



Publication No. WI-2014-12

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## Hollister Hills SVRA Sediment Basin Volumes: Water Year 2012– 2013

FALL 2013

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## Acknowledgements

- Wes Gray, Matthew Allen and Hollister Hills SVRA Park Staff
- Field assistants---Brady Latham, Christina Hall, August Delforge, James McClure, Andrea Goodmansen, and John Urness
- Partial funding provided by CSUMB UROC

This report may be cited as:

Teaby A, Silveus, J, Smith D. 2013. Hollister Hills SVRA Sediment Basin Volumes: Water year 2012–2013. The Watershed Institute, California State Monterey Bay, Publication No. WI–2014–12, 27 pp.

## Executive Summary

The sediment control best management practice utilized by resource managers in Hollister Hills State Vehicular Recreation Area (SVRA) to effectively manage erosion within their off-road vehicle park include trapping eroded sediment in retention basins located throughout the park. As part of the long-term BMP maintenance, these sediment basins are routinely extracted on a multi-year timeframe. This report details the topographic surveys of a subset of 6 of 10 sediments basins selected by park staff. High precision total station and RTK GPS surveys were used to determine the initial basin volumes. Sediment retention was measurable in only three of the sediment basins after the first water year (WY 2013). Precipitation during the winter of 2012–13 was very light. Only three basins captured sediment during the winter, with a total retained sediment volume of 12 m<sup>3</sup> (16 yd<sup>3</sup>).

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# **1 Introduction**

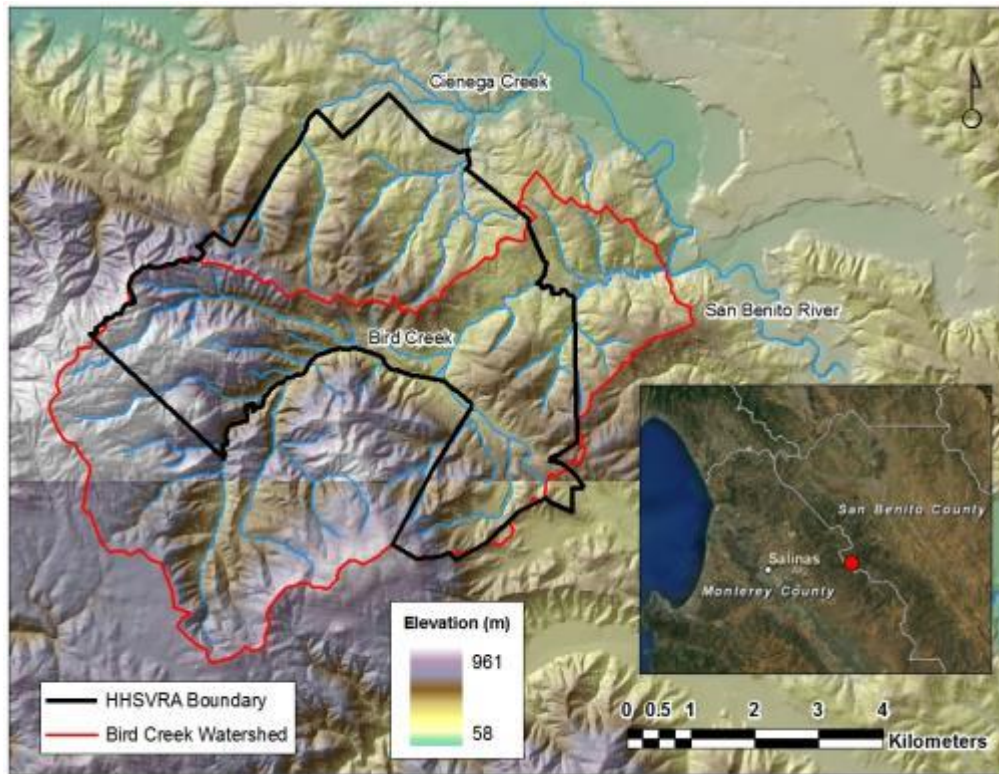
## **1.1 Background**

As part of its ongoing effort to improve park resource management, Hollister Hills State Vehicular Recreation Area (HHSVRA) contracted the Watershed Geology Lab at California State University Monterey Bay to estimate sediment retained by sediment basins within the park. This report presents initial basin volumes and estimates of the volume of sediment retained following the 2013 water year (WY) (October 1, 2012 to September 30, 2013).

The Radio Ridge rain gage in HHSVRA captured 248 mm (9.78 in) of rain in water year 2013, which is well below the 419 mm (16.50 in) annual average (Smith et al. 2014). This low rainfall total is in keeping with statewide drought conditions for the year. Sixty percent of the annual rainfall was concentrated in two periods in December 2012. During those two periods, cumulative rain over several days produced the only storm runoff events of the year. The results presented here report on the sediment retained following those runoff events.

## **1.2 Study Area**

HHSVRA is located in San Benito County, 35 miles east of Salinas. The park offers outdoor recreation to picnickers, campers and riding enthusiasts (Fig. 1). The sediment basins in this study trap sediment derived from the watershed slopes and trails before it enters Bird Creek, the main stream channel leaving the SVRA.



**Figure 1. Location map for Hollister Hills State Vehicular Recreation Area and the Bird Creek watershed.**

### 1.3 Goals

HHSVRA best management practices include trapping eroded sediment in retention basins located throughout the park. Sediment is removed from the basins on a multi-year time frame as part of long-term sediment management. Many basins were scheduled for cleanout in fall 2012. This cleanout cycle was targeted to initiate a long-term program for more precise accounting of sediment retention. The three goals of this study were to establish a system of benchmarks for precise time-series surveys of the basins, determine the initial volumes, and estimate the sediment retention during the first year of runoff. Precise total station and RTK GPS surveys were used to establish initial basin volume, and a variety of techniques were used to determine sediment retention in the first year (WY 2013).

## 2 Methods

### 2.1 Surveyed basins

The current study included a subset of 6 of 10 sediment basins located within the HHSVRA (Fig. 2). The subset of basins chosen for analysis included: Gilmore, Grand Prix 1 (GP1), Office, Sycamore, Whoopdeedoo, and Woodwardia (Fig. 2). These basins were surveyed prior to the runoff from WY 2013 and were used for initial assessment of sediment retention from WY 2013.

The rest of the basins were not excavated and were not initially surveyed until the beginning of WY 2014. All basins surveyed were selected for study by the park staff.

