

Survey to Estimate the Volume of
Madrona Pool 1D at Saguaro National Park
by
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WRB-WRD

Saguaro Nat'l Park
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On February 5, 2004 Park staff from Saguaro National Park and the Water Resources Division – Water Rights Branch (WRB) performed a survey to estimate pool volume in Madrona Pool 1D at the request of Don Swann, Wildlife Biologist, Saguaro NP.

Survey References

Madrona pool 1D is located in a series of pools near the Madrona Ranger Station (Fig 1). A permanent aluminum monument, STN 1 was set in the bedrock near the pool and coordinates were established by park staff using GPS¹. A total station was set up directly over STN 1 while performing the survey. Two other reference marks were surveyed, RM 1 and RM 2, (Fig 2), which were previously set in the bedrock upstream and downstream of STN 1. The back sight was located on a rusted bolt on a concrete slab south of STN 1. All values were recorded in feet.

Survey Methods

Sixteen cross sections were measured with a steel tape approximately every two feet starting at the outlet of the pool and moving upstream. A steel survey tape was stretched across each cross section held in place tightly by park personnel. Survey intervals for verticals along the steel tape were taken as follows;

- 1) Every 4 feet when no water was present,
- 2) Every 2 feet when surveying the pool's water depth, and
- 3) At every point where the water's edge came in contact with the bedrock.

A fisherman's float tube, extendable survey rod and hand level were used by the rod man to survey deeper sections of the pool (Fig 3 and 4). Rope was attached with carabineers to opposing sides of the tube and held in place by personnel holding the survey tape. The day was breezy and it was necessary to attach a rope to the front of the tube in order to steady the rod man and keep the tube in line with the tape.

Data Reduction

The survey data was imported from the data collector into Carlson Survey Software² to apply corrections to rod heights and point descriptors (Left Bank (LB) or Right Bank (RB)). The data was then imported into Microsoft Excel³. Each cross section was graphed using the easting for distance versus elevation. Descriptors for all survey points were verified and corrected.

The easting, northing and elevation's (XYZ) from the survey were saved as a comma delimited file in Excel and imported into Surfer 7.05⁴. A "grid file" which utilizes the Kriging method⁵ was created from the previously imported data (XYZ). A contour map was constructed using the "contour map" option (Fig 5). A "wireframe" map was created using the grid file (Fig 6). This created a three dimensional display of data using color zones, independent X,Y,Z scaling, and orthographic or perspective projections at any tilt or rotation angle.

¹ GPS coordinates are invalid spatially but accurate vertically. The park gave WRB coordinates as easting - northing rather than northing - easting. Elevations were provided in feet. WRB entered coordinates into the total station data collector as provided and assumed the coordinates were in northing - easting format. This established an arbitrary datum in feet for northing - easting - elevation.

² Carlson Survey 2004, Carlson Software Inc., October 7, 2003.

³ Microsoft® Excel 2002 (10.6713.6735) SP3, Copyright© Microsoft Corporation 1985-2001.

⁴ Surfer Version 7.05 – Oct 24, 2001. Surface Mapping System. Copyright© 1993-2001, Golden Software, Inc.

⁵ Kriging is a geostatistical gridding method that has proven useful and popular in many fields. This method produces visually appealing maps from irregularly spaced data. Kriging attempts to express trends suggested in your data, so that, for example, high points might be connected along a ridge rather than isolated by bull's-eye type contours.

Pool volumes may be computed from either map. Volume calculations on each grid cell were performed for water surface elevations defined by upper and lower limits. In areas where the surface was tilted at the top or bottom of a grid cell, Surfer approximates the volume of the prism at the top or bottom of the grid cell column. Inputs for the upper and lower surface were defined as follows. The upper surface was set as a constant and elevations of water surface were input. The grid file was used to define the lower elevation. Volumes were approximated by the Trapezoidal, Simpson's or Simpson's 3/8 Rule. A separate volume report was generated for each water surface elevation.

