Findlay TOYOTA

# Off Highway Vehicle Demonstration Park


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# Acknowledgements

The work done to complete this project could not have been done by the students of the Findlay 4Runner Capstone group alone. It is with the support of the faculty at Northern Arizona University, the Findlay Auto Group, and members of the community that the Findlay Toyota Off-Highway Vehicle Park capstone project transformed from an idea into a solid design.

The Findlay 4Runner capstone team would like to acknowledge the following individuals and businesses for their support in the development in the Findlay Toyota OHV Park:

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*Marketing/Fleet Director of the Findlay Auto Group*

**Jeremy DeGeyter, E.I.T.**
*Technical Advisor, Speedie & Associates*

**Mark Lamer, P.E.**
*Grading Instructor, Lecturer at Northern Arizona University*

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*Rental of Geotechnical Sampling Equipment*

The Findlay 4Runners capstone team appreciates the time, effort, and dedication that the individuals above selflessly contributed to aid in the completion of the Findlay Toyota OHV Park design.

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| | |
|---|---|
| **4WD** | Four-wheel Drive |
| **AASHTO** | American Association of State Highway and Transportation Officials |
| **ADA** | Americans with Disabilities Act |
| **CECMEE** | Civil Engineering, Construction Management and Environmental Engineering |
| **CoF** | City of Flagstaff |
| **E.I.T.** | Engineer In Training |
| **FTP** | Findlay Toyota Park |
| **HAC** | Hill Start Assist Control |
| **LID** | Low-Impact Development |
| **NAU** | Northern Arizona University |
| **OHV** | Off-Highway Vehicle |
| **SUV** | Sport Utility Vehicle |
| **USDA** | United States Department of Agriculture |

# 1.0 Project Description

The Findlay Toyota Off-Highway Vehicle Park capstone project is a collaborative venture between the Findlay Toyota Auto Dealership in Flagstaff, Arizona and the Northern Arizona University Toyota 4Runners capstone team. The purpose of this project is to create a preliminary design of an off-highway vehicle (OHV) park to be built for Findlay Toyota, on which customers interested in test driving a Toyota vehicle with four-wheel drive (4WD) can experience the handling and features that Toyota 4WD vehicles have to offer.

The client of this project, Findlay Toyota, wishes to use the Findlay Toyota OHV Park (FTP) to feature the off-road capabilities of the Toyota Tacoma pickup truck and the Toyota 4Runner Sport Utility Vehicle. The client would like the FTP to demonstrate 4WD features specific to Toyota, including the Hill Start Assist Control (HAC) and Crawl Control .

The development and construction of the FTP aims to improve the Toyota 4WD test-driving experience as well as advertise the presence of the Findlay Toyota dealership. It is the goal of the Findlay 4Runners capstone team with guidance from Findlay Toyota to design an OHV course that will increase the number of potential clients to Findlay Toyota and ultimately increase the sale of Toyota 4WD vehicles.

## 1.1 Client and Stakeholders

The preliminary client of the Findlay OHV Park is the Findlay Toyota Auto Dealership in Flagstaff, Arizona. The client is represented by Mark Monthofer, Marketing/Fleet Director of the Findlay Auto Group, and all communication between the team and the client is done through this single point of contact.

The Findlay Toyota OHV Park has four stakeholders relevant to the design and success of the project. The stakeholders are identified as the Findlay Toyota Auto Dealership, the Flagstaff Auto Park, the Northern Arizona Department of Civil Engineering, Construction Management, and Environment Engineering, as well as the clients and customers of Findlay Toyota. Factors that determined the stakeholders of the Findlay Toyota OHV Park include the location of the project, users of the FTP, as well as the beneficiaries of monetary and reputational gain resulting in the implementation of the Findlay Toyota OHV Park.

