay type soil), it can be broken up and/or some sand or gravel added, but should then be re-tamped to the proper depth as calculated (Saguarobylin_dot_com 2009).

If the zip-lock tie marking the one foot distance above ground level has been removed from the saguaro stem, it may be possible to still see the original soil line, or use the butt or the taper of the stem at the base to approximate the original ground level.

Final Inspection and Placement of Saguaro in the Hole

In addition to using the zip-lock tie to determine the proper depth to replant the saguaro, the tags held by the zip-lock marking the north side should be used to turn the saguaro to face north once again. If the north marking tag has been lost, the north side may be determined by:

(1) Saguaros generally have a sloping top that is oriented to the south, and
(2) The north side of the saguaro is a lighter green color than the south side (Saguarobylin_dot_com 2009).

If for any reason the north side cannot be identified, this should be documented and the replanted saguaro should be covered with a shade cloth (Emming 2017).

Prior to lowering the saguaro into the hole, the roots should be re-examined to determine if they are suitably callused, and/or if there has been any new damage or deterioration. Any new damage should be trimmed away, and any other pertinent observations should be recorded. The root mass should again be dusted/sprayed with additional fungicide (including Bordeaux mix) and anti-bactericide (NRCS 2009, Thorton 2017). Use of a root stimulating hormone (indole acetic or buteric acid) has also been suggested (Thorton 2017). With the saguaro still attached to the cradle for both support and safety, either visually, or using a plumb line (and a ladder or the cherry-picker lift), assure the saguaro is vertically straight and balanced. To avoid crushing the excavated tap root with the weight of the saguaro, it is imperative that the saguaro is still supported on the cradle as the pea-gravel backfill is added and tamped around the roots until there is a sufficient quantity of compacted backfill to support the cactus.

Backfill and Backfilling

Pea gravel is recommended for the backfill material (Byrd 2017). Given that root rot is probably the most significant detrimental factor to overcome, and the likelihood that "once-move" and other time constraints in a large scale transplant operation will often preclude the recommended one to two weeks for air-drying roots, the extra drainage inherent with the pea-gravel medium is considered to be the best backfill choice to avoid prolonged, excessively moist conditions. No other amendments are recommended.

To avoid crushing the tap root, it is important that the saguaro is supported on the cradle as it is lowered to the proper depth into the hole. The pea gravel backfill should be incrementally added and firmly compacted around the saguaro. This is best accomplished by adding 3-5 inches of pea gravel, tamping it down, and repeating this process until the hole is filled (Elliot 2003, Emming 2007, Mielke et. al. 2012). A 3x3 inch tamping rod, preferably with a rounded tip, is

recommended. Caution should be used when tamping to avoid striking or otherwise damaging the carefully trimmed, treated and callused roots. Fresh wounds can easily defeat all the previous efforts to avoid root rot. Accidental damage should not be ignored; rather, that area should be re-excavated, trimmed again, and treated with fungicide, bactericide and/or extra sulfur. Another technique rather than tamping (which as just noted could strike and damage a root) is to use a heavy bar inserted into the fill to agitate and settle the fill material with circular or back and forth motions (Peachey 2017). Once the roots are adequately covered, some of the native soil can be used to cover the top few inches of the hole and tamped down. If the soil seems particularly heavy (clayey), some river sand can be added. This finer fill material will slowly work its way into the upper interstices of the pea gravel and serve to lock some of the gravel together and provide extra support (Peachey 2017).

If any native soil is used as backfill (even though this is not recommended as a BMP), it is especially important to remove any rocks or caliche chunks over three inches (Mazier & Schatt 1998) in diameter. These larger rocks, as they are tamped down in the hole, could easily damage roots with which they might be in contact.

Stem Cone and Retention Basins

Create a tapered mound or cone of soil around the base of the saguaro to divert water away from the stem (Elliot 2003). This precludes excess accumulation of water around the stem that could promote rot, and/or prevents the spores of pathogens from contact with the stem base. The cone is not compacted so it will eventually erode away (see Appendix 12.6).

Some of the excavated dirt should be used to create a water-collecting basin around the saguaro. These basins should be three times the diameter of the saguaro, with a 4-6 inch berm around the basin circumference to retain water. This basin will capture some rainfall, but is primarily intended to assure the most efficient usage of supplemental water. A similar technique identified by Mazier & Schatt (1998) is to dig a donut-shaped canal around the saguaro starting about 18 inches from the stem. This design will also facilitate the efficient use of supplemental water, but will also be able to capture some additional runoff water from rainfall events. Note that using pea-gravel as backfill (instead of using the native soil excavated from the hole) will also promote the infiltration of water into the excavated area.

Temporary Support of Transplanted Saguaros

After transplantation, the biomass of a saguaro is now supported by about 20 percent of a recently traumatized root mass (especially the loss of most of the extended lateral support roots) in freshly disturbed soil or pea gravel that has just been tamped down. When this situation is combined with the cost and effort involved in the transplant process, it makes sense to provide additional temporary support which can augment the survival rate of the cactus.

Experience at the Pima County Native Plant Nursery indicates that saguaros less than 12 feet do not require additional support if the backfill is well tamped. This height can be extended to 15 feet for spears (saguaros with no arms). Accordingly, saguaros over 15 feet tall or those between 12-15 feet with arms should have additional support or bracing (Byrd 2017, Emming 2017).

The preferred support system consists of three guy wires strung through sections of fiber-

reinforced hose or tree straps. Galvanized wire rope (1/8 inch wire with 2000 lb breaking strength) is recommended. Sections of hose are placed around the plant two thirds up from the base of the saguaro; the cherry-picker lift or ladders may be useful to facilitate attachment of the collar and guy wires, especially on taller saguaros. Triangulate the three guy wires from the hose sections surrounding the plant column and stake them into the ground using 24-inch #4 rebar. Ensure that the collar is not too tight around the stem. As the saguaro settles, and after watering, the guy wires can be re-adjusted to maintain a balanced tension if necessary. Guy wires should be flagged at 5-6 feet above ground level as a safety measure (see Appendix 12.6).

Note that the cactus should be well balanced and able to stand by itself. The guy wire support is to prevent tilting in any direction until such time as re-rooting stabilizes the cactus. Once the guy wires are attached and staked and it has been verified that the replanted saguaro is stable, the cactus can be detached from the support cradle. If a saguaro falls over, it will likely perish from internal damage even if it is erected again. A falling saguaro also poses grave danger to workers (Emming 2007).

The support system should be left in place for two growing seasons. In order to stabilize, the saguaro must replace much of the estimated 80 percent of its roots (especially the extensive laterals) that were truncated during excavation. This is very unlikely to be accomplished in two growing seasons, and will probably require much longer. Peachey (2017) believes that roots grow and extend at a pace similar to stems and arms. In addition, damage to saguaros is not always readily apparent, especially if internal. Having the support system will help keep the saguaro upright as it heals and re-establishes. For longer term projects, especially those that are being actively monitored, there is also no reason that the support systems cannot be left longer on selected saguaros that might benefit from this additional time. Once the system is in place, there is little to no additional cost.

The use of 2x4 supports that are covered with carpet at the point of contact with the stem are not recommended. Not only do the boards press against the stem and damage the spines (sometimes excessively as the saguaro settles into the soil), but the carpet can retain moisture which promotes decay where it is in contact with the stem. The guy wire system is also less expensive than the 2x4 support system.

Re-Measure the DBH[1] and take New Photos

Prior to removal from the point-of-origin location and after the saguaro was rehydrated by supplemental watering (if necessary), the diameter at breast height (DBH) was measured and recorded. Now that the saguaro has been replanted (whether as a once-move, or after any length of time in temporary storage), the DBH should again be measured. These data will indicate if the saguaro has lost mass during the move (and/or storage), and serve as the baseline measure for monitoring new water uptake and transplant success. New photos should also be taken to document the saguaro transplantation.