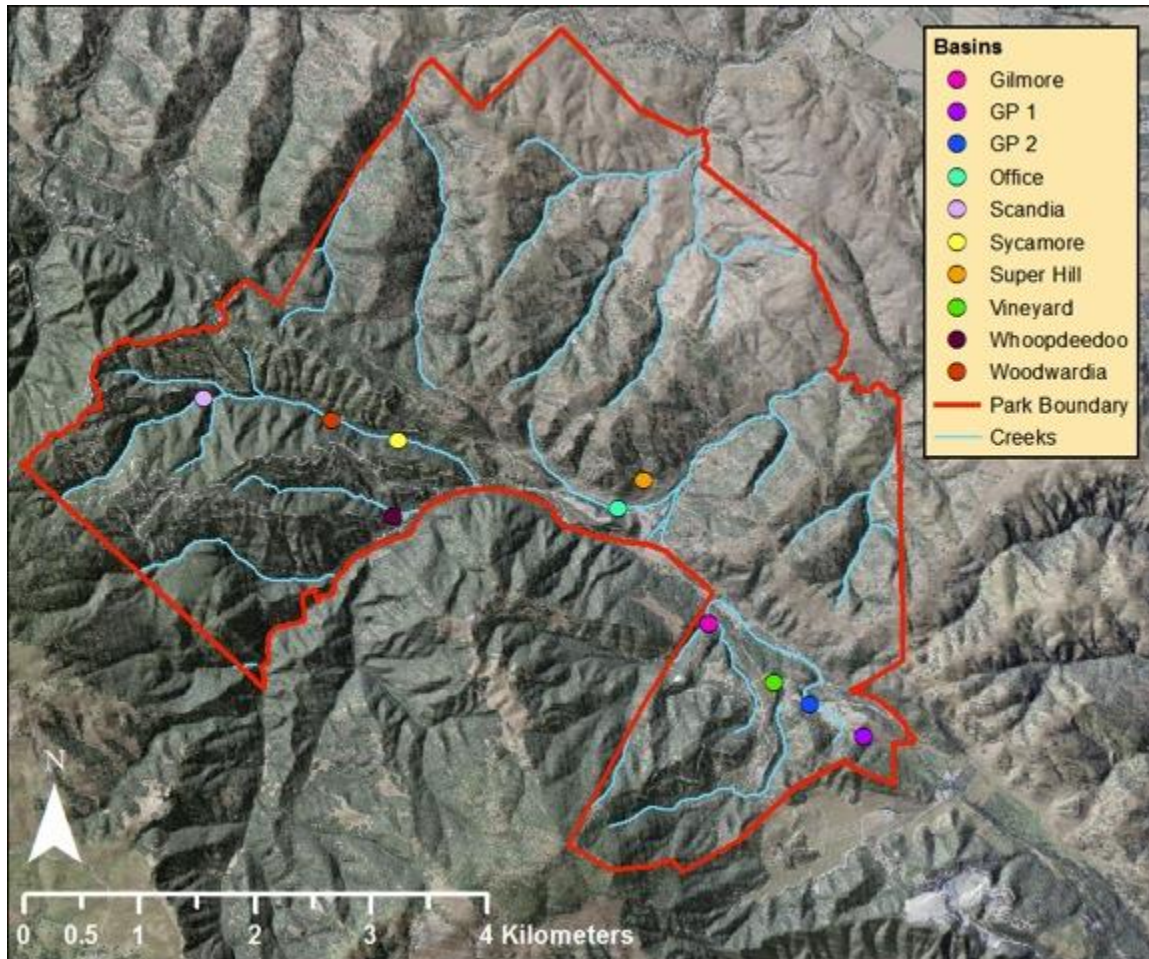


Figure 2. Location of all sediment basins within the HHSVRA.

## 2.2 Survey Methods

Two types of survey techniques were used to measure the elevation of the selected basins: Real-Time Kinetic (RTK) Global Position System (GPS) and a total station. Both methods utilized a permanent benchmark (BM). Basins located in dense trees, without a clear view of the sky, were surveyed using the total station, which included: Gilmore, GP 1, Sycamore and Woodwardia. The Office and Whoopdeedoo basins were surveyed using RTK GPS.



## 2.3 Surface Modeling

Data points from the total station were downloaded directly as comma separated value files. Data points from the RTK GPS were downloaded and post-processed using the NOAA Online Positioning Unit Service. All data points were used to make a digital elevation model (DEM) of each basin using the *Natural Neighbor* tool in ArcMap 10.1. The *Surface Volume* tool was used to calculate the initial area and volume for each basin below the spill point elevation of each basin.

## 2.4 Sediment Volume Analysis

Resurveys were performed on basins where new sediment deposits were present following the 2012–13 winter. Gilmore and Sycamore Basins were resurveyed using a total station because the sediment deposits were thick enough to be quantified with that instrument. Data points from the Gilmore and Sycamore basin resurveys were used to create DEMs using the same method as above. The volumes of sediment retained in Gilmore and Sycamore basins were calculated using the ArcMap *Cut Fill* tool, which provides a table showing volumes of net aggradation and degradation of sediment.

GP 1 basin had a recent veneer of sediment that was too thin to be quantified by total station. In GP 1 the sediment volume was estimated by the thickness of many random positions in the deposit using a millimeter scale and multiplying the averaged thickness by the areal extent of the deposit.

# 3 Results

## 3.1 Basin and Sediment Volumes

The area and initial volume of each basin was calculated below the elevation of the spillway in each basin (Table 1). Post-winter sediment retention volume was calculated for the three basins that contained new deposits. The total sediment retained between the three basins was approximately 12 m<sup>3</sup> (16 yd<sup>3</sup>). Gilmore retained 10 m<sup>3</sup> (13 yd<sup>3</sup>), Sycamore retained 2 m<sup>3</sup> (2 yd<sup>3</sup>). GP 1 retained 1 m<sup>3</sup> (1 yd<sup>3</sup>), based upon an average deposit thickness of 0.007 m (0.0076 yd) over an area of 140 m<sup>2</sup> (167 yd<sup>2</sup>).



**Table 1. Dimensions of basins surveyed based on elevation of spillway. Basins marked with an asterisk (\*) indicate surveys conducted with the total station. Others were surveyed with RTK GPS.**

Basin	Initial Survey Date	Spillway Elevation (m)	Area (m <sup>2</sup> )	Initial Volume (m <sup>3</sup> )	Initial Volume (yd <sup>3</sup> )	Sediment Retained (yd <sup>3</sup> )
Gilmore*	31-Oct-12	270	1244	1564	2046	13
GP 1*	14-Nov-12	359	1138	725	948	1
Office	12-Nov-12	222	1795	1681	2199	-
Sycamore*	14-Nov-12	285	683	374	489	2
Whoopdeedoo	14-Nov-12	274	3300	7565	9895	-
Woodwardia*	12-Nov-12	313	1436	742	970	-
Total		1723	9596	12651	16547	16

The following figures show the DEM of the baseline surveys for each basin. For the basins surveyed using the total station, the elevations are in reference to the BM. For the basins surveyed using RTK-GPS, the elevations are vertically referenced (NAVD88).