## 1.3 Project Site Location and Current Condition

The Findlay OHV park project is located at 5130 N. Test Dr., near the intersection of Test Dr. and Historic Rte. 66, on the Eastern side of Flagstaff, Arizona. The location of the project site within Flagstaff, AZ is outlined in red below in *Figure 1: Project Site Location within Flagstaff, AZ.*

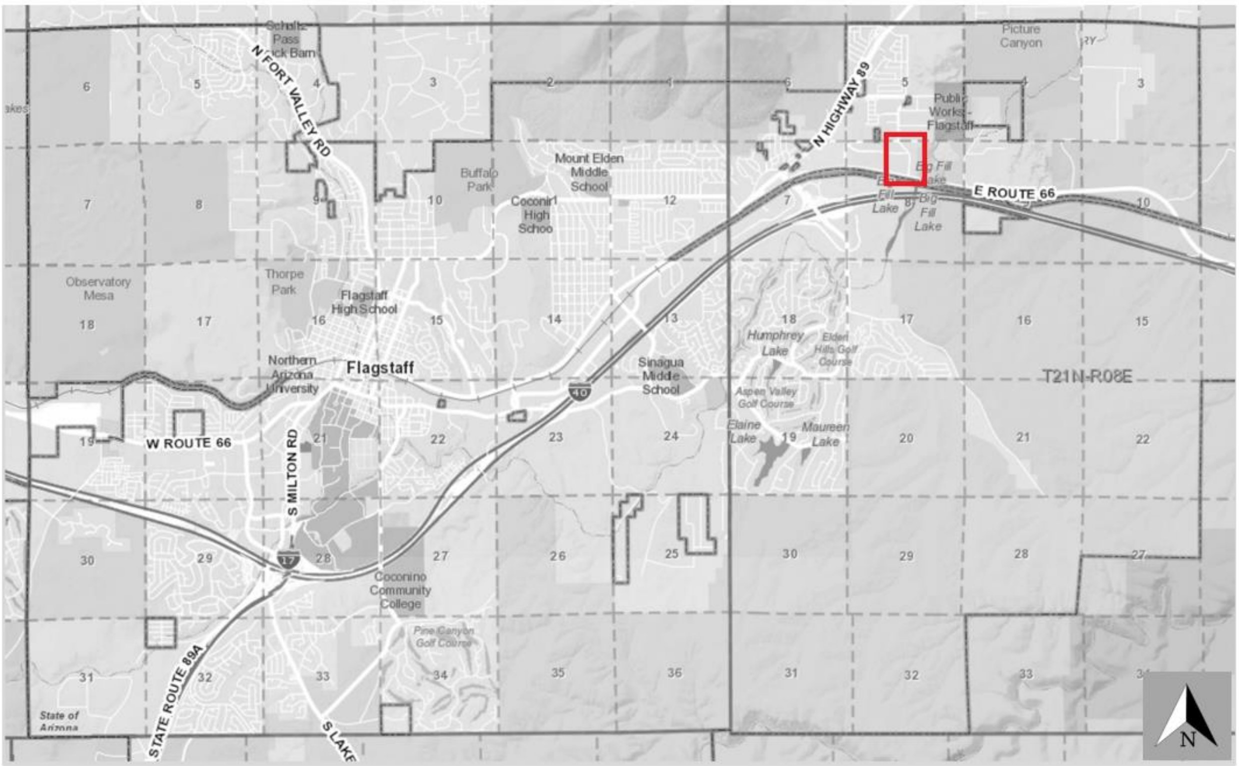


*Figure 1: Project Site Location within Flagstaff, AZ*

The area for the project site is approximately 3.11 acres and is currently undeveloped, bar preliminary landscaping along Test Dr. to the West and water, sewer, natural gas, electrical, and fiber-optic telecom utilities present on the parcel. The water, sewer, and natural gas utilities are present in the form of utility stubs that enter the project site off of Test Dr. Arizona Public Service (APS) power lines  cross the project site next to the Eastern parcel boundary, with telecom fiber-optic cables running below-ground underneath the same lines. There are two steel utility poles on the project site that are approximately 2 ft in diameter and are located next to the Eastern parcel boundary. An aerial view of the project site taken from the Coconino Parcel Viewer can be seen below in *Figure 2: Aerial View of the Project Site.*


*Figure 2: Aerial View of the Project Site*

The project site is located approximately 1/5th of a mile from The Findlay Toyota Dealership. The close proximity allows convenient access to the site by the client and valuable street visibility for Findlay Toyota.