POST-PLANTING CARE AND MONITORING

Use of Shade Cloth

It is recommended to use shade cloth to provide additional protection and reduce stress on newly transplanted saguaros (Byrd 2017, Saguarobylin_dot_com 2009, Desert Botanical Garden 2010, Emming 2007, Emming 2017, Kelly and Grumbles 2009, Mielke et. al. 2012, Thorton 2017, Tucson Saguaro and Succulent Society 2013). Cover each transplanted saguaro with 30 percent shade cloth, secured around the stem and arms with cordage and completely covering the southern and western exposures (i.e., shade cloth seams should be on the north side). The cloth should be left covering the saguaro through the first summer season. Care should be taken that folds and overlaps in the cloth do not effectively double or triple the protection. Any lightening of the skin to a paler green or yellowish to white color is an indication of sun burn. Such areas should be covered immediately with 30 percent shade cloth.

Watering of Transplanted Saguaros

Saguaros' ability to store large quantities of water is an adaption that allows them to survive extended dry periods in the desert. The previous BMP to make sure they are well hydrated prior to transplantation seeks to maximize the benefits of this adaptation. The saguaro should be re-planted into dry ground, backfilled with well compacted pea gravel, and not watered immediately to "settle" the backfill. If any rot starts in the root area from mechanical damage or stress from the transplantation, the dry, well drained, backfill should be conducive for the natural defenses of the cactus to deal with the problem (Elliott 2003). Recommended watering regimes will vary by season and transplantation date. Initiate post-transplant saguaro watering according to the following guidelines:

- The newly replanted saguaro has lost perhaps 80 percent of its roots. Saguaro roots are known to be very susceptible to root rot (facilitated by damaged roots and excessive moisture). The initial post-transplant watering regime should emphasize avoiding prolonged excessively moist conditions by providing intermittent watering in well drained (pea gravel) conditions.
- Saguaros transplanted in the spring, summer, or early fall months should remain in the dry backfill soil for 2 to 4 weeks before initial watering begins. Two weeks are sufficient for those whose roots were allowed the recommended two weeks air drying time; the additional weeks in dry soil are given (proportionately) to those saguaros that received less or effectively no air drying time.
- If saguaros are transplanted in the later fall or early winter, they should have a full month of dry soil time to reduce any onset of root rot, but can receive an initial watering after this dry period if there has been no rainfall. Although virtually all experts concur that transplanted saguaros should receive supplemental water, many caution against watering during the winter months, because root development and activity is generally inhibited by the cooler weather, and the cool, moist conditions may facilitate root rot. However, it is also not advisable that a newly transplanted saguaro should stand without any water for many months. The recommended schedule is to provide some water for those saguaros which are disposed to use it, but also long enough periods between watering to deter the continued development of any root rot that might start.

- Once air temperatures reach about 90°F, watering should begin according to the Water Schedule. (Note: the temperature guideline provided (60°F ground temperature and 90°F air temperatures) are general guidelines. In reality, natural processes operate on a continuum; not an absolute on-off switch. If a given saguaro is ready to grow roots, it can only do so if soil moisture is available.

Water Schedule

In the spring and summer, the watering schedule should be once every three weeks, especially during the first season as soil dries in 7 to 14 days (Desert Botanical Garden 2004, Mielke et. al. 2012, NRCS 2009). When temperatures exceed 110°F, watering may need to be increased to once every two weeks (Emming 2017, Mazier, no date).

Water schedules during non-summer months are more variable. It must be recognized that some winters are much warmer or cooler than the normative years, and that saguaros are well adapted to the winter rains in Arizona. The BMP is to try to simulate the average rainfall for the locale, based on available climate records and/or monitored by a rain gauge network established throughout the project area. If winter rains (as measured by the rain gauge network) are near the historic record norms, then supplemental watering is not needed. However, if winter months have little to no rain, and/or the temperatures are unseasonably warm, then supplemental water can be applied, but no more frequently than once per month. Saguaros may or may not be able to take advantage of this extra moisture. Because their roots are known to be active at night time air temperatures above 60°F, if day time air temperatures still reach into the 70°s or 80°s, the desert soils tend to absorb this heat which might stimulate root activity near the surface. A monthly watering, even if not utilized by the saguaro, is very unlikely to cause the development of root rot which is promoted by more chronic soil moisture. The widely spaced watering should not be detrimental to a healthy saguaro. Even in the event that there is some extant rot root as a result of the transplant process, the occasional watering is not expected to encourage the significant spread of this rot. This is because the wet conditions will not be prolonged, especially with the extra drainage provided by the pea gravel backfill.

There are other factors that can modify watering frequency. Spring, summer and/or winter rains, depending on the quantity, can substitute for one or more of the watering intervals. A distribution of rain gauges throughout the replant areas (existing network available via county flood control maps or installed network for the project) can be used to determine where and how much rain has fallen, and these data can be used to adjust the watering plan. Soil texture is another consideration. Sandy soils have poor water retention properties while clay soils hold water. This becomes an important factor as the roots grow from the well-drained pea gravel backfill into the surrounding native soil.

Water Application Methods

There are a variety of methods to apply water to accommodate different conditions within the project area. These methods are:

Jet-spray Tank Truck

Low-pressure jet-spray is a hose that extends from a tank truck that can quickly saturate soils to a depth of 4 to 5 inches (NRCS 2009). The hose system would allow one or more

workers to walk from saguaro to saguaro; the jet spray would allow the required water to be applied to each unit quickly.

ATV Tank
In settings where the truck/hose system does not have good access to some of the saguaros, a similar system can be mounted on an ATV equipped with a water tank. This more mobile ATV delivery system would require frequent refilling from a larger tank truck.

Octopus Hose Systems
Octopus hose systems are designed to operate from a manifold attached to a tank truck. Five to ten hoses can be run to as many saguaros, which are then watered simultaneously for a specified time. This system would best be used in conjunction with small basins prepared at the base of each saguaro.

(Note: Drip systems are ***not*** recommended. Drip systems are generally used to maintain soil moisture over an extended or even continuous period of time. Such an approach does not mimic natural precipitation events in the Arizona desert. This prolonged moisture regime might facilitate root rot.)

Ultimately, which ever system(s) is used, the appropriate amount of time to deliver a known number of gallons and to what depth this water penetrates must be determined. The number of gallons applied can be determined by using flow meters on the hoses.

Water Quantity
The Tucson Cactus and Succulent Society applied two gallons every two weeks to 2 to 3 foot saguaros (Thorton 2017), similar to a more moderate recommendation of 10 to 30 gallons every three weeks, depending on size of saguaro (Emming 2017). A very general rule of thumb is one gallon per linear foot of the cactus, including the arms, for each watering.

Initially, the trimmed root mass might be some 24 to 36 inches wide, and 12 to 24 inches deep. The first watering must penetrate to this area. This can only be determined by applying a measured volume of water to an area, and then either using a soil moisture meter, or digging a trench in an adjacent test area (e.g., an excavated hole backfilled with pea gravel) to observe the actual moisture penetration level. Several repeats of this experimental measuring (preferably using both methods), should yield a useful approximation of the amount of water (in gallons) that needs to be applied. Once this quantity has been ascertained, flow meters can be attached to hoses to measure how many gallons pass through in a given time period.

As the roots begin to expand laterally and grow nearer to the surface (over multiple growing seasons), the water application should strive to meet the 4 to 5 inch penetration level, over a broader area. This can be easily verified with soil moisture meters.