The water surface elevations for the sixteen cross sections were averaged in Excel. This resulted in a water surface elevation of 3420.9 feet. The maximum and minimum water surface elevations surveyed were 3421 and 3420.7 feet, respectively. A visual outline of the water surface is displayed in figures 5 and 6. At the time of the survey water was spilling over the bedrock control (fig 3 and 4). The outline actually displays the water surface traversing along the edge of the bedrock accounting for more water than just at the spill way. After plotting various water surface elevations, an elevation of 3420.8 feet was selected to display the water spilling over the bedrock control.

Results

Pool volumes (cubic feet) were computed for elevations up to 3421.2 feet. This is the elevation of the reference mark the park staff established for future measurements. The minimum depth surveyed in the pool was 3410.2 feet. Surfer interpolated that the pool volume would be zero at an elevation of 3409.7 feet. This may or may not be the absolute pool depth due to interpolation. The point of zero flow, lowest point at the spill way was 3420 feet. Madrona pool 1D was approximately 10.7 feet deep at the time of the survey. Table 1 shows pool volume for a given elevation for each tenth of a foot.

Table 1 MADRONA POOL 1D ELEVATION (FEET) VERSUS VOLUME (CUBIC FEET) SAGUARO NATIONAL PARK										
ELEVATION FEET	CUBIC FEET									
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
3409								0.07	0.3	0.69
3410	1.23	1.92	2.79	3.83	5.05	6.42	7.94	9.61	11.4	13.4
3411	15.5	17.8	20.2	22.8	25.6	28.6	31.9	35.9	40.4	45.4
3412	50.8	56.6	62.8	69.3	76.1	83.2	90.6	98.2	106.1	114.3
3413	122.7	131.3	140.2	149.4	158.7	168.3	178.1	188.1	198.4	208.8
3414	219.5	230.4	241.5	252.9	264.4	276.2	288.3	300.7	313.4	326.4
3415	339.7	353.4	367.5	382	396.8	412.1	427.8	443.9	460.4	477.3
3416	494.5	511.9	529.8	548	566.5	585.4	604.6	624.2	644.1	664.4
3417	685.1	706.2	727.7	749.6	771.9	794.7	817.9	841.6	865.7	890.3
3418	915.3	940.8	966.7	993.2	1020	1048	1076	1105	1135	1166
3419	1198	1231	1265	1301	1338	1376	1416	1457	1500	1544
3420	1590	1639	1690	1743	1798	1857	1921	1992	2075	2170*
3421	2276	2390	2510							

*Water Surface Elevation on February 5, 2005. Determined from STN 1.

Diagrams for each cross section and associated survey results are located on the attached disk.