Being an undeveloped parcel, the parcel is populated by low-lying grasses and shrubs. Portions of the project site are bare, with gravel and man-made debris covering the ground. The surface debris includes sections of barbed wire, concrete and asphalt chunks, broken plastic geo-grid material, and trash from public dumping. A view of the site taken from Google Street View can be seen below in *Figure 3: Street View of the Project Site.*

*Figure 3: Street View of the Project Site*

## 1.4 Project Design Considerations and Constraints

Through evaluation of the objectives of the project from the client, the team focused their research and design around five design considerations; project budget, course durability, year-round usability, course feature variety, and course aesthetics. The project budget is the paramount design consideration set by the client. Findlay Toyota assigned all creative liberties regarding the layout and design of the FTP to the capstone team, with the only defined project consideration ensuring that the project budget remain as close to zero as possible. It is the client's wish to construct the FTP at little or no cost to Findlay Toyota.

The team developed an additional four project design considerations during the design process to ensure a usable, safe, and profitable final product. The ultimate goal was increasing Toyota 4WD vehicle sales. Two of the design considerations, course durability and year-round usability, are considered to ensure that the FTP has a long design life, and maximum season of use. The features present in the FTP are designed to require little maintenance and no reset time after a vehicle travels through the course. To maximize the effect that the FTP has on potential clients of Findlay Toyota looking to purchase 4WD vehicles, the team aimed to create a wide variety of park features to justly demonstrate the off-road capabilities of Toyota 4WD vehicles. This includes considering features simulating varying terrain, as well as a suite of off-road scenarios that one would be expected to encounter. The final design consideration that the team focused on in developing the FTP is the assurance that the park will be aesthetically engaging to the public. Findlay Toyota is interested in building an OHV course that not only provides potential clients a place to test drive Toyota 4WD vehicles, but that entices passersby into test driving a Toyota vehicle on the FTP.

The client expressed a single project constraint to the team, which is to keep one-third of the lot undeveloped to avoid the potential of accidentally developing the parcel beyond the Eastern and Southern property boundaries.

### 1.5 Project Exclusions

The team has identified five exclusions that are not included in the final project design. These exclusions consist of a utility plan, a traffic-impact analysis, a building/facilities plan, a course maintenance plan, and a landscaping plan. The team is not addressing these exclusions due to the time constraint of the project design.

## 2.0 Project Background Research

When it comes to OHV park design, there are no existing manuals or instructions as one might find with a motocross course. Therefore, the FTP relies on information from similar projects for park feature variety and design and the American Mud Racing Association for a portion of the park feature design.

### 2.1 Similar Project

To gain realistic information on the design and layout of an OHV park team collected information on a local OHV park located at the Mormon Lake Lodge in Mormon Lake, AZ. The team visited the Mormon Lake OHV Park (MLP) on November 4th, 2016 with the Findlay Toyota Marketing Director Mark Monthofer. The team used photogrammetry to determine the dimensions of the features present at the MLP by placing an optical scale on a feature and capturing a high-resolution photograph. These photographs were then imported into Bluebeam Revu where they were adjusted to real-size using the optical scale and the dimensions of each feature were recorded. The Findlay Toyota OHV Park is designed based on the information on OHV park layout and features collected from the MLP.

# 3.0 Project Data Collection

The team compiled information on the project site, municipal code, and effects of the development of the parcel in order to design the course to comply with local design code and be used as intended.

## 3.1 Site Survey and Topographic Map Development

The team has done surveying work on the site to compile topographical information, though it was not enough data to complete the topographic map required. The data collected only includes the general site layout but does not include any parking lot, sidewalk, curb, gutter, and utility stubs.