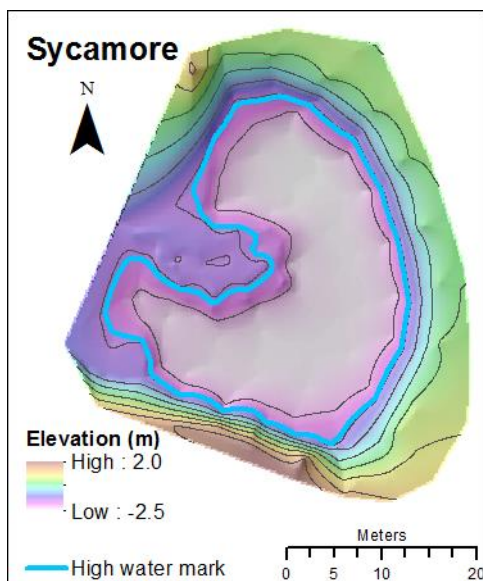
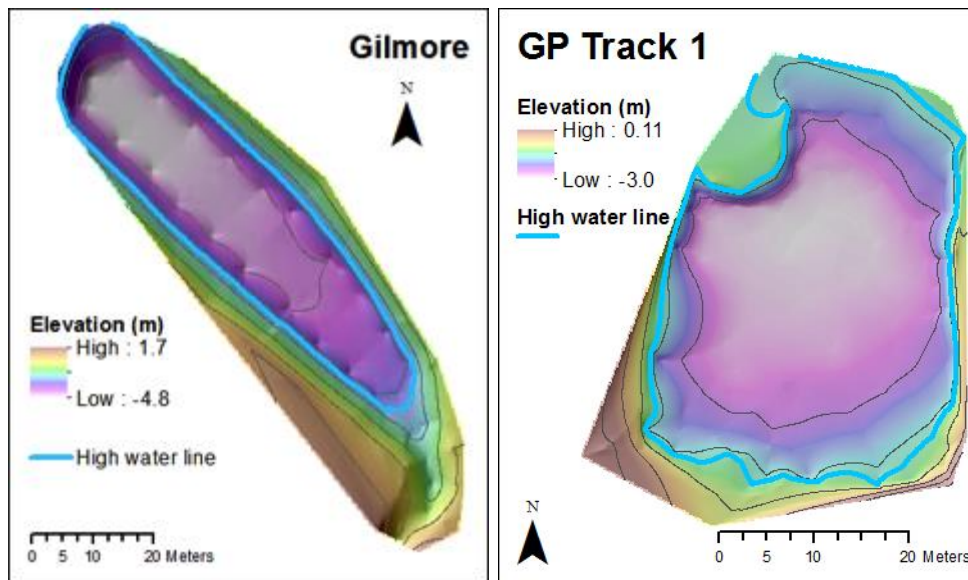
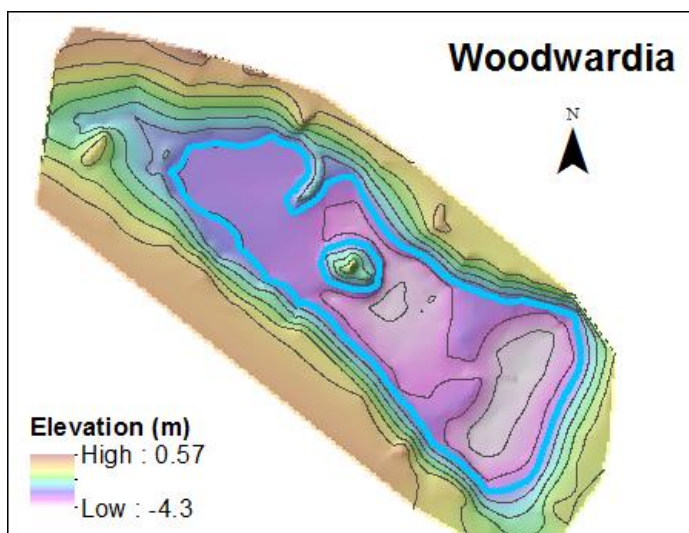


Figure 3. DEMs for basins surveyed with the total station. The elevations are in reference to the benchmark. The blue contour line indicates the elevation of the outflow pipe or spillway.



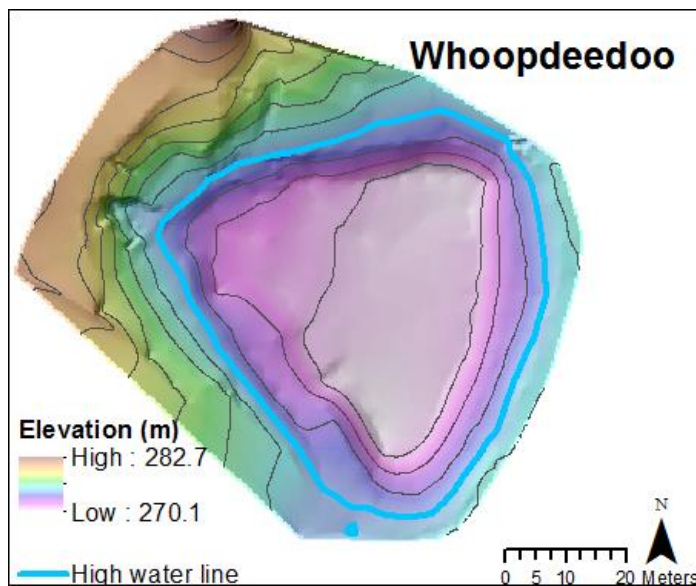
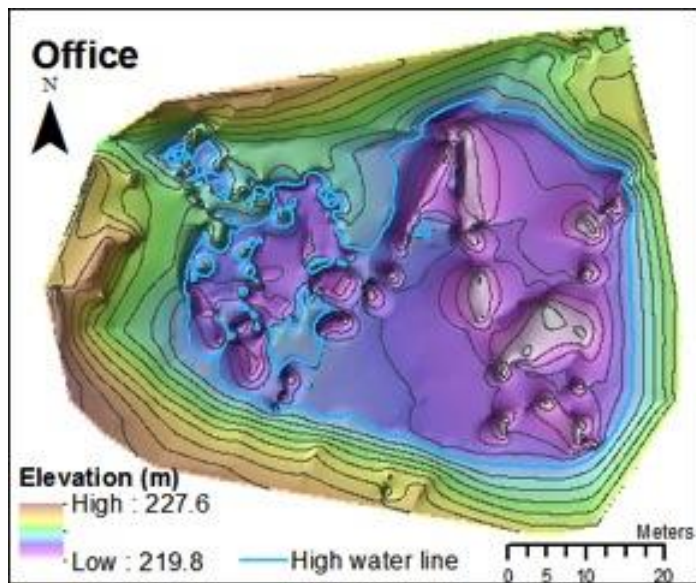


Figure 4. DEMs for the basins that were surveyed using RTK-GPS. The blue contour line indicates the elevation of the outflow pipe or spillway.

## 4 References

- Nicol C, Smith D, Nitayangkul K, Williams C, Moreland S. 2011. Hollister Hills SVRA Sediment Budget: Water year 2010–2011. The Watershed Institute, California State Monterey Bay, Publication No. WI-2011-04b, 25 pp.
- Smith D, Goodmansen, A. Silveus, J. 2014. Hollister Hills SVRA Sediment Budget: Water Year 2012–2013. The Watershed Institute, California State Monterey Bay, Publication No. WI-2014-01, 17 pp.

## 5 Appendix A – Survey Descriptions

### 5.1 Gilmore Basin

The Gilmore Basin is located in the Upper Ranch. To get to the basin, turn right from Cienga Road, approximately 0.65 miles southeast from the main SVRA entrance. Pass through a gated entrance to the Area 5 Group Campgrounds. Follow the dirt road past the campgrounds towards the hills in a southwest direction and the dirt road will lead to the Gilmore Basin. The basin is surrounded by a wood slat fence, has dirt trails running along both sides, and a large open space on the east side. Gilmore Basin extends approximately 20 meters from north to south, and 60 meters from east to west. The input for the basin is located in the southeast corner of the basin, and the outflow is located in the northwest corner.

As one stands in the middle of the east edge of the basin facing west, there are two distinct oak trees on the other side of the fence, one to the right, and one to the left. The basin's benchmark (BM) is located approximately 2 meters from the base of the tree to the right, and the basin's back-shot (BS) is located 1 meter from the base of the tree to the left. From the basin BM, the BS is located approximately 14 meters to the south, at a bearing of  $184^{\circ}$ . The BM was assigned a local position of 0,0,0 (E,N,Z) and the direction from the BM to the BS was used as the false northing.