Recommendations

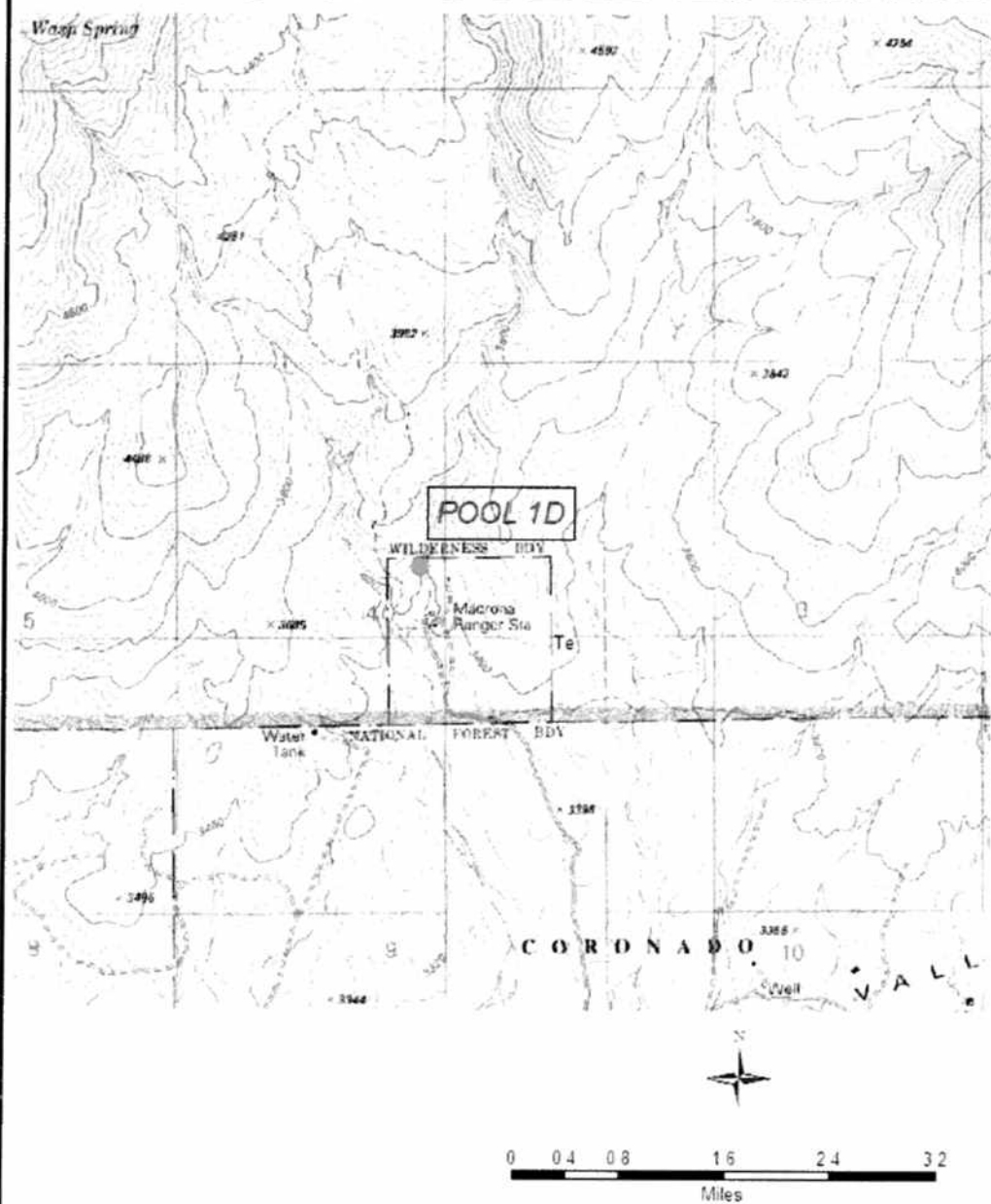
Install a reference bolt to extend over the pool so one person can accurately and easily measure the water surface of the pool.

Acknowledgments

This project could not have happened without the dedicated personnel who assisted in the collection of data: Matt Daniels, Carmia Fiechtner, Colleen Filippone, Vicki Gempko, John Newton, and Don Swann.



MADRONA POOL 1D LOCATION



Produced by C GABLE WRD NPS

MAY 2005

Figure 1. Location of Madrona Pool 1D, Saguaro National Park.
USGS 7.5 Minute MICA MOUNTAIN Topographical Map, 1981.