Although most experts agree that supplemental watering is beneficial to saguaro transplants, it is worth reiterating that most desert plants are more tolerant of too little water than too much (Kelly and Grumbles 2009). Supplemental watering and the concern of over-watering or facilitation of

root rot conditions should also be considered from the viewpoint of whether or not it is a chronic shift from natural conditions. Desert conditions are characterized as normally dry. Sometimes, even in the winter months, there are periods of considerable rainfall which may extend for a week or two. Providing very frequent and/or excessive supplemental water (e.g., via a drip system) would be a departure from typical desert conditions. A moderate or even heavy watering once a month, even during the winter months when the roots may or may not be active, is not a departure from typical desert conditions.

Duration

Most experts recommend that transplanted saguaros be watered at least through the first summer season, and often for another one to two years. However, a 10-year study of transplanted saguaros in the Tucson area determined that the impact of transplantation on water uptake by saguaros persisted for four years (Harris et. al. 2004). Accordingly, the Department recommends supplemental watering for at least four years from the transplant date.

Monitoring DBH

A diameter at breast height (DBH) measurement should have been taken prior to extraction and immediately post-transplant. For the duration of the post-transplant monitoring, DBHs should be recorded 10 days after each watering or rainfall event that exceeds a quarter of an inch. If the roots are starting to function and water uptake has occurred, the diameter of the saguaro will increase. Although most successful transplants should show increasing girth by the end of their first growing season, saguaros that are planted at less optimal times of the year (e.g., winter), or less vigorous individuals, might have a tendency to lag behind with root development and overall reestablishment (Emming 2017). Specific site conditions can also be expected to influence response time. Saguaros that show no increased girth (despite supplemental watering) after the second full growing season should be flagged as likely failures, but still receive supplemental care and monitoring as long as other cohorts are, or until there are obvious signs of rot or death. If the circumference of the saguaro increases, this can only result from growth which does require the uptake of water and nutrients, which in turn means that the roots are functioning. This definitive increase in circumference will define that the transplant has been successful[4]. A healthy saguaro will appear full with its ribs apart. Other indicators of growth include new arms or spines, or growth at the apices (ends) that can be pushing against the shade cloth (Byrd 2017, Saguarobylin_dot_com 2009, Desert Botanical Garden 2010, Kelly and Grumbles 2009).

Although DBH can be measured with a flexible tape measure, it will be quicker and more accurate to use a larger sliding caliper (e.g., a Haglof Mantax or similar device). The precise measuring points can be marked with white correction fluid (and renewed when these marks

[4] One reviewer (Peachey 2017) pointed out that an ongoing study of saguaros on Tumamoc Hill in Tucson which continuously measures the diameter of subject saguaros has found that there seems to be two minimum diameter low points each year and that the resultant sine-waves for each saguaro differs from the others. Accordingly, he questions whether the DBH measurements will truly be indicative of saguaro re-establishment and growth. However, there will be many DBH measurements for each saguaro over the duration of the project monitoring years. There should be adequate measurements to account for these suggested sine-wave fluctuations. More importantly, each individual saguaro is only being measured against itself as a long-term trend indicator. It can only continue to grow if the roots are functioning to uptake water and nutrients.

show signs of fading). The problem with using a measuring tape is that it must be carefully worked down through the spines to be truly accurate.

Other Post-Planting Management Practices

Do not cultivate and otherwise disturb the area around the trunk (up to seven feet diameter) to avoid damaging shallow roots. Do not mulch with any material that reflects or intensifies light. Do not cover soil with plastic sheets (Elliott 2003, Kelly and Grumbles 2009). Fertilization is generally not necessary.

PESTS AND DISEASES

Rots result from various forms of injury. Bacterial soft rot (*Erwinia carnegiana*) is a primary disease of saguaro and control measures include removal of the soft, black rotting tissue and treating with a 10 percent household bleach solution (Kelly and Grumbles 2009). Powdered sulfur can also be dusted into the wounds of saguaros as a healing aid. Sometimes an infection can develop in a saguaro through an injury or as a result of frost damage. It may be long after the actual event, but brownish or black ooze coming out of the trunk will indicate a problem. If the problem results from a localized injury, the suggested treatment can be successful. Sometimes, however, the problem is systematic (e.g., the plant has actually been killed by a hard freeze) and the emergent ooze is the first manifestation that the saguaro is standing but already dead (Desert Botanical Garden 2010).

In addition to the bacteria-caused soft rot, saguaros are also affected by wood-rotting "white" fungi. *Poria carnegiea* and *Phellinus texanus* are two types of fungi known to attack the lignin rich parts of the saguaro: woody roots and the butt (base) portion of the stem. It is most commonly found on mature plants and rarely on those less than 12 feet tall. *P. carnegiea* was found to be associated with 68 percent of saguaro wind-throws surveyed from 1961-1966 in the eastern section of Saguaro National Park (Lindsey 1975, Peachey 2017).

RECOMMENDED RESEARCH STUDIES

The topics listed below were identified while reviewing expert opinions and trying to resolve conflicts between various ideas and recommendations during development of the BMPs. The Department encourages further evaluation of these topics, especially when a large number of saguaros are proposed for transplanting. If such studies are to be incorporated into the project, work with AGFD's Research Branch and university/institutional experts to develop a detailed experimental protocol. Results from these studies could be used to improve these BMPs.

Ideal Root Length

Experts have suggested various lengths to which roots should be trimmed; these can generally be grouped into shorter (6-12 inches), longer (12-24 inches) and some extra-long (>24 inches) if they can be extracted without significant damage. Keeping track of final roots lengths for each saguaro, and monitoring the survival, health, and growth of transplanted saguaros in your project will help to determine which length is more advantageous. It may require sacrificing (or partially excavating) some of the transplanted saguaros to obtain information on the actual growth and condition of the roots.

Artificial Acceleration of Root Drying

Allowing time for the roots to air dry and callus after being extracted from the ground is a standard recommendation. Minimum times were 2 to 4 days; others were 1 to 2 weeks. It was also recommended, especially for larger saguaros, that they be removed from the ground and replanted in a "once-move" manner. Trying to follow both of these recommendations, along with it being prohibitive to leave a saguaro on the cradle for an extended period of time (even several days) because the equipment is needed for the next saguaro, leads to a conflict. To better inform these BMPs, a study should be designed to determine the most beneficial duration for drying, and whether alternative methods of drying are effective (i.e. can fans or blowers be used to artificially accelerate root drying; is the result physiologically and functionally the same or similar enough).

Use of a Root Growth Hormone

Although only one expert specifically recommended the use of a root growth hormone (indole acetic or buteric acid), given that nearly 80 percent of the root mass is lost during excavation, anything that accelerates the growth of new roots post-transplant so that the saguaro can uptake more water and nutrients and re-anchor itself, seems logical. This is why supplemental watering is recommended. Application of root hormones is a common horticultural practice for transplants. There is, however, some debate on this matter, which is summarized in an article in Appendix 12.7. It is recommended that a research protocol be developed to ascertain if the application of root hormones are beneficial when transplanting saguaros. Note that the protocol may include the sacrifice of some transplanted saguaros as a direct method of evaluating root growth.

Evaluation of Watering Methods

There are wide ranging opinions on when and how, and how much, to water transplanted saguaros, although virtually all experts agree this is beneficial. An experimental protocol should be developed and implemented to statistically determine the following:

1) When watering should begin?
2) What is the ideal frequency and what parameters should be used to guide the frequency?
3) Which seasons should or should not be emphasized, again with guiding parameters such as rainfall and temperature?
4) What quantities of water should be applied?
5) What are the best application methods, e.g., jet spray, hose, drip, use of small basins, etc.?

In any project that involves a large number of saguaros, it should be possible to design a robust experimental protocol.