The total station was set up on the BM and was oriented to a false north using the BS. Using a prism pole and prism, transects of the basin were surveyed by traversing from the top of the berm from south to north taking points at the top left of the berm, left break in slope, left bottom of slope, the floor of the basin, right bottom of slope, right break in slope, and right top of the berm. Transects were performed approximately every 2 meters from the east to the west edges of the basin using the same feature class designations for each transect. A more random survey of topographic features was used to record the gully created by the input in the southeast corner, in an attempt to capture the highly variable topography in that location.

In addition to the BM and the BS, four other monuments from previous surveys were located during the survey. The first monument is located approximately 8 meters from the BM and should NOT be used or mistaken for the BS in future surveys. Two monuments on the southeast slope of the basin were located and included in the survey as “LFT1” (point 8) and “LFT2” (point 11). Additionally, a monument was located on the northwest slope of the basin and included in the survey as “Top Right” (point 94).

**Table 1. Approximate coordinates (UTM) of benchmarks, backshots, and monuments and features of the Gilmore Basin, obtained from Google Earth.**

Description	Name	Type	Easting (UTM)	Northing (UTM)
Benchmark (BM)	BM1	Rebar	642213.00	4069710.00
Backshot (BS)	BS1	Rebar	642209.00	4069703.00
Inlet	GMI	Pipe	642208.00	4069699.00
Outlet	GMO	Pipe	642159.00	4069761.00



**Figure 5. Photograph of the total station and the basin facing west (left), total station and backshot facing south (right), and the basin taken from outlet pipe facing northeast (bottom).**

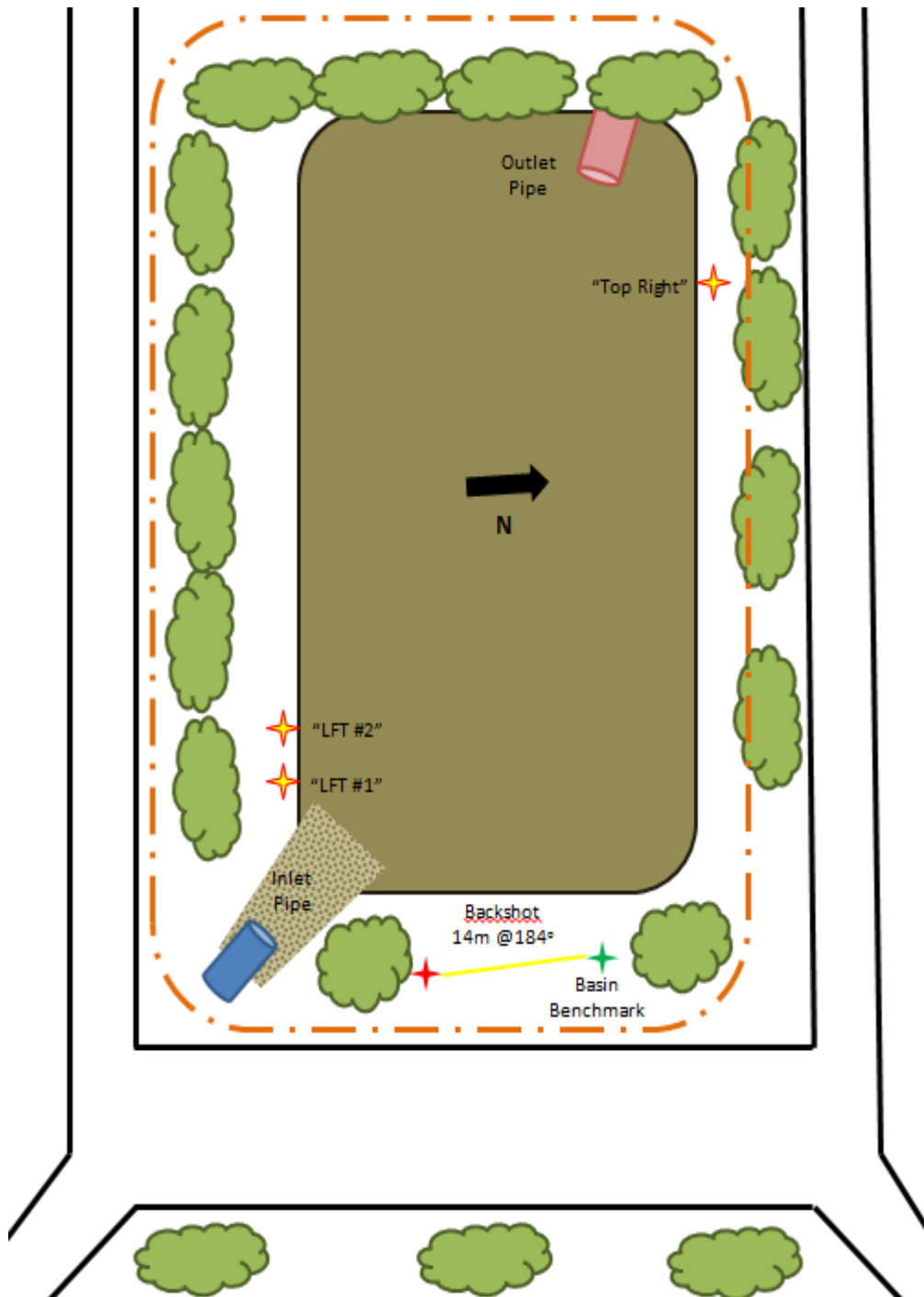


Figure 6. Diagram of Gilmore Basin showing the surrounding roads (black), the fences (orange), trees (green), inflow pipe (blue), and outflow pipe (red). The basin benchmark is shown as a green star, the backshot as a red star, and additional survey monuments are shown as yellow stars with red borders.

## 5.2 GP Track Basin 1

The GP Basin 1 is located in the Upper Ranch. To get to the basin, travel approximately 1.5 miles, past the Main SVRA Entrance, southeast on Cienega Road to the GP Track Entrance on the right. Once inside the entrance, follow road up and take first left-hand turn up to the day use area above the GP Track. The basin is roughly square and surrounded on the northwest and southwest sides by bushes, with a large circular patch of tall reeds in the northeast corner. The Main Park Road runs along the northwest side of the basin, and a large open field extends from the northeast edge of the basin. The outflow for the basin is located on the southeast side of the basin.