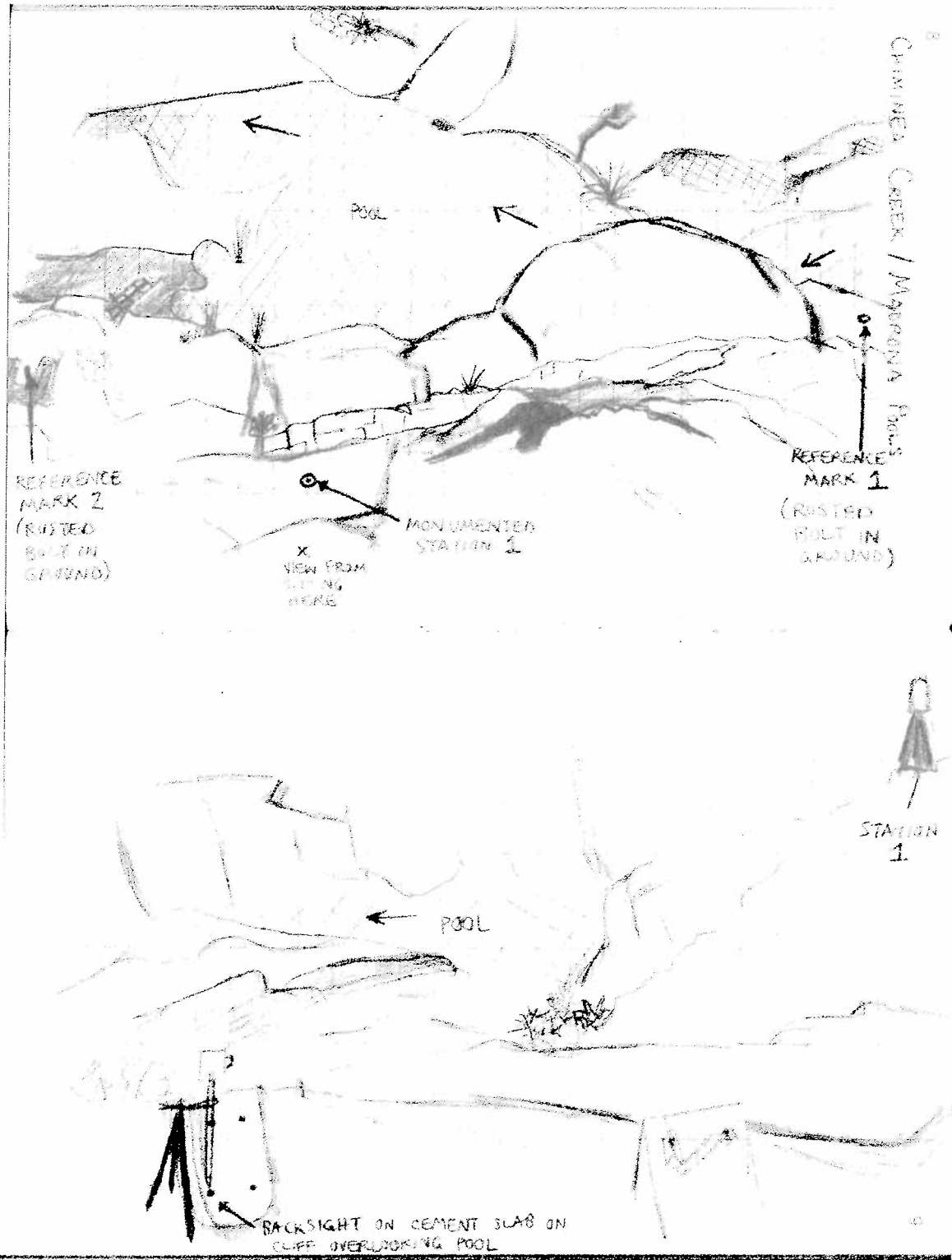


Figure 2. Field note sketch of Madrona Pool 1D survey, Saguaro National Park
C. Fiechtner, February 5, 2004.