The team contacted the City of Flagstaff's Engineering Department in order to get a topographic map of the area. The topographic map requested from the city contains many of the features that are needed by the team to use for future purposes such as for drainage design grading. Additionally, the team created a topo map that included the elevations within the site. The city's map as well as the team's map can be seen in Appendix D: Maps. The team used information on the site orientation, property boundaries, and municipal and public utility setbacks obtained from the Coconino County Assessor's database as well as site plan sheets sent from the CoF City Engineer's office.

## 3.2 Code Review

The City of Flagstaff Title 13 Engineering Standards were used as a guide for designing parts of the OHV park. While a literature review of various of these standards were done, the ones that applied to our site and were actually used for design within the site are: parking, water, sewer and utilities, and stormwater management. City of Flagstaff's low impact development manual was also part of the code review. The team has completed their review of city code and relevant sections will be brought up during the technical sections in which they were used. [1],[2].

The Americans with Disabilities Act (ADA) provides standards for accessible design which must be followed to be protected by the ADA. For the design of the OHV park, the standards regarding parking will be the only applicable standards. Chapter 5 of the accessible design standards outlines the parking space dimensions requirements to be ADA compliant. Section 502.2 defines the dimensions for both car and van parking spaces while section 502.3 provides the spacing requirements for access aisles [3].

## 3.3 Geotechnical Sampling and Analysis

To reduce the project costs associated with the delivery of soil and fill onto the project site, the team collected samples of the soil currently on the project site to determine if the current site material can be used for the track surface and park features. The desirable soil composition to be used in the FTP is defined by the Gravel Road Maintenance Manual published by the Maine Department of Environmental Protection Bureaus of Land Resources and Water Quality, which provides guidance regarding road surface and road base material. The recommended soil specifications from the park surface and base material are below in *Table 1: Recommended Specification for Well-Graded Gravel Material for Roads*

*Table 1: Recommended Specification for Well-Graded Gravel Material for Roads*

| Recommended Specifications for Well-Graded Gravel Material for Roads | | | |
|---|---|---|---|
| **Road Base Material** | | **Road Surface Material** | |
| *All material less than 6" in size* | | *All material less than 2" in size* | |
| % by Weight | Is Smaller Than | % by Weight | Is Smaller Than |
| 78-100 | 1 ½" | 85-100 | ¾" |
| 55-75 | ¾" | 70-100 | ½" |
| 30-55 | ¼" | 55-85 | ¼" |
| 8-22 | #40 (sand) | 20-35 | #40 (sand) |
| 0-7 | #200 (silt) | 7-12 | #200 (silt) |

The team completed field testing and soil collection on February 25th, 2017, with the assistance of Geotechnical Engineering E.I.T. and technical advisor of the project, Jeremy DeGeyter.

Working with Jeremy DeGeyter, the team dug five test-pits on the project site at predetermined locations, shown in the Soil Boring Location Plan in Appendix E. The team used a CASE 580N backhoe and a ring sampler to collect seventeen individual samples of soil from the five test-pits, with samples ranging in depth from ground level to 10’ below the surface of the project site. The types of soil samples collected include five 5-gallon bulk samples (one from each test pit), ten 1-gallon auger samples of soil that looked to have a distinctly different composition than a majority of the soils pulled from the test pits, and two ring samples of common soil from two of the test-pits. An example of a non-homogenous soil that was collected for sampling can be seen below in *Figure 4: Non-homogeneous soil sample collected for testing*

*Figure 4: Non-homogeneous soil sample collected for testing*

A list of items and tools that were used in the collection of soil samples from the project site can be found in appendix E, and seen on the next page in *Figure 5: Equipment used to collect soil samples on the project site*

*Figure 5: Equipment used to collect soil samples on the project site*

Geotechnical testing of the soil was performed, with sieve analysis and Atterberg limits testing completed for all five of the bulk samples. The team used the professional soil testing procedures found in the US Army Corps of Engineers' Laboratory Soils Testing manual [4], Gerjen Slim's Geotechnical Engineering Laboratory Manual [5], as well as ASTM International Geotechnical Engineering Standards [6] to complete the soil geotechnical testing of the soil. As each laboratory test was conducted, the data was recorded in custom data sheets. The data collected from the results of the sieve analysis and Atterberg limits testing was used to classify the soils to both United States Department of Agriculture (USDA) and American Association of State Highway and Transportation Officials (AASHTO) classification standards [7],[8].