Alternate Method of Staking Saguaros

There is an alternative method for staking saguaros from those presented in these BMPs that was described in an early edition of Lyle Benson's "Cacti of Arizona" (Thorton 2017). It states, "When the plant is first moved drive three or four pieces of pipe into the hole the saguaro is to occupy. Anchor roots may be wired to the pipes after wrapping with burlap where the wire goes around the roots. Use plain 9 or 12 gauge wire and it will rust away by the time the plant is able to support itself." This method would negate the necessity of removing guy wires after the saguaro is established and avoid the risk of injury from people running into guy wires. The pipe can be substituted with #4 rebar. This technique, if it can be demonstrated to facilitate the stability of larger saguaros, offers an easier, less expensive, and safer way to provide additional support. A suitable number of transplanted saguaros, taller than 15 feet, should be evaluated to determine if this method is advantageous.

Necropsy Saguaros

Transplants are never 100 percent successful. Root rot and the development of new roots in the absence of root rot are important factors that influence the survival of transplanted saguaros. The necropsy of dying saguaros might shed considerable light on what is actually going on within the normally unobservable root zone.

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APPENDICES

12.1 Summary of Studies
12.2 Technical Reviewers and Contributors
12.3a Data Collection Information Fields
12.3b Proposed Saguaro Condition Rankings
12.4 Partial Equipment List and Web-links
12.5 Agri-Mycin® 17
12.6 Planting Design from ADOT
12.7 Article Discounting Vitamin B-1 for Root Stimulation
12.8 Summary Version of BMPs (printable for handouts)

- Planning and Other Activities prior to Saguaro Removal
- Removal, Transport and Temporary Storage
- Re-Planting the Saguaro
- Post Planting Care

Summary of Saguaro Survival and Health Condition by Height Class from 2 Long-Term Studies

HEIGHT	HEIGHT	Tucson Study	ADOT	SR86 Covered Wells		SR87 Tombstone		SR188 Resort to Devore		US93 Kaiser Spring	
(meters)	(feet)	9 years	Studies:	4.5 years		11 years		4 years		8 years	
		survival %	HEIGHT	survival %	condition	survival %	condition	survival %	condition	survival %	condition
	overall:	66%		66% (1)		68%		72%		78%	
0.1 - 0.9	4 in - 3 ft	76									
1.0 - 1.9	3ft 3in - 6ft 3in	80	0 - 6ft	68	good	63	good	91	good	76	excel-good
2.0 - 3.9	6ft 6in - 12ft 9in	71	6 - 12ft	64	good	93	good	70	good-fair	71	good
4.0 - 4.9	13ft 1 in - 16ft	56									
			12 -20ft	55	fair	64	good-fair	78	good-fair	63	good-fair
5.0 - 6.9	16 ft 5in-22ft 8 in	55	>20	57	fair-poor	n/a		56	fair-poor	n/a	
>7.0	>23ft	40									
		with arms		88	fair-poor	23	dead	20,41,19,20	Gd,Fr,Pr,Dd	35,18,12,35	Gd,Fr,Pr,Dd
		without arms		58	good	7	dead	68,15,6,6	Gd,Fr,Pr,Dd	73,9	Ex-Gd, Pr-Dd
		with tapered base		63	good	72,21,5	Gd, Fr,Pr	84,6,3	Gd,Fr,Pr	79,17,1	Gd,Fr,Pr
		without tapered base		19	good	53,30,16	Gd,Fr,Pr	29,47,22	Gd,Fr,Pr	61,22,7,10	Gd,Fr,Pr,Dd
							Gd=Good; Fr=Fair; Pr=Poor; Dd= Dead				

(1) poorest survival of the 4 sites, but also received lowest amount of rainfall relative to long term average.

Tucson Study: Harris, Lisa K., Elizabeth A. Pierson, Carianne Funicelli, William W. Shaw, Susana Morales, Kelly Hutton, and Jennifer Ashbeck. 2004. Long-term Study of Preserved and Transplanted Saguaros in an Urban Housing and Golf Course Development. Desert Plants 20(1):33-42.

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Appendix 12.2 – Technical Reviewers and Contributors

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Appendix 12.3a – Data Collection Information Fields

The following are data fields for information that should be collected for every saguaro cactus. Additional fields can be added as required. It is anticipated that a smart device app will be developed to facilitate data collection, storage and management.

Unique ID Number (this number should also be recorded on a tag and affixed to the cactus)
Geo-coordinate location of cactus (and geo-coordinate datum).
Height Number of arms and length of each arm.
Condition (see Appendix 12.3b for proposed condition rankings).
Other observations (e.g., color, especially if abnormal; number of holes; damage, etc).
Photos (from all 4 cardinal directions) and any particular close-ups if necessary.
DBH (diameter-at-breast-height)
[Measured at 4 feet, 3 inches from ground level, or 15 inches from top, whichever is closest to the ground]
Stem ridge (pleat) angle
Nurse tree Setting Yes/No Photo (if Yes)
Dates Information Recorded

Pre-Removal Hydration: Dates (may be multiple) Amount of Water

Extraction: Date Time (24 hr basis)
Length of Roots (after trimming) Lateral (1, 2, 3, etc) Length
Tap Root Length
Photos of Roots (with legible measuring stick)
Root Treatments Agri-Mycin Fungicide Sulfur
Root Air-Dry Time Start: Finish: Total Hours:

Temporary Nursery Storage Yes/No If Yes: Date/Time IN Date/Time OUT

Re-Plant Date Time
New Geo-Coordinates (and datum)
Confirm Planting Depth (based on original depth)
Confirm Orientation (based on original orientation)
Any Additional Root Treatments (trimming to remove damage)
Agri-Mycin Fungicide Sulfur
DBH Measurement Pleat Angle Measurement
Photos (from 4 cardinal directions)

Support System Use Yes/ No Date Photo

Supplemental Water Dates (may be multiple) Time Amount of Water
Re-Measure DBH / Pleat Date (10 days after watering) Time Diameter

Misc Observations Date (can be any time cactus is visited) Notes

Annual Monitoring Date Condition

Appendix 12.3b – Proposed Saguaro Condition Rankings

Score	Condition	Description
0	Dead	Dry, brown, no green tissue
1	Imminent Mortality	Dry, brown base, no green tissue connecting base and upper green, partly green or yellow tissue.
2	Poor	Yellowish color, evident damage or rot on skin, appearance of wrinkling or wilting. Retains tissue connection to base. Thin. Leaning. Top of main stem shrunken or leaning.
3	Fair	Generally green, holes or marks with some indication of rot. Skin generally uneven in texture. Lacking girth.
4	Good	Green throughout, some holes or marks, but no evidence of rot. Skin generally even and smooth, appearance generally plump.
5	Excellent	Vibrant green, few holes or marks, no evidence of rot or damage. Plump. Evidence of new growth.

Appendix 12.4 – Partial Equipment List and Web-links

- Saguaro cradles and hydraulics (attached to truck; attached to backhoe). Review various designs and select best features. Determine number of units required based on moving plan and other logistics.
- Padding material (old carpet, foam, etc) and cordage.
- Hand Tools (extraction and planting): shovels, picks, digging bars, pneumatic diggers, tamping rod.
- Hand Tools (trimming): knives, pruners, pruning saws (various).
- Plumb bob and cord; ladders; calipers and diameter measuring tapes: large sliding caliper (e.g., a Haglof Mantax or similar device); white correction fluid; large zip ties for affixing tags.
- Shade cloth (30%).
- Hand truck, wheelbarrow (both with never flat tires), slings (all for moving smaller cacti).
- Wire Support Rigging: wire (1/8th inch galvanized wire rope, 2000 lb breaking strength), fiber reinforced hose, 24" #4 rebar stakes, sledge hammer, flagging to mark guy wires, ladders.
  Other options:
  http://www.treestaking.com/?gclid=EAIaIQobChMIrNOXiLnr1gIVBIxpCh1syQxbEAMYASAAEgJprfD_BwE
  https://www.amleo.com/better-bilt-earth-anchor/p/VP-BBEA/
- Ag Chemicals: Agri-Mycin® 17, fungicide (Bordeaux Mix), powdered sulfur, applicators, protective gear. Bleach and container for sterilizing cutting tools.
- Pea gravel for backfilling.
- Water tank trucks; hoses and/or sprayers; hose-end flow meters; water moisture meters; rain gauges.
- Towable cherry-picker lift (attach padding, determining plumb, attach support wires)
  http://www.towbehindboomlifts.com/
  [for illustrative purposes; not a brand or company recommendation]

Appendix 12.5 – Agri-Mycin® 17

Agri-Mycin® 17

FUNGICIDE

Protect Ornamentals with Agri-Mycin® 17.