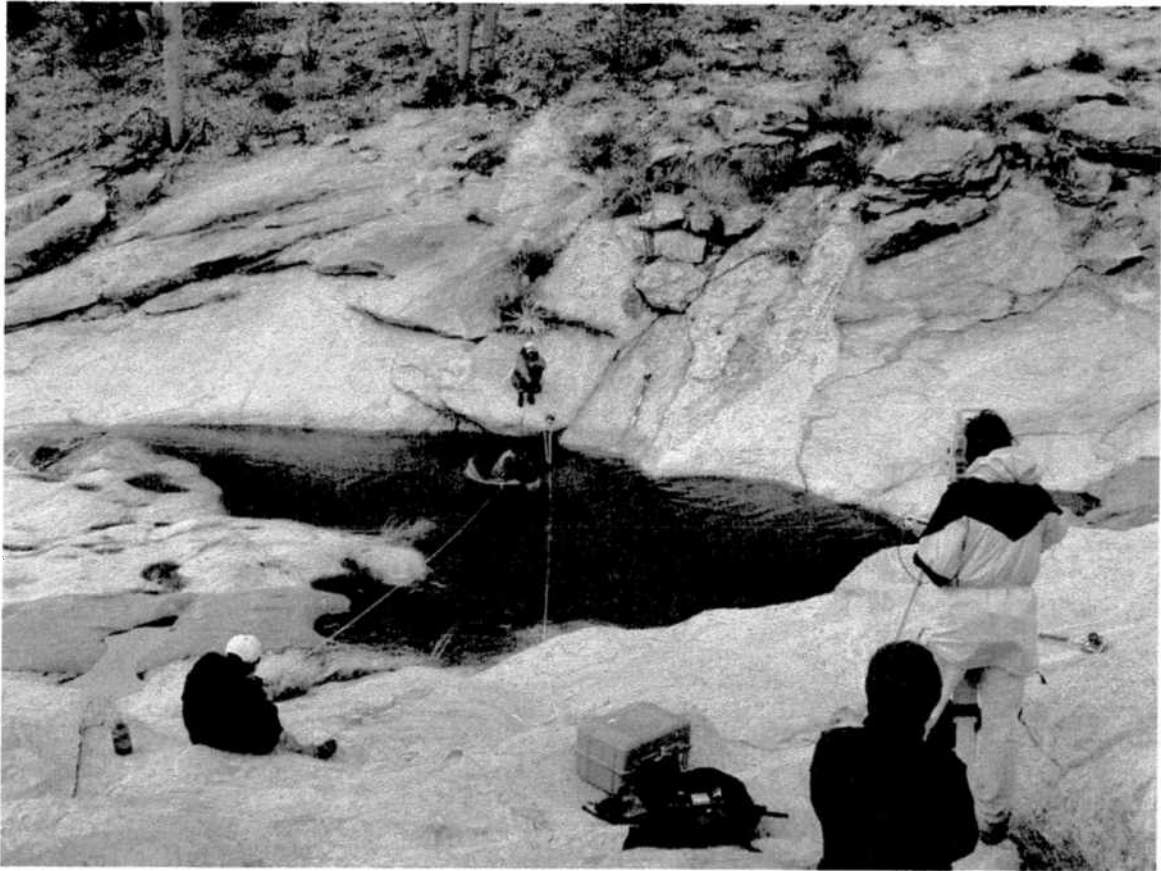


Figure 3. Madrona Pool 1D, Saguaro National Park. Survey from Monument, STN 1 February 5, 2004. Personnel from left to right: Matt Daniels, Colleen Filippone, Vicki Gempko, Carmia Fiechtner and Christine Gable.



Figure 4. Madrona Pool 1D. Photo of surveyed cross section. Saguaro National Park. Personnel from left to right: Colleen Filippone, Vicki Gempo, Don Swann. February 5, 2004.