The results of the sieve analysis testing show that the soil collected on the project site are relatively homogeneous, with particle size distribution differing no more than 13%, as shown below in *Figure 6: Equipment used to collect soil samples on the project site*

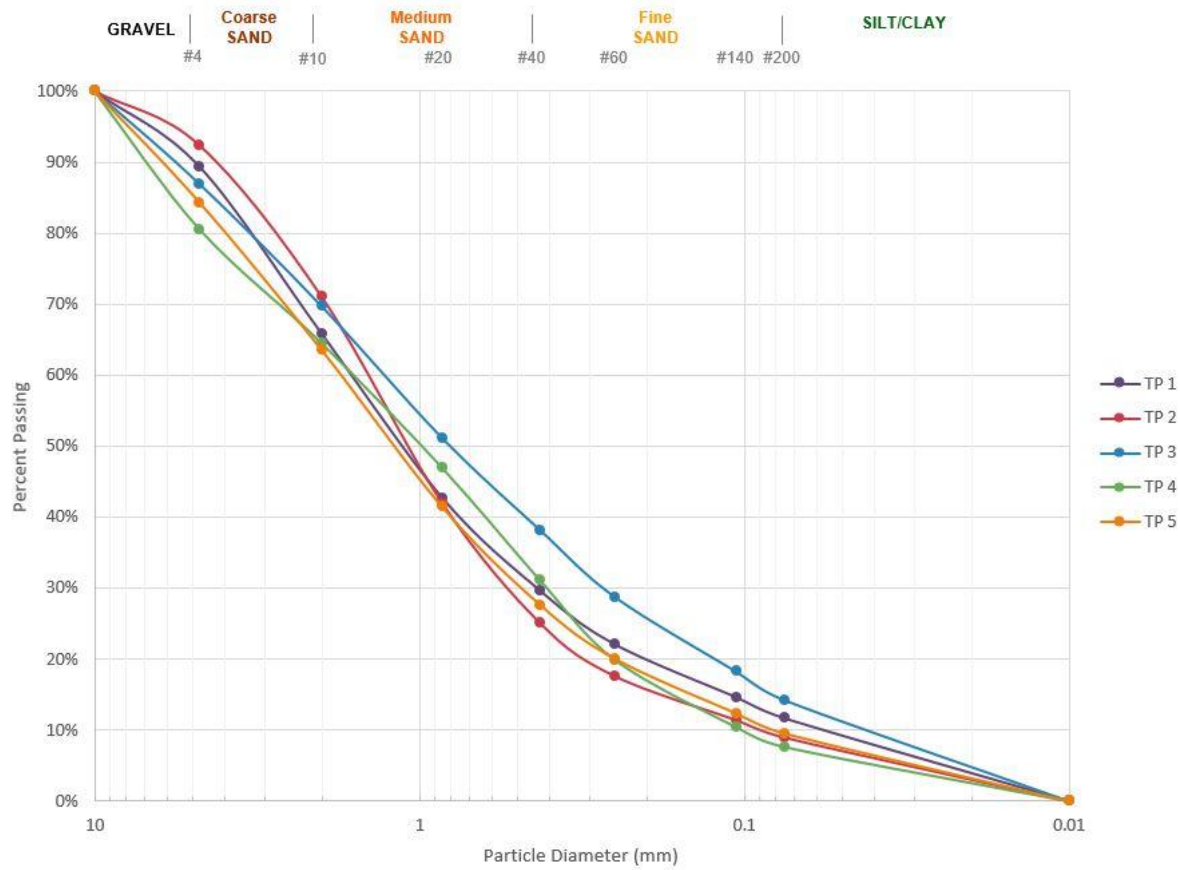


*Figure 6: Overlay of Particle Distribution Curves*

The data sheets from the sieve analysis and Atterberg limits testing can be found in Appendix G.