For years, Agri-Mycin® 17 has been the industry standard bactericide. It provides effective, economical control for three to four days. Its specific mode of action is unique to streptomycin and is an essential part of any bacterial disease control program.

SETTING THE STANDARD IN DISEASE CONTROL

- PROTECTION – Superior protection against certain diseases including leaf rot, bacterial stem rot, bacterial wilt and crown gall roses
- COMPATIBLE – Compatible with most commonly used pesticides
- GENTLE – Easy on target crop

EPA REG. NO.	55146-96
ACTIVE INGR.	streptomycin sulfate *(22.4%)*
FORMULATION	water soluble powder
CHEM. FAMILY	glucopyranosyl antibiotic
FRAC NO.	25
REI	12 hours
PACKAGE SIZE	10 x 2 lb bag
APPLICATION	spray, dip

FIELD-GROWN NURSERY
CONTAINER-GROWN NURSERY
GREENHOUSE
OMRI LISTED
CAUTION

Nufarm

Agri-Mycin® 17

FUNGICIDE

KEY USES

Chrysanthemums
Dieffenbachia cuttings
Philodendron
Roses

KEY DISEASES CONTROLLED

(See product label for complete list)
Leaf rot *(philodendron)*
Bacterial stem rot *(dieffenbachia cuttings)*
Bacterial wilt *(chrysanthemums)*
Crown gall roses *(New Jersey area)*

APPLICATION RECOMMENDATIONS

DISEASE AND CROP	RECOMMENDED CONCENTRATION	FIRST SPRAY	FOLLOW-UP SPRAY SCHEDULE
Bacterial leaf rot *(philodendron)*	200 ppm	Apply as a preventive or at first signs of water-soaked areas on leaf.	Apply every 4–5 days.
	For curative action	Remove all rotted leaves from plant and then spray at 200 ppm every 4 days.	
Bacterial stem rot *(dieffenbachia cuttings)*	200 ppm	Soak cuttings in streptomycin solution for 20 minutes; plant cuttings in sterilized rooting medium.	
	100 ppm	To check spread of stem rot in stock plants, use 100 ppm streptomycin spray every 5–7 days.	
Bacterial wilt *(chrysanthemums)*	50 ppm	Soak plant cuttings in streptomycin solution for 4 hours; plant as usual.	
Crown gall roses *(New Jersey area)*	200 ppm	Remove infected plant. Cut out gall tissue. Soak the plant root system and cut surfaces of the infected area in streptomycin solution for 15 minutes. Replant rose bushes in soil free of crown gall organisms.	
	50 ppm	Use 50 ppm streptomycin in watering solution and in foliar sprays applied weekly starting one week after planting as an adjunct to this treatment.	

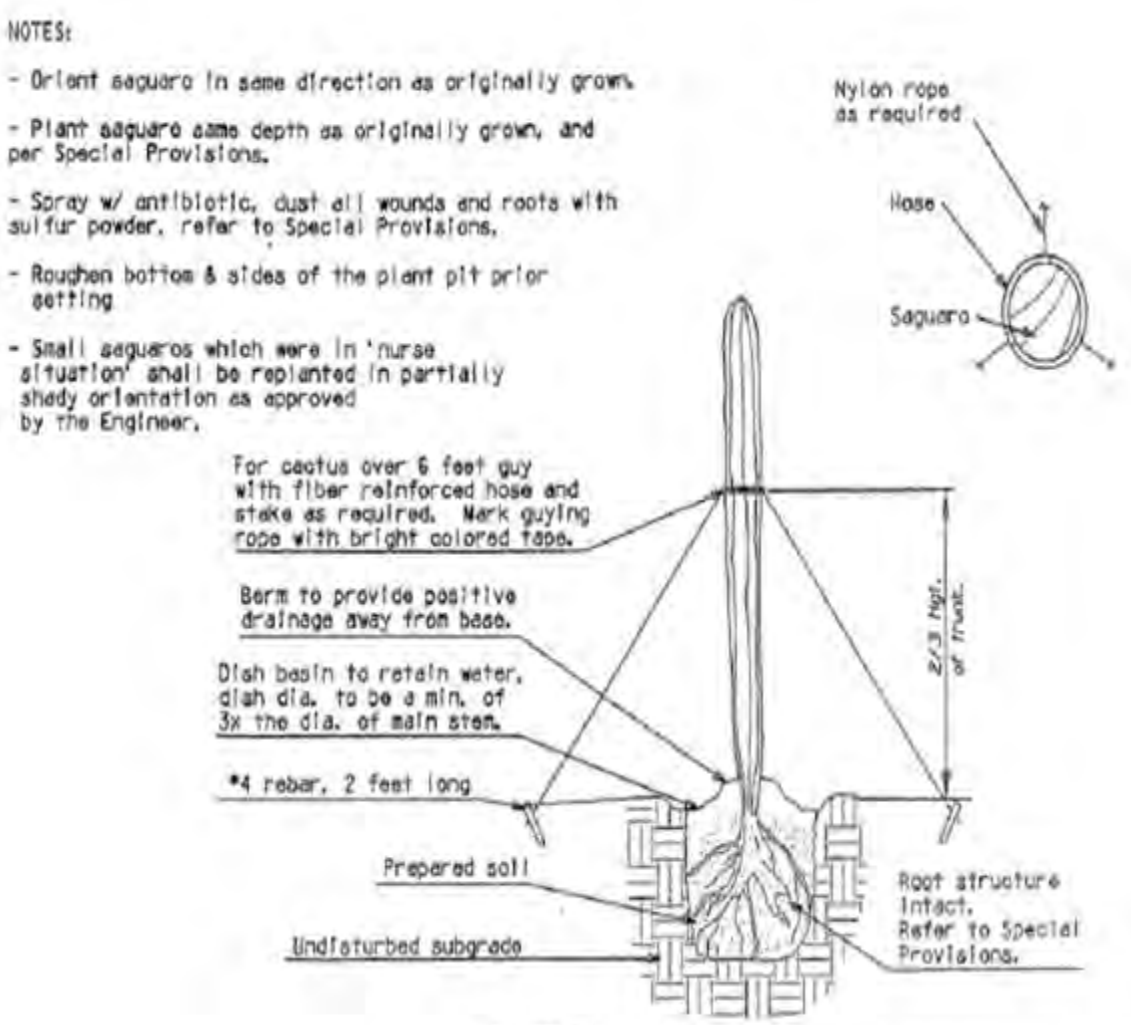
See label for complete application rates and recommendations.

MIXING INSTRUCTIONS

CONCENTRATION DESIRED	QUANTITY PER VOLUME OF WATER		
Parts per million	10 gals	50 gals	100 gals
50	0.4 oz	2.0 oz	4.0 oz
60	0.48 oz	2.4 oz	4.8 oz
100	0.8 oz	4.0 oz	8.0 oz
200	1.6 oz	8.0 oz	16.0 oz

See label for complete mixing instructions.