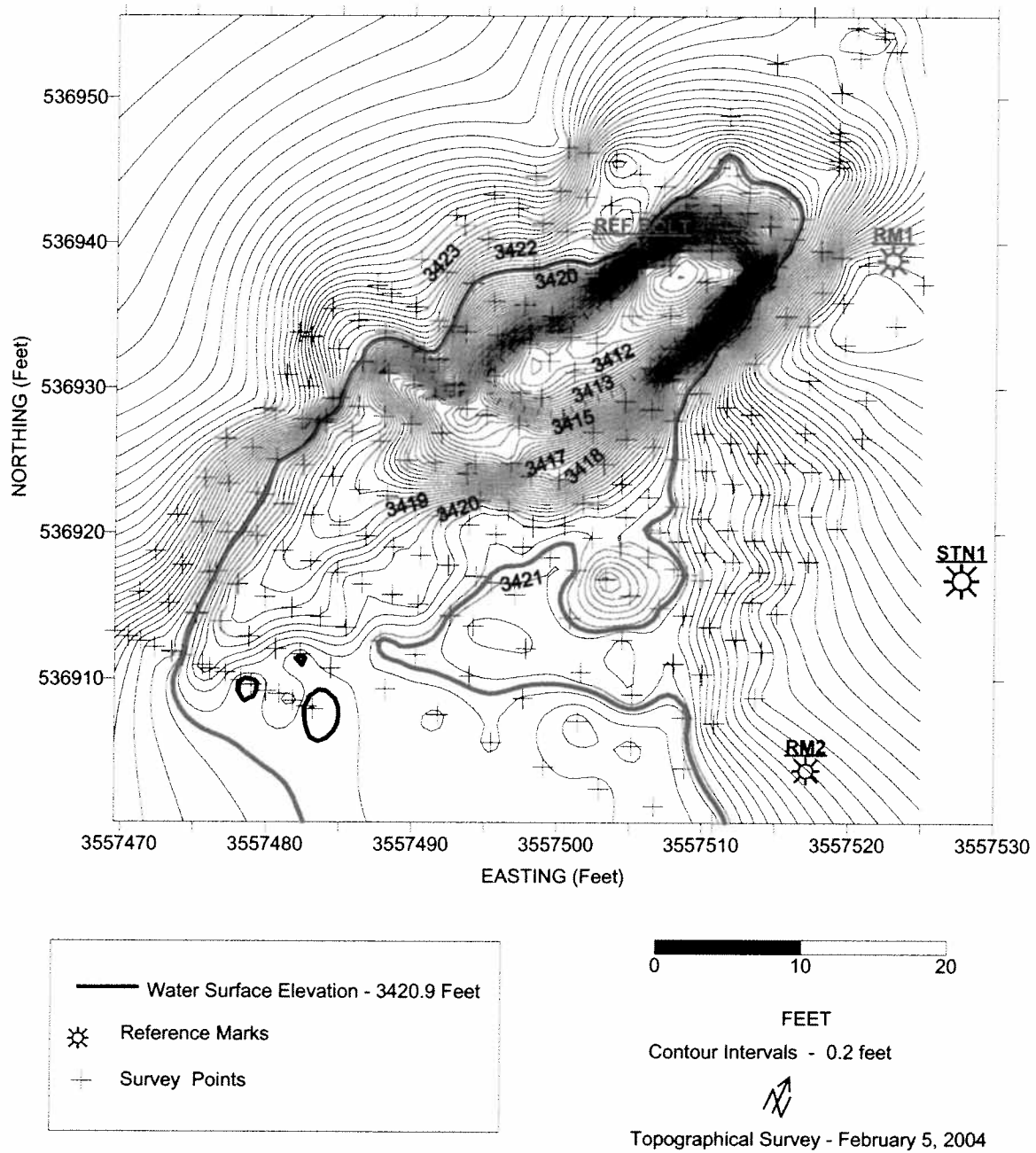


Figure 5 Contour map of Madrona Pool 1D, Saguaro National Park. Surfer 7.05 (2003). February 5, 2004.