The tables on the next pages, *Table 2: Atterberg Limits Testing Results* and *Table 3: Sieve Analysis Testing Results* show the results of the Atterberg limits testing as well as the sieve analysis.

*Table 2: Atterberg Limits Testing Results*

| Bore Location | PL | LL | PI | Notes |
|---|---|---|---|---|
| **B-1** | 19.4 | 25.7 | **6.3** | |
| **B-2** | 20.3 | 22.6 | **2.3** | |
| **B-3** | 24.5 | 34.9 | **10.4** | |
| **B-4** | NA | 27.9 | **NA** | Did not exhibit plasticity |
| **B-5** | 19.5 | 23.9 | **4.4** | |

*Table 3: Sieve Analysis Testing Results*

| | | Cumulative Percent Passing | | | | |
|---|---|---|---|---|---|---|
| **Sieve #** | **Sieve opening (mm)** | **B-1** | **B-2** | **B-3** | **B-4** | **B-5** |
| **4** | **4.75** | 89.37% | 92.38% | 86.93% | 80.54% | 84.33% |
| **10** | **2** | 65.88% | 71.07% | 69.72% | 64.51% | 63.57% |
| **20** | **0.85** | 42.74% | 41.99% | 51.14% | 46.94% | 41.44% |
| **40** | **0.425** | 29.68% | 25.10% | 38.19% | 31.13% | 27.68% |
| **60** | **0.25** | 22.11% | 17.62% | 28.76% | 19.90% | 20.08% |
| **140** | **0.106** | 14.67% | 11.44% | 18.27% | 10.45% | 12.40% |
| **200** | **0.075** | 11.69% | 8.97% | 14.22% | 7.64% | 9.55% |
| **Pan** | **0.01** | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |

Using the results of the sieve analysis and Atterberg limits testing shown in the above tables, the soil from each test pit was classified using USDA and AASHTO standards. The decision regarding the usability of the soil currently present on the project site as a surface material and/or subgrade is made using the recommendations from the Gravel Road Maintenance

Manual, shown in *Table 1: Recommended Specification for Well-Graded Gravel Material for Roads*. A table displaying the classifications of the soil from the test pits as well as their determined usefulness can be seen in the table below *Table 4: Project Site Soil Usability*

*Table 4: Project Site Soil Usability*

| Bore Location | USDA Group Symbol | AASHTO Classification | Description | Use as Surface Material | Use as Subgrade |
|---|---|---|---|---|---|
| **B-1** | SW-SC | A-2-4 | Well-graded sand w/ clay/silt | Yes | No |
| **B-2** | SW-SM | A-2-4 | Well-graded sand w/ silt | Yes | No |
| **B-3** | SM | A-2-4 | Silty sand | No | No |
| **B-4** | SP-SM | A-2-4 | Poorly-graded sand w/ silt & gravel | Yes | No |
| **B-5** | SW-SC | A-2-4 | Well-graded sand w/ clay & gravel | Yes | No |

The analysis of the soil presently on the project site revealed the composition of the soil, including the presence of fine silt and clay, as well as pieces of industrial scrap (such as concrete, brick, metal fragments, wire, pipe, and rebar) and garbage at alarmingly deep depths. Man-made debris was found at depths as deep as 9' below ground-level, signifying that a portion of the soil currently on the proposed project site is fill dirt. For this reason, the team does not recommend using the soil that is currently on the project site for the park features or subgrade, and suggests that soil from an outside source be used instead.