Appendix 12.6 – Planting Design from ADOT



(ADOT 2002: 39-40)

Mielke, Judy, Tisha Curella, Jenni James and Wayne Colebank. 2012. Evaluation of Salvage and Replanted Native Plants on ADOT Projects. Final Report No. FHWA-AZ-12-587 for ADOT Contract No. T0749A0029. Logan Simpson Design, Inc. Tempe, AZ. 115 p. https://apps.azdot.gov/adotlibrary/publications/project_reports/PDF/AZ587.pdf.

Appendix 12.7 – Article Discounting Vitamin B-1 for Root Stimulation

DYNA-GRO
ADVANCED SCIENCE SIMPLIFIED

HOME ABOUT PRODUCTS DG UNIVERSITY NEWS FIND A STORE CONTACT

< Previous

Vitamin B-1 Myth

Plants manufacture vitamins and hormones used to regulate their growth. In many instances, supplying these hormones, auxins and vitamins to plants can stimulate the growth of roots and foliage, regulate growth, internodal spacing and promote flowering. While many of these occur naturally in plants, man-made versions which have the effect of naturally occurring plant hormones can the same effect as those naturally occurring hormones, auxins & vitamins.

You can find vitamin B-1 on the shelves in many garden centers. Typical claims are that applying vitamin B-1 to new plantings helps to overcome transplant shock. Is there any truth to this claim or is this merely another horticultural myth?

Studies at the University of California, Davis conclude that there is no basis to support the claim that vitamin B-1 benefits plants by stimulating root growth or reducing transplant shock as many advertisements claim.

Jeff Schalau, an extension agent with the Arizona Cooperative Extension, Yavapai County wrote: "Application of vitamin B-1 (thiamine) to root systems of whole plants does not stimulate root growth. This myth arose from early work on plant growth regulators, called auxins, which were mixed with vitamin B-1. . . Various studies using both woody plants and annual flowers and crops failed to demonstrate that vitamin B-1 treatments provide any subsequent growth response."

Robert Cox, Horticulture Agent, Colorado State University Cooperative Extension wrote: "Several studies using (a variety of herbaceous and woody plants) have failed to demonstrate

http://dyna-gro.com/vitamin-b-1-myth/ 10/2/2017

that vitamin B-1 treatments provide any type of growth response. While root stimulator products are not necessary for transplant success, if you do use one, make sure it contains a rooting hormone and fertilizer rather than just vitamin B-1. The vitamin B-1 is for marketing purposes rather than actual effect."

An independent study to test the claim that vitamin B-1 applied to plants result in better foliage or root growth was conducted by the editors of *Sunset Magazine*, the results of which were published in the magazine. Starting with fast growing bedding plants, six different treatments were used:

1. B-1 alone
2. B-1 with phosphorous
3. B-1 with 3-10-3 fertlizer
4. B-1 with 10-10-10 fertilizer
5. 10-10-10 fertilizer alone
6. Plain water

The results at two weeks showed new leaves and growth on all plants except those given vitamin B-1 alone. The B-1 only plants showed no growth at all. The plants in treatment 5 (fertilizer alone) were blooming after four weeks. Those receiving B-1 with fertilizer (treatments 2, 3 & 4) took two more weeks to bloom. After six weeks, fertilized plants had better color, more blooms and more foliage. The shocking conclusion: **Plants that received only water out performed those receiving solutions treated with B-1!** Lesson: stick with water and nutrients. Skip vitamin B-1.

As a result of in-house testing of vitamin B-1, Almaden Valley Nursery, a retail garden center, pulled vitamin B-1 products from their retail shelves, refusing to subject their customers to another snake oil product. These studies should convince you that proper nutrition applications are the best bet for healthy plants.

What can you do to promote root growth?

For propagation of vegetative cuttings or promoting root growth when transplanting, there are effective options. Both IBA (Indole-3-butyric acid) and NAA (1-Naphthalene acetic acid) are auxins that stimulate root growth. Some B-1 products contain one or both of these auxins which will be beneficial when transplanting. One "Super ..." product consists of NAA and B-1 despite claims of more vitamins and hormones than exist in nature.

NAA is particularly effective in inducing root growth on cuttings because its primary effect is to enhance lateral root growth rather than primary root growth. However, NAA, like IBA suppresses top growth of plants and, therefore, should not be used on a continuing basis. One or two applications after transplanting rooted cuttings or other plants into new containers or the ground will suffice to promote lateral root growth. The plant can take over from there with its naturally generated hormones and auxins. For optimum results, insure that your plants are receiving complete nutrition*, adequate water and proper levels of light.

Dyna-Gro™ KLN Concentrate™ and Root-Gel® contain both IBA and NAA and are very effective for vegetative propagation and stimulating root growth at any time. KLN Concentrate™ is most effective on herbaceous cuttings in general while Root-Gel® is often more effective for more difficult to root, woody cuttings. In addition, Dyna-Gro™ Pro-TeKt®: The Silicon Solution® has produced 100% success rate in rooting vegetative cuttings without the application of any auxins or hormones. Combined with KLN Concentrate™, the two are even more effective used as a drench into the rooting medium before or after sticking the cuttings.

Appendix 12.8 Summary Version of BMPs

The following summary version of the Best Management Practices is designed to be printed and handed out to staff as needed for improved project implementation. The BMPs are divided into four sections:

- **Planning and Other Activities prior to Saguaro Removal**
- **Removal, Transport and Temporary Storage**
- **Re-Planting the Saguaro**
- **Post-Planting Care**

Planning and Other Activities Prior to Saguaro Removal

Identification of Individual Cacti. Every cactus to be moved needs to be identified and tagged. Minimum identification data includes a unique ID number, geo-coordinates, height, number of arms, whether or not in nurse tree setting, overall condition, and DBH (diameter at breast height). The DBH is measured at 4 feet, 3 inches from the ground level, or 15 inches from the top, whichever is closest to the ground, using a large sliding caliper. Photos should be taken. Tagging should include the AZ Dept. of Ag NPL and unique ID tag, affixed on the north side of the cactus, using zip-lock ties at a distance of 1 foot above natural ground level.

Planning. Meticulous planning of the salvage and transplant operation is critical. Beyond the numbers of cacti to be moved, there are major logistical variables that impact time, costs and final results. These include the timeline for the project itself; Dept. of Ag. Permits and tags; seasons to transplant the cacti (or will temporary storage be required); special time and handling considerations (i.e., once-move technique) for legacy cacti (those over 15 feet and/or with multiple arms); acquisition or scheduling of equipment, and treatment chemicals; labor requirements (number of specialized hydraulic saguaro cradles needed); time for air-drying roots; pre-removal and post-transplant irrigation needs, watering methods and equipment; long-term monitoring plan; implementation of research studies if planned, etc. Planning also includes identification/assignment of replanting sites for each cactus (including elevation concerns if planting saguaros above 2800 feet).

Seasonal Considerations. The saguaro cactus can be successfully transplanted throughout the year. The ideal season to transplant saguaros is the spring. The warmer weather promotes root growth and faster re-establishment. Transplanting can be done during the hotter summer months, but is less ideal because of the added stress on the cactus from the extreme heat. Summer times with heavy monsoon rains should be avoided due to excessive soil moisture that can promote root rot. Planting can continue into the fall and winter, with the understanding that new root growth might be delayed during these cooler months. Cacti transplanted during the cooler months should have up to a month in dry soil prior to any supplemental watering (if applied). Advantages of winter planting include decreased chance of sunburn, and less heat stress on both cacti and human workers. It is recommended that if larger, legacy cacti are being transplanted, they should be prioritized for the spring months if possible.