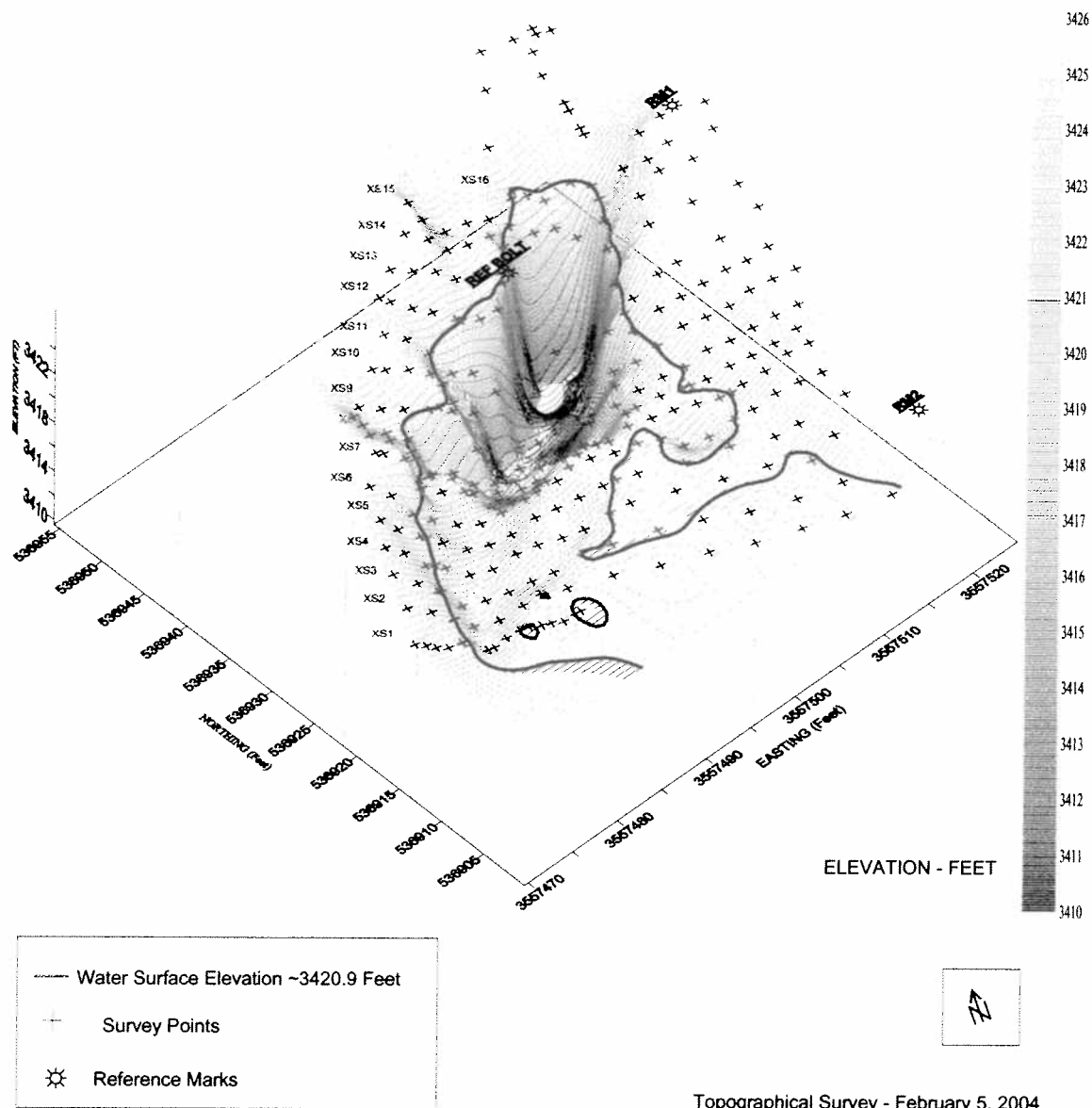


Figure 6. Location of cross sections and 3D display of Madrona Pool 1D, Saguaro National Park. Surfer 7.0 5 (2003). February 5, 2004.

Colleen
(with a cc to Kurt),

I am going to send you two sets of data related to Madrona pools - thank you!...if you have a chance, and would like to crunch some data to estimate pool volume. I should be able to do this first part (except for my question below), but thought you might want to try it.

This first set is from Pool 1d (I have also included the data from pool 1L and the staff gage at Pool 1; see the chart for how they track), and represents the data we have gathered since Chris helped us map the pool. The numbers for Pool 1d and 1L represent the distance (in feet) from the reference point down to the surface of the water. The reference point in pool 1d is at an elevation of 3421.2 feet, according to the report.

I am still struggling with one thing about the report that I don't understand. Chris measured the elevation of zero flow (the lowest point on the spillway) to be 3420 feet, and the elevation of the surface of the water when we were working in the pool to be 3420.9 feet. But this would suggest that the elevation was 0.9 feet over the spillway when we were working there - and this was certainly not what I remember. So, I think that one of these numbers must be incorrect. I thought I asked you before I ask Chris, though, since I am probably missing something important (again).

Currently, there is just a bit of flow in pool 1d over the spillway (about 0.05 feet). Based on our reference mark, I estimate that the actual elevation of zero flow to be 3420.5 feet. This would be about 0.5 feet more than Chris measured, which is a pretty substantial difference.

Thanks for all your help.

Don



MadronaWater.xls