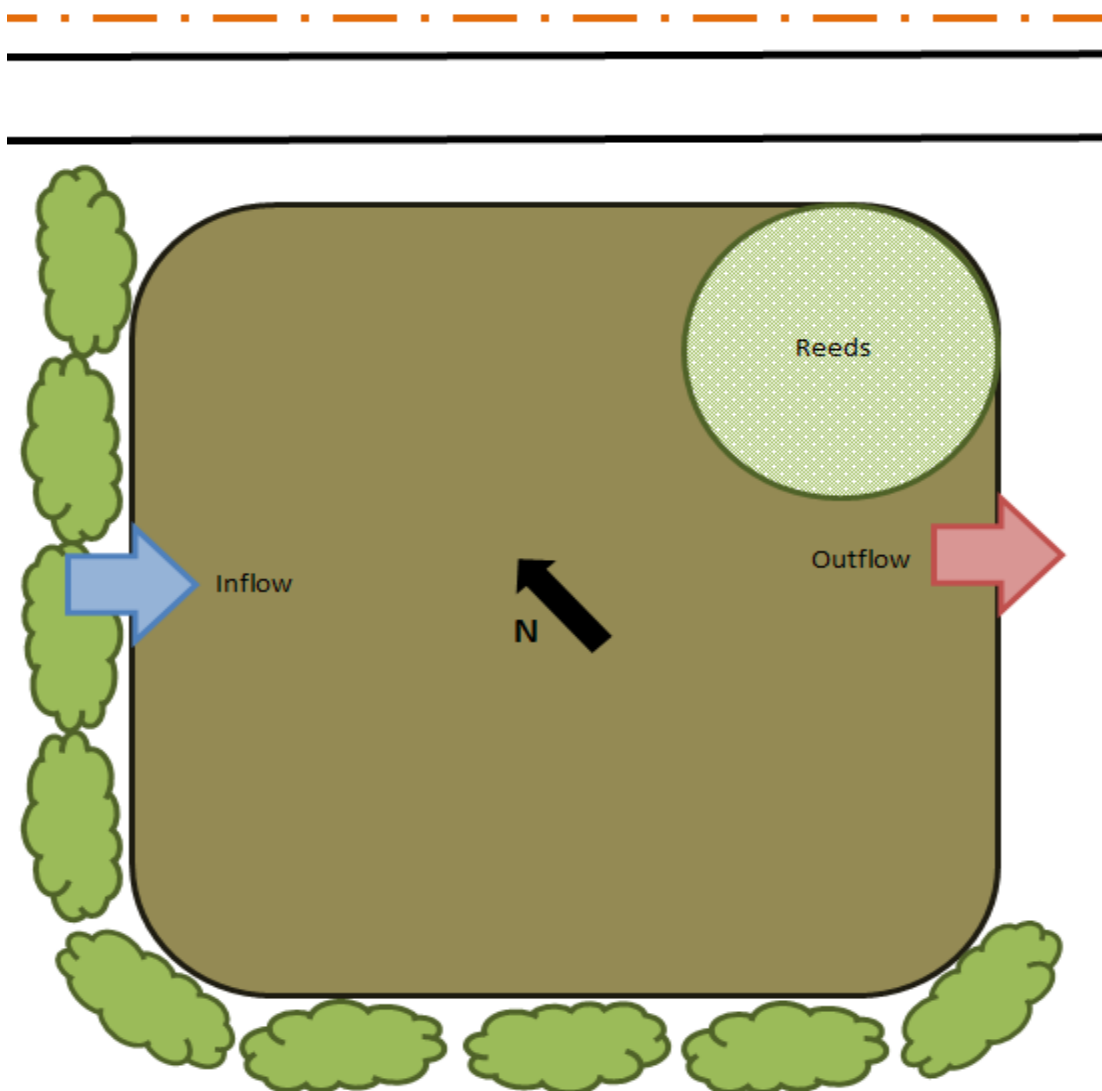


Figure 7. Diagram of GP Track Basin 1





**Figure 8. Photograph of the GP 1 Track Basin facing east (left) and the view from the backshot facing the location of the total station (right).**

### **5.3 Office Basin**

The Office Basin is located in the Lower Ranch Property on the Main Park Road. To get to the basin, travel west on the Main Park Road approximately 300 meters; the basin is on the right side of the road nestled between the Day Use Parking Lot on the eastern side, and a large pullout with a handicap accessible restroom on the western side. The basin is bordered by the Main Park Road on the southern side and dirt trails on the north side, and is surrounded on all sides by a wood slat fence. The basin is trapezoidal with the western edge measuring approximately 20 meters across and the eastern edge approximately 30 meters across. The basin is approximately 50 meters from east to west.

Because of the amount of tall vegetation that can occur near the center of the basin, the basin BM for the survey was placed on the hillside to the south of the basin to ensure good line of sight throughout the survey. The BM is located across the Main Park Road approximately 35 meters up the slope from the southern edge of the road at the base of a large, solitary oak tree. Two monuments were used for reference during the survey; both pieces of rebar hammered flush to the ground. The first backshot (BS #1) is located on the plateau on the west side of the basin, inside and approximately 5 meters from the wood slat fence. The second backshot (BS #2) is located outside of the wood slat fence on the southern edge, approximately at the middle of the basin at a bearing of 70° from the benchmark on the southern slope.

The total station was set up on the BM and oriented to a false north using the BS on the western side of the basin (BS #1). Using a prism pole and prism, transects of the basin were surveyed by traversing from the top of the berm from north to south taking points at the top left of the berm, left break in slope, left bottom of slope, the floor of the basin, right bottom of slope,

right break in slope, and right top of the berm. Transects were performed approximately every 2 meters from the north to the south edges of the basin using the same feature class designations for each transect. A more random survey of topographic features was used to record unique features and the around the vegetated plateau in the center of the basin to capture the highly variable topography at that location.

Additionally, the Office Basin was surveyed on at least two other occasions using RTK/GPS equipment. For these surveys, the monument denoted as BS #1 for this survey was used as the BM and points were taken throughout the basin complex, including the monuments used for the total station survey. From these surveys we have the UTM coordinates for BS #1 (641346.45E, 4070719.4N), and for the benchmark (BM #1) on the slope of the southern side (641342.45E, 4070646.9N) used in the total station survey of the basin.

**Table 2. Approximate coordinates (UTM) of benchmarks, backshots, and monuments and features of the Office Basin, obtained from Google Earth.**

Description	Name	Type	Easting (UTM)	Northing (UTM)
Benchmark (BM)	BM1	Rebar	641345.00	4070652.00
Backshot (BS)	BS1	Rebar	641349.00	4070722.00
Backshot (BS)	BS2	Rebar	641399.00	4070689.00
Inlet	OBI	Channel	641361.00	4070736.00
Outlet	OBO	Channel	641421.00	4070736.00