Re-Hydration of Cacti prior to Extraction. Unless the cactus is judged to be in superb condition, it should be watered prior to extraction. A healthy saguaro will appear full with its ribs apart. There should also be signs of growth such as new arms starting, new spines, or growth at the apex (tips) of the plant. The cactus will lose 80% of its roots, and 30-50% of its total biomass during the transplant process. The cactus should be watered, preferably two times, several weeks prior to extraction. Given that the native growing saguaro prior to excavation still has its extensive, shallow root system intact, a jet hose can be used to apply water over these widespread roots to a depth of 4-6 inches. The very minimum recommended is a slow watering to a depth of 12 inches, two weeks before removal. A soil moisture probe can be used to verify the water penetration depth. Ten days after watering, the DBH should be measured and compared to the original measurement recorded when the cactus was inventoried. An increase in the DBH indicates that water uptake has occurred.

Removal, Transport and Temporary Storage

Handling Saguaros. Saguaros less than six feet tall can be moved relatively easily using a hand-cart (dolly) with pneumatic (preferably never flat tires), wheelbarrow or slings if adequate workers are available. Depending on the height and girth, these 5-6 foot cacti can weigh 300-600 pounds. Sufficient padding should be used so that no damage to the spines and trunk occur, and the cactus should be well secured to the dolly. Adequate padding should be used to cushion the side and spines lying on the bed of the truck or trailer, and these spears should be tied down so they do not bounce. Cacti can be stacked 2-3 high, depending on size, if sufficient padding is used. They should also be covered with shade cloth to prevent sunburn.

Saguaros taller than 6 feet are best handled with a special cradle for support and usually a hydraulic system for lifting and tilting. Prior to moving, while the cactus is still upright, pad trunk and arms generously; then secure the wrapped carpet with cordage. Arms more than three feet in length should also be supported and the cactus should be firmly attached to the cradle device for safety.

Excavation of the Cactus. Prior to excavation, verify that the north direction tag is attached with a zip-lock band placed 1 foot above ground level. Record the DBH. For cacti taller than 6 feet, start digging the trench around the cactus at the two foot radius from the outside of the stem. If lateral roots can be easily exposed, longer lengths can be retained. Undercut the cactus to sever the tap root at no less than 18 inches; if removing from a sandy soil, even more of the tap root can sometimes be extracted. For cacti less than two feet tall, the goal is to remove the entire root mass, and to remove as much as possible for cacti that range from 2 – 6 feet tall. Considerable care is important because saguaro roots can be very brittle.

Root Trimming and Treatments after cactus has been removed from the hole. After a careful excavation, trimming and treatment of the roots may be the next most important action towards achieving a successful transplant. Not only does the saguaro lose the majority of its root system from the excavation process, it also has the proclivity to suffer from root rot. Any damaged parts of roots should be carefully trimmed away. All tools such as knives, pruners and saws should be sharp and sterile. Use a 10% household bleach solution to clean tools between individual cacti. Retain 12-18 inches of solid, healthy lateral roots, and longer if possible. All of the tap root that was removed without damage should also be retained. The trimmed roots should be well dusted with a fungicide and Agri-Mycin® 17. Sulfur powder can be used as a last resort, but may not be very effective against white fungi. A photo of the roots should be taken following excavation. The photo should include a legible measuring stick.

Air Drying Roots. Ideally, the freshly trimmed roots should have 1-2 weeks to air-dry in the shade. This process allows the recently traumatized roots time to form a protective callus, which helps prevent the entry of pathogens and subsequent root rot. For small projects moving only a few saguaros, this BMP can be readily accommodated. However, when dozens or hundreds are being moved, with a limited number of hydraulic cradles, this length of time is unlikely to be available. A single large saguaro cannot be allowed to sit on the cradle for a week or more. Additionally, the large "legacy saguaros" are best transplanted using a "once-move" method. This also precludes the recommended drying time. Smaller saguaros, especially spears, can be stacked on a flatbed trailer and left for the recommended air-drying period (under shade). Some techniques that may help mitigate insufficient air-dry time are: (1) use of fungicide and/or sulfur powder; (2) utilizing weekend time for extra drying days as much as possible; (3) recognize that the moving wind around the open air roots during transport should facilitate drying; and (4) consider the use of blowers to hasten drying time. Because all translocated saguaros are unlikely to

receive the BMP recommended air-dry time, it becomes very important to keep accurate records of how long (probably in hours) each individual cactus is allowed to have its roots exposed to the air (and/or drying fans if used). When large numbers of cacti are transplanted, this information will help to analyze the impact of varying air-drying times on the survival of the cacti.

Cover cacti during transport. All parts of the cactus, including the roots, should be covered with carpet, other protective covering, or 30% shade cloth during transport. The coverage must be well secured for any required highway travels so that it does not blow open and expose the cactus to possible sunburn.

Temporary Storage. Storing saguaro cacti should only be done when absolutely necessary. Immediate transfer of plants to their permanent location reduces the amount of mechanical handling and probability of damage to the plant, and ensures the best survival rate. This "once-move" approach is especially important when transplanting the larger and/or multi-arm cacti. The need for temporary storage, locations, and durations are key factors that should be addressed during the planning stage of a transplanting project. Storage areas should be open to allow good air circulation. The cacti should be both properly oriented using the tag placed on the north side, and covered with shade cloth (30%) to prevent sunburn. The cacti must remain in an upright position. Pea-gravel is the recommended backfill. If this backfill is well packed, cacti up to 12 feet tall (with or without arms) and spears (cacti without arms) up to 15 feet should not require additional support. Cacti taller than 12 feet with arms and any cacti taller than 15 feet should be supported with guy wires and stakes. Saguaros have been kept in nursery storage for two years.

Re-Planting the Saguaro

Select an advantageous aspect when planting at elevations above 2800 feet. In these settings, the saguaro should be planted on south- and west-facing slopes; north-facing slopes should be avoided. If planting on a north-facing slope is unavoidable, the plants should be placed near the top of the slope rather than near the base.

Hole Preparation: width and depth. Excavate the new hole to a width twice as wide as the extant root ball. If longer lengths of some lateral roots were successfully excavated without excessive damage, those longer than 18-24 inches can be buried in a trench dug especially to accommodate them (i.e., like laying pipe), rather than expanding the diameter of the entire hole. The saguaro should be replanted no deeper (or within 1-2 inches) than its original level in the ground. The zip-lock tie placed 1 foot above the original ground level, along with the vertical length of the extant root mass, including the tap root, can be used to measure precisely how deep the hole should be (after subtracting the extra foot). The soil at the bottom of the hole should be able to promote good drainage (a sandy type soil). If it's too hard and compact (a clay type soil) it can be broken up and/or some sand or gravel added, but should then be re-tamped to the proper depth as calculated.

Proper Re-orientation and final steps before backfilling the hole. Using the tag attached on the north side of the cactus, orient the cactus to face north once again. Prior to lowering the cactus into the hole, trim off any damaged roots, and again dust/spray the root mass with additional fungicide and anti-bactericide. Use of a root stimulating hormone (indole acetic or buteric acid) has been suggested. Either visually, or using a plumb line, assure the cactus is vertically straight and balanced. Note the cactus is still attached to the cradle for support and safety. If the cactus is simply lowered into the hole, its massive weight is likely to crush the tap root which could very well result in rot. If the cactus is lowered into the hole and supported by the cradle as the hole is backfilled, damage to the tap root can be avoided.

Backfill. Pea gravel is recommended for the backfill material. If properly tamped and packed, it provides the necessary support for the cactus. It also drains well and precludes excessively wet conditions around the recently traumatized roots that may or may not have received sufficient air-dry time.

Tamping backfill around the cactus and its trimmed roots. The backfill must be firmly compacted around the plant. This is best accomplished by adding a few inches of pea gravel, tamping it down well, and repeating this process until the hole is filled. As this is done, the cactus should still be supported to avoid crushing the tap root. Caution should be used when tamping to avoid striking or otherwise damaging the carefully trimmed, treated and callused roots. Fresh wounds could easily defeat all the previous efforts to avoid rot root. Any accidental damage should not be ignored; rather, that area should be dug out, trimmed again, and treated with fungicide, bactericide and/or extra sulfur. Another suggestion, instead of tamping (which as just noted could strike and damage a root) is to use a heavy bar inserted into the fill to agitate the fill material with circular and/or back and forth motions.