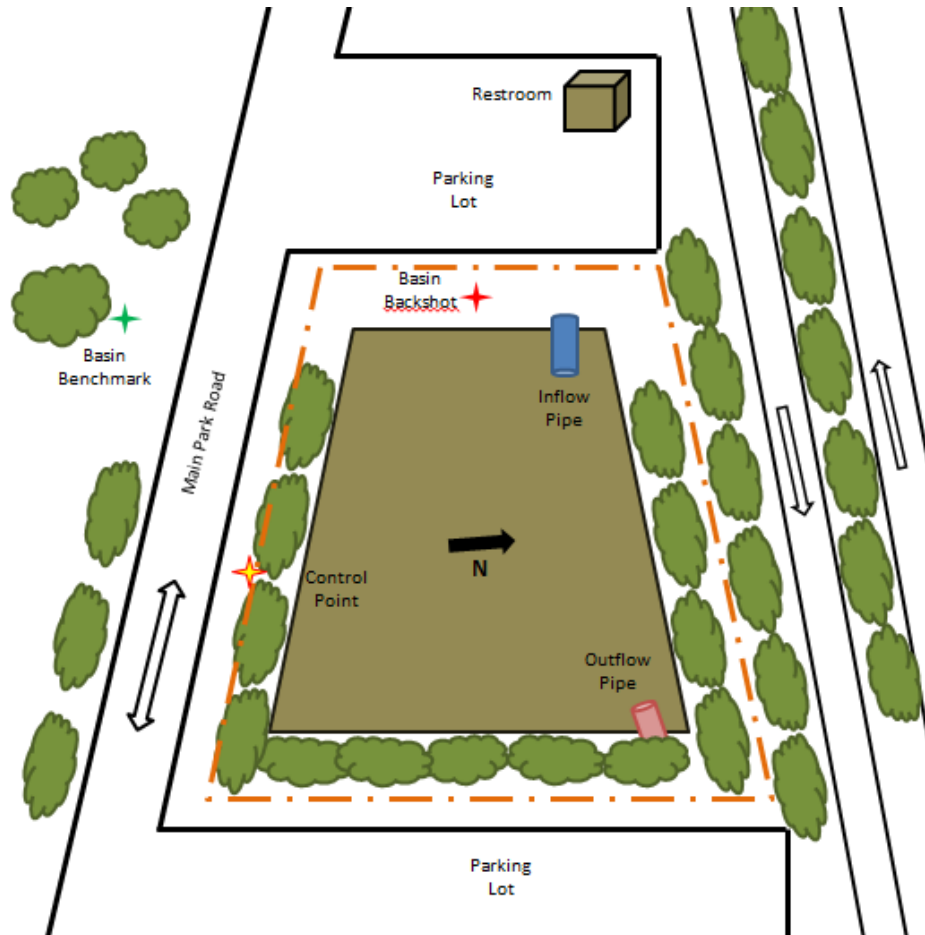


Figure 11. Diagram of the Office Basin showing surrounding roads (black), the direction of travel on roads (black arrows), fences (orange), trees (green), inflow pipe (blue), and outflow pipe (red). The basin benchmark is shown as a green star, the backshot as a red star, and additional survey monuments are shown as yellow stars with red borders.



Figure 12. Ariel photograph of the Office Basin showing the location of the basin benchmark (BM#1) (left); a view of the basin from the basin benchmark (middle); and a view of the basin from the basin benchmark showing the RTK/GPS base station set up on the back-shot used for the total station surveys (BS #1) (right).



Figure 13. Photograph of the location of the basin benchmark (BM #1) from the southern edge of the basin (left); the location of the backshot (BS #1) used for the total station surveys (middle); and the location of the second backshot (BS #2) used for the survey (right).

## 5.4 Sycamore Basin

The Sycamore Basin is located in the Lower Ranch property on Harmony Gate Road. To get to the basin, take the Main Park Road west from Park Headquarters until you reach Lodge Lake. Turn right onto Harmony Gate Road at Lodge Lake and Sycamore Basin is located approximately 0.3 miles up Harmony Gate Road on the left. The basin is roughly oval with a channel cut island on the western edge. The basin is surrounded by a wood slat fence, has dirt trails running along both sides, and a trail crossover on the east edge. The basin is approximately 40 meters from north to south and 20 meters from east to west. Water enters the basin through the channel on the western edge and exits through the outlet pipe located in the southeast corner of the basin.

The BM is located inside the fence perimeter, about half way between the north and south edges, and about 1 meter west of the fence. The BS is a piece of rebar in the ground, 27 meters from the BM at a bearing of  $330^\circ$ . Nail #1 is located in an oak tree about 1.9 meters from the ground, is approximately 23 meters to the north, at a bearing of  $337^\circ$  (points 2 and 190). Nail #2 is located in an oak tree is located on the southwest face of a hillside bordering the basin is at a bearing of  $222^\circ$  from the BM, at a distance of approximately 30 meters (points 4 and 133).

The BM was assigned a local position of 0,0,0 (E,N,Z) and the direction from the BM to the BS was used as the false northing. Using a prism pole and prism, oval transects of the basin were

**Table 3. Approximate coordinates (UTM) of monuments and features of the Sycamore Basin from Google Earth.**

Description	Name	Type	Easting (UTM)	Northing (UTM)
Benchmark (BM)	BM1	Rebar	639504.00	4071311.00
Backshot (BS)	BS1	Nail	639499.00	4071327.00
Inlet	SBI	Channel	639483.00	4071308.00
Outlet	SBO	Pipe	639504.00	4071298.00

surveyed by taking points along similar elevations around the ring of the basin, and then moving down the slope of the basin in a concentric manner. Survey points of the general shape of the basin were taken approximately every square meter, and more a random survey of topographic features was used to record the channel cut island created by the input on the western edge in an attempt to capture the highly variable topography in that location.



**Figure 16. The Sycamore Basin viewed from the southeast corner of the basin showing the channel cut island (left); the location of the basin benchmark near the fence at the center of the eastern edge of the basin (middle); and the location of the nail in the oak tree used for the backshot in the northeast corner of the basin (right).**

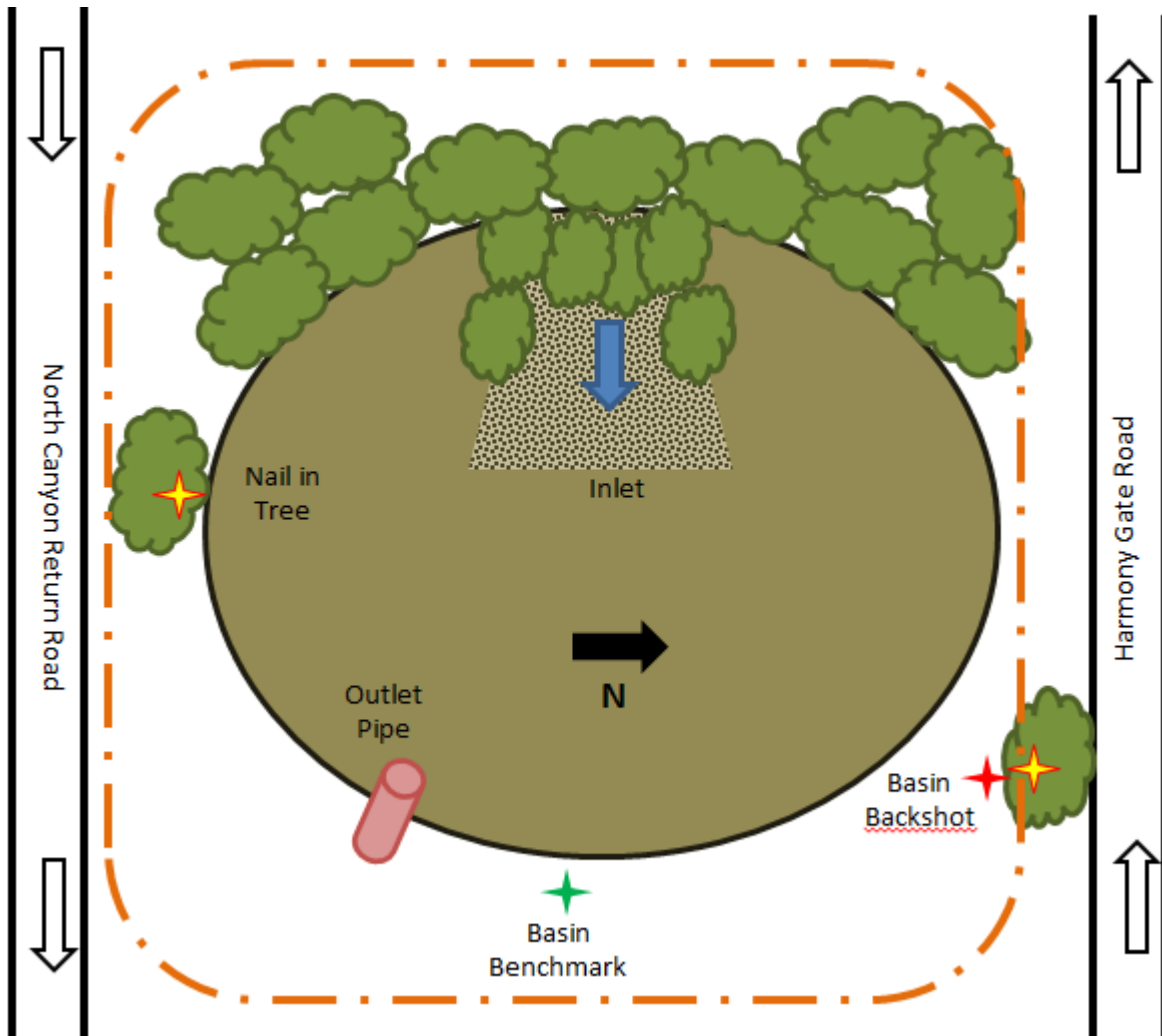


Figure 17. Diagram of the Sycamore Basin showing surrounding roads (black), fences (orange), trees (green), inflow (blue), outflow pipe (red), and channel cut island (dark brown). The basin benchmark is shown as a green star, the backshot as a red star, and additional survey monuments are shown as yellow stars with red borders.



## 5.5 Whoopdeedoo Basin

The Whoopdeedoo Basin is located in the Lower Ranch property on Long Canyon Road. To get to the basin, take the Main Park Road west from Park Headquarters until you reach Lodge Lake. Turn right onto Harmony Gate Road at Lodge Lake, travel approximately 0.3 miles on Harmony Gate Road and then turn right onto Long Canyon Road. Whoopdeedoo Basin is located at the entrance to Long Canyon Road on the right. Whoopdeedoo is a large and deep basin bordered on the south side by Long Canyon Road with dirt trails bordering all other sides of the basin. The basin is trapezoidal with the narrow end at the western edge where the inlet pipe is located, with a triangular alluvial fan cut with multiple dykes channeling water into the basin. The outlet of the basin is located in the northeast corner of the basin next to a dirt trail and covered in thick coyote bushes. Unlike other basins in this survey, the outlet is a vertical drainpipe cut with outlet ports. The outlet pipe leads to a concrete channel with a cross section of approximately one square meter and a length of approximately 10 meters.

The RTK/GPS base station was set up on the single basin benchmark located in the northeast corner of the basin next to the concrete channel. The UTM coordinates for the benchmark established by the RTK/GPS unit during the survey are 639401.56E, 4070719.4N.

**Table 4. Approximate coordinates (UTM) of benchmarks, backshots, and monuments and features of the Whoopdeedoo Basin, obtained from Google Earth.**

Description	Name	Type	Easting (UTM)	Northing (UTM)
Benchmark (BM)	BM1	Rebar	639490.00	4070658.00
Inlet	WDI	Pipe	639409.00	4070658.00
Outlet	WDO	Pipe	639486.00	4070658.00



**Figure 21. Aerial photograph of the Whoopdeedoo Basin showing its trapezoidal shape (left); view of the western side of the basin and the basin inlet from the basin benchmark (middle); and view of the eastern side of the basin from the basin benchmark (right).**





Figure 22. View of the western side of the Whoopdeedoo basin and the basin inlet from the basin benchmark (left); the basin benchmark located in the northeastern corner of the basin and next to the concrete culvert (middle); and view of the concrete culvert that diverts water from the basin outlet (right).

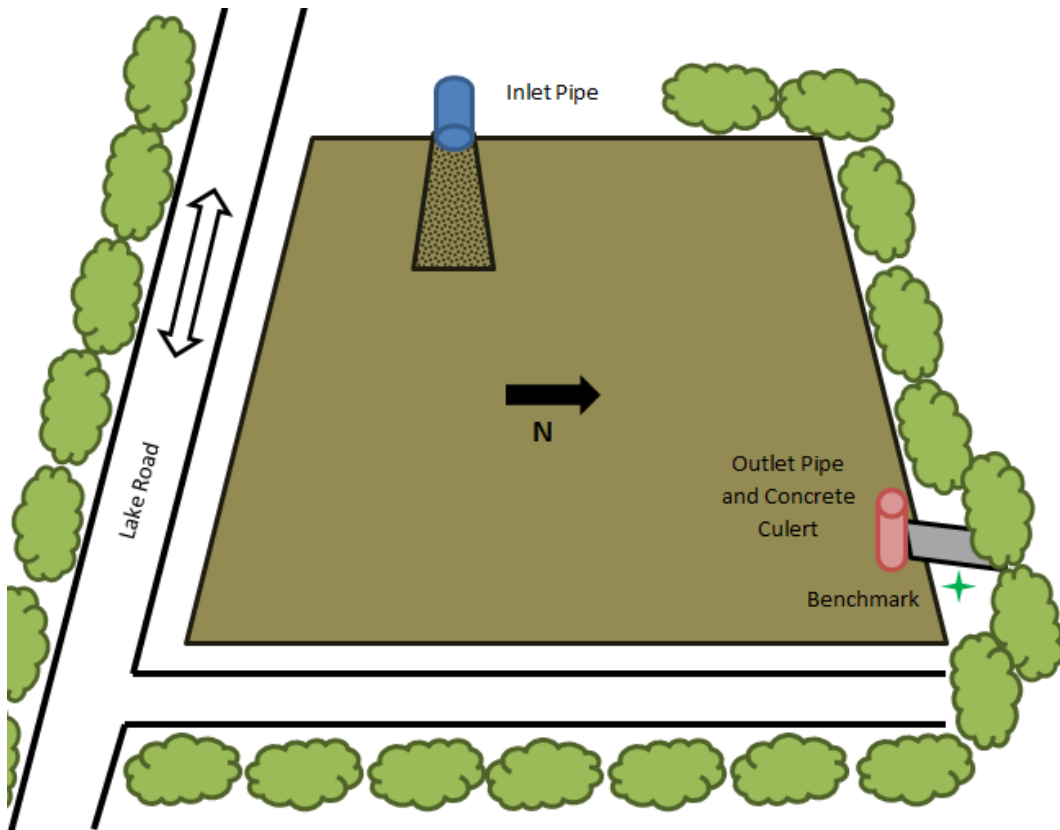


Figure 20. Diagram of the Whoopdeedoo Basin showing surrounding roads (black), direction of travel on roads (black arrows), trees (green), inflow pipe (blue), and outflow pipe (red). The basin benchmark used for RTK/GPS is shown as a green star in the northeastern corner of the basin.

## 5.6 Woodwardia Basin

The Woodwardia Basin is located in the Lower Ranch property on Harmony Gate Road. To get to the basin, take the Main Park Road west from Park Headquarters until you reach Lodge Lake. Turn right onto Harmony Gate Road at Lodge Lake and Woodwardia Basin is located approximately 0.5 miles up Harmony Gate Road on the left. The basin is bordered on both sides by dirt trails and wood slat fences, with a large island and a wood slat fence bisecting the basin. A trail crossover from east to west borders the southern edge. The northern section is predominantly filled with dirt and is used heavily by off-road vehicles, while the southern section is covered with wetland vegetation. Extreme caution should be used when working in the northern section of the basin. The basin is approximately 60 meters long from north to south, and 30 meters from east to west. Water enters the basin through a channel in the northwest corner, and exits through the outlet pipe in the southwest corner of the basin.