Build a stem cone and water retention basin around the base of the stem. The stem cone or tapered mound will divert water away from the stem and prevent accumulation of excess water and possibly pathogen spores from contact with the stem. The water retention basin should be 3 times the diameter of the stem, with a 4-6 inch berm to retain the water. This basin will capture some rainfall, but is primarily intended to assure the most efficient usage of supplemental water. A similar technique is to dig a donut-shaped canal around the saguaro starting about 18 inches from the stem. This design will also facilitate the efficient use of supplemental water, and will be able to capture some additional runoff water from

rainfall events. Note that using pea-gravel as backfill (instead of using the native soil excavated from the hole) will also promote the infiltration of water into the area excavated.

Additional Temporary Support – Staking the Taller Transplanted Saguaros. Any saguaro over 15 feet tall and 12-15 foot saguaros with arms should have additional support. The preferred support system consists of three guy wires strung through sections of fiber-reinforced hose. 1/8th inch galvanized wire rope (2000 lb breaking strength) is recommended. Sections of hose are placed around the plant two thirds up from the base. Triangulate the three guy wires from the hose sections surrounding the plant column and stake them into the ground using 24 inch #4 rebar. Guy wires should be flagged at 5-6 feet above ground level as a safety measure. The support system should be left in place for at least two growing seasons. Once staking is complete, the cactus can be detached from the cradle. The use of 2x4 supports, covered with carpet at the point of contact with the stem are not recommended.

Re-measure DBH. This measure will indicate if the cactus has loss mass during the move (and/or storage) and serve as the baseline measure to monitor new water uptake and transplant success. New photos should be taken.

Use Shade Cloth. Cover each newly transplanted saguaro with 30% shade cloth, secured around the stem and arms with cord and completely covering the southern and western exposures. Leave the cloth on through the first summer season. Care should be taken that folds and overlaps in the cloth do not effectively double or triple the protection.

Post-Planting Care

Watering newly transplanted saguaros. Plant the cactus into dry ground, backfill with pea gravel, and do not water immediately to "settle" the backfill. Recommended watering regimes will vary by season and transplantation date. Initiate post-transplant saguaro watering according to the following guidelines:

- The newly replanted saguaro has loss perhaps 80% of its roots. Saguaro roots are known to be very susceptible to root rot (facilitated by damaged roots and excessive moisture). The initial post-transplant watering regime should emphasize avoiding prolonged excessively moist conditions by providing intermittent watering in well drained (pea gravel) conditions.
- Saguaros transplanted in the spring, summer, or early fall months should remain in the dry backfill soil for 2-4 weeks before initial watering begins. Two weeks are sufficient for those whose roots were allowed the recommended two weeks air drying time; the additional weeks in dry soil are given (proportionately) to those cacti that received less or effectively no air drying time.
- If saguaros are transplanted in the later fall or early winter, they should have a full month of dry soil time to reduce any onset of root rot, but can receive an initial watering after this dry period if there has been no rainfall. Root development and activity is generally inhibited by the cooler weather, and the cool, moist conditions may facilitate root rot. However, it is also not advisable that a newly transplanted saguaro should stand without any water for many months. The recommended schedule is to provide some water for those cacti which are disposed to use it, but also long enough periods between watering to deter the continued development of any root rot that might start.
- Watering should definitely be regular once air temperatures have regained about 90°F, when roots are actively growing.

Water Schedule

Saguaros should be watered once every three weeks; especially during the first summer (soil dries in 7 to 14 days). When temperatures exceed 110°F, watering may be increased to every two weeks.

Water schedules during non-summer months are more variable. It must be recognized that some winters are much warmer or cooler than the normative years, and that saguaros are well adapted to the winter rains in Arizona. The BMP is to try to simulate the average rainfall for the locale, based on available climate records and monitored by a rain gauge network established throughout the project area. If winter rains (as measured by the rain gauge network) are near the historic record norms, then supplemental watering is not needed. If the winter months have little to no rain, and/or the temperatures are unseasonably warm, then supplemental water can be applied, but no more frequently than once per month. Saguaros may or may not be able to take advantage of this extra moisture since their roots are known to be inactive until night time air temperatures are above 60°F. However, if day time air temperatures still reach into the 70s or 80s, the desert soils tend to absorb this heat which might also stimulate root activity near the surface. A monthly watering, even if not utilized by the saguaro, is very unlikely to cause the development of root rot which is promoted by more chronic soil moisture.

There are other factors that can modify watering frequency. Spring, summer and/or winter rains, depending on the quantity, can substitute for one or more of the watering intervals. A distribution of rain gauges throughout the replant areas can be used to determine where, and how much, rain has fallen. This data can be used to adjust the watering plan. Soil texture is another consideration. Sandy soils have poor water retention properties where clay soils hold water well. This becomes an important factor as the roots grow from the well-drained pea gravel backfill into the surrounding native soil.

Water Application Methods

There are a variety of methods to apply water to accommodate different conditions within the project area. These methods are:

Low-pressure Jet-spray Tank Truck

This is a hose that extends from a tank truck that can quickly saturate soils to a depth of 4-5 inches. The hose system would allow one or more workers to walk from saguaro to saguaro; the jet spray would allow the required water to be applied to each unit quickly.

Octopus Hose Systems

Octopus hose systems are designed to operate from a manifold attached to a tank truck. Five to ten hoses can be run to as many saguaros which are watered simultaneously for a specified time once the manifold is opened. This system would best be used in conjunction with small basins prepared at each saguaro.

ATV Tank

In settings where the truck/hose system does not have good access to some of the saguaros, a similar mini-system can be mounted on at ATV equipped with a water tank. This more mobile delivery system would require frequent refilling from a larger tank truck.

(Note: Drip systems are ***not*** recommended. Drip systems are generally used to maintain soil moisture over an extended or even continuous period of time. Such an approach does not mimic natural precipitation events in the Arizona desert. This prolonged moisture regime might facilitate root rot.)

Water Quantity

A general rule is one gallon of water per linear foot of cactus, including the arms, for each watering.

Duration

Provide supplemental watering for at least 4 years from the transplant date.

Use the DBH to Monitor Cactus. DBH measurements have been recorded both prior to extraction and immediately post-transplanting, and 10 days after each supplemental watering, or rainfall event that exceeds one quarter inch. A large sliding caliper (e.g., a Haglof Mantax) is recommended. The precise measuring points can be marked with white correction fluid (and renewed when these marks shown signs of fading).

If the roots are functioning, the diameter of the saguaro will increase. Although most successful transplants should show increasing girth by the end of their first growing season, saguaros that are planted at less optimal times of the year (e.g., winter), or just certain individuals, might have a tendency to lag behind with root development and overall reestablishment. Saguaros that show no increased girth after the second full growing season can be flagged as likely failures, but should still receive supplemental care and monitoring as long as other cohorts are, or until there are obvious signs of rot or death. If the circumference of the saguaro increases, this can only result from growth which does require the uptake of water and nutrients, which in turn means that the roots are functioning. Thus a definitive increase in circumference will define that the transplant has been successful. Other indicators of growth include new arms or spines, or growth at the apices (ends) that can be pushing against the shade cloth.

Other Post-Planting Management Practices

Do not cultivate and otherwise disturb area around the trunk (up to seven feet diameter) to avoid damaging shallow roots. Do not mulch with any material that reflects or intensifies light. Do not cover soil with plastic sheets. Fertilization is generally not necessary.