Due to the length of the basin and the island with large trees in the middle of the basin, two benchmarks and total stations were used to survey the basin, one at the northern end and one at the southern end of the basin. The north basin benchmark (BM #1) is chiseled into a rock at the base of a large oak tree in the northeast corner of the basin. The south basin benchmark (BM #2) is a piece of rebar located at the top of the berm approximately half way across the southern edge of the basin. The BS is chiseled into a large rock located in the center of the island that bisects the basin and was used as the BS for both BMs. The BS is approximately 30 meters from the northern benchmark (BM #1) at a bearing of  $125^\circ$ , and approximately 30 meters from the southern benchmark (BM #2) at a bearing of  $306^\circ$ . The northern TS was setup on BM #1 and assigned a local position of 0,0,0 (E,N,Z) and the direction from the BM to the BS ( $125^\circ$ ) was used as the false northing. The southern TS was setup on BM #2 with a position of 86.808, -62.816, -1.172 (E,N,Z) and the direction from the BM to the BS ( $306^\circ$ ) was used as the false northing.

There are 5 monuments used for reference in the Woodwardia Basin complex. Monuments 1 through 3 are nails in trees used for reference with the northern BM, and nails 4 and 5 were used for reference for the southern BM. All nail monuments are hammered flush to the tree surface, and located approximately 2 meters from ground level facing the appropriate BM. From the northern BM, Nail #1 is approximately 20 meters southwest at a bearing of  $145^\circ$ . Nail #2 is approximately 15 meters west at a bearing of  $215^\circ$ , and Nail #3 is approximately 20 meters east at a bearing of  $80^\circ$ . From the southern BM, Nail #4 is approximately 20 meters northeast, and nail #5 is approximately 20 meters east; no bearings for these monuments are currently available and should be obtained during the next survey. The BM was assigned a local position of 0,0,0 (E,N,Z) and the direction from the BM to the BS was used as the false northing

Using a prism pole and prism, transects of the basin were surveyed by traversing from the top of the berm from west to east taking points at the top left of the berm, left break in slope, left bottom of slope, the floor of the basin, right bottom of slope, right break in slope, and right top of the berm. Transects were performed approximately every 2 meters from the north to the south edges of the basin using the same feature class designations for each transect. A more random survey of topographic features was used to record unique features and the around the island in the center of the basin to capture the highly variable topography at that location.

**Table 5. Approximate coordinates (UTM) of benchmarks, backshots, and monuments and features of the Woodwardia Basin, obtained from Google Earth.**

Description	Name	Type	Easting (UTM)	Northing (UTM)
Benchmark (BM)	BM1	Rock	638881.00	4071508.00
Benchmark (BM)	BM2	Rebar	638961.00	4071455.00
Backshot (BS)	BS1	Rock	638917.00	4071484.00
Backshot (BS)	N1	Nail	638893.00	4071488.00
Backshot (BS)	N2	Nail	638866.00	4071503.00
Backshot (BS)	N3	Nail	638910.00	4071512.00
Backshot (BS)	N4	Nail	638944.00	4071488.00
Backshot (BS)	N5	Nail	638974.00	4071478.00
Inlet	WWI	Channel	638855.00	4071512.00
Outlet	WWO	Pipe	638948.00	4071450.00

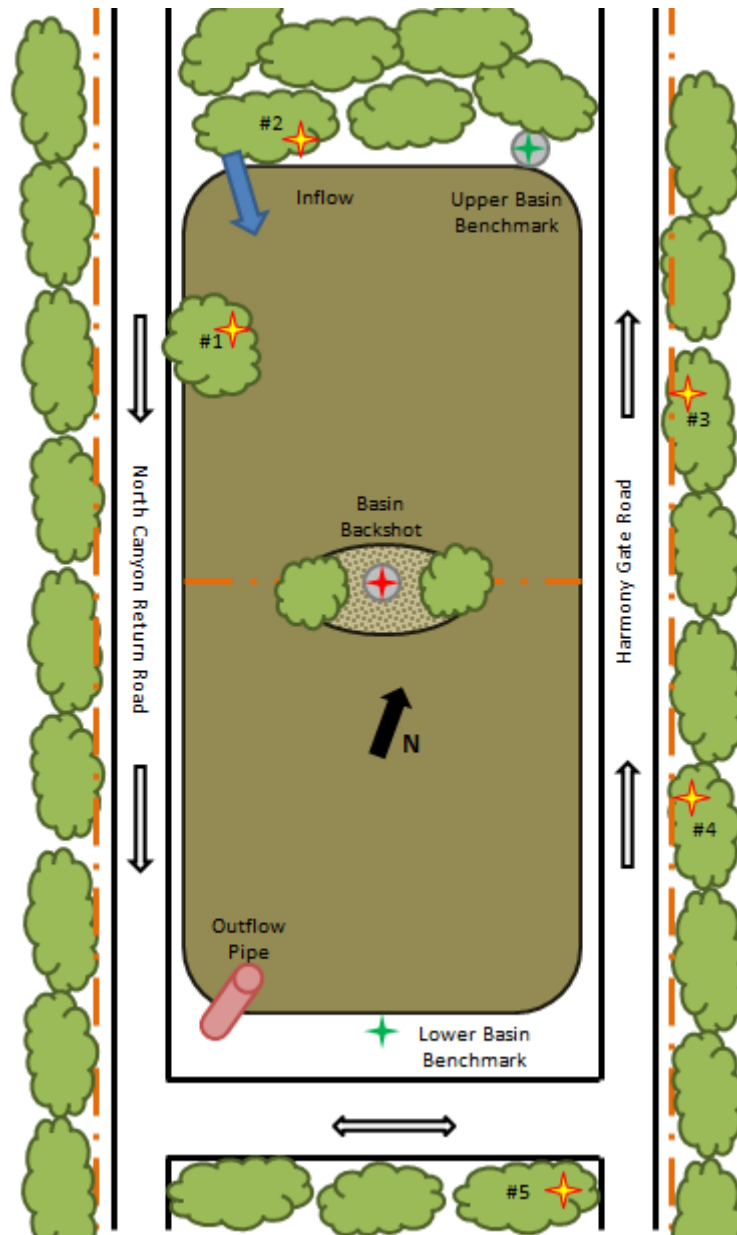


Figure 23. Diagram of the Woodwardia Basin showing surrounding roads (black), fences (orange), trees (green), rocks (grey), inflow (blue), and outflow pipe (red). The basin benchmarks are shown as a green stars, the back-shot as a red star, and additional survey monuments are shown as yellow stars with red borders. Numbers indicating monument identifications have also been included.

**Table 6. Approximate location of the backshot and reference monuments of the Woodwardia Basin taken from the northern benchmark (BM #1).**

Description	Name	Type	Reference	Distance (m)	Bearing (X°)
Backshot (BS)	BS1	Rock	BM #1	30	125
Monument (N)	N1	Nail	BM #1	20	145
Monument (N)	N2	Nail	BM #1	15	215
Monument (N)	N3	Nail	BM #1	20	80

**Table 7. Approximate location of the backshot and reference monuments of the Woodwardia Basin taken from the southern benchmark (BM #2).**

Description	Name	Type	Reference	Distance (m)	Bearing (X°)
Backshot (BS)	BS1	Rock	BM #1	30	306
Monument (N)	N4	Nail	BM #1	20	NE
Monument (N)	N5	Nail	BM #1	20	E



**Figure 24. The Woodwardia Basin viewed from the northeastern corner of the basin showing the northern benchmark and the island that bisects the basin (left), the northern benchmark (middle), and the island in the middle of the basin with the large rock on which the backshot is located (right).**



**Figure 25. The tree with monument #1 (far left), the tree with monument #2 (middle left), the tree with monument #3 (middle right), and the view from the southern benchmark (BM #2) showing the basin, the island, and the location of the northern benchmark (BM #1) in relation to the southern benchmark (far right).**