## 3.4 Hydrological Analysis

In accordance with the Flagstaff City Code and the Americans with Disabilities Act, a parking lot with an impervious asphalt surface has been designed for placement on the proposed project site [1], [3]. A stormwater analysis has been completed on the proposed parking lot design to calculate the amount of runoff caused by the first inch of rainwater on the impervious surface. Per Flagstaff city code and their Low Impact Development (LID) manual, this runoff must be redirected into a retention or detention basin to avoid overwhelming the municipal sewer and stormwater system [2]. A figure depicting the impervious surfaces used to calculate the stormwater runoff can be seen below in *Figure 7: Impervious Surfaces on the Project Site.* The amount of stormwater required to be captured is calculated to be 1,082 cubic ft, or 8,094 US gallons.

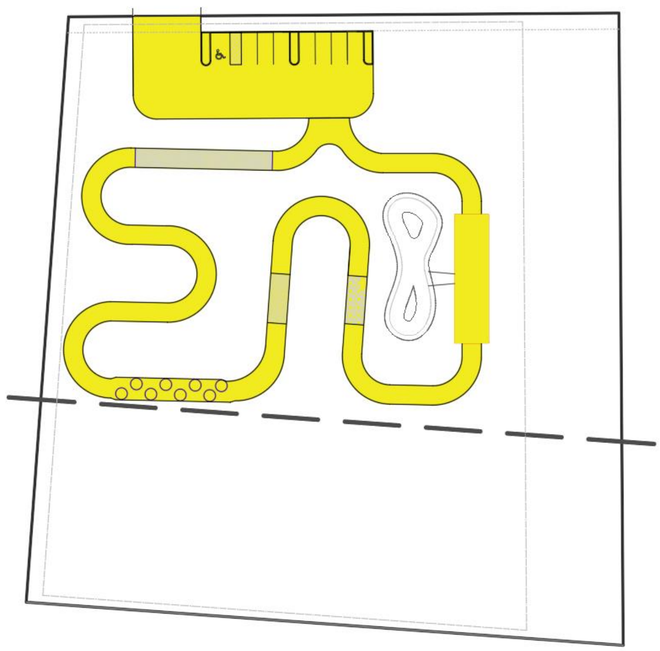

*Figure 7: Impervious Surfaces on the Project Site*

To utilize the stormwater runoff from the parking lot, the team will be designing a retention basin that will serve both to capture the required amount of runoff as well as serve as a mud-pit feature within the OHV park. The mud-pit feature will be designed in such a way that it does not have the potential to overflow in an uncontrolled fashion which has the potential to compromise and erode other features. Excess stormwater that is not required to be retained will be routed into a riprap lined detention basin, which will be integrated with the boulder garden feature. The riprap will protect the course from scour and water erosion and allow stormwater to percolate back into the ground, all while blending in with the existing course features.

The soil that will be used as the OHV course fill and track is unconstrained and therefore highly susceptible to water, wind, and mechanical erosion. Damage to the course caused by water erosion can be reduced through proper path-surface design, eliminating problems such as pooling and channeling of water on the track. The team has decided to design the track profile for straight segments with a 2% slope crown to divert water onto either side of the track, and a 2% slope superelevated profile to divert water to one side of the track for curved segments. An outslope shoulder of 2:1 proportions will lead into an armored ditch which will divert water to the mud-pit or rip rap detention basin. The team will determine the design slopes of the armored ditch system once the site design is complete. The team will be designing rolling dips as a form of ditch relief, as it is more cost effective than relief via a culvert and can be filled with riprap to serve as a feature and blend in with the course.

The track profile is designed in accordance with Publication 8262 - Rural Roads: A construction and Maintenance Guide for California Landowners and Gravel Roads Construction & Maintenance Guide [9], [10]. The roadside ditch will be designed in accordance with the California Department of Transportation Highway Design Manual, as it contains advanced details on design of ditches [11]. The placement and flow direction of the drainage channels on the project site can be seen below in *Figure 8: Runoff Channels (flow direction follows arrows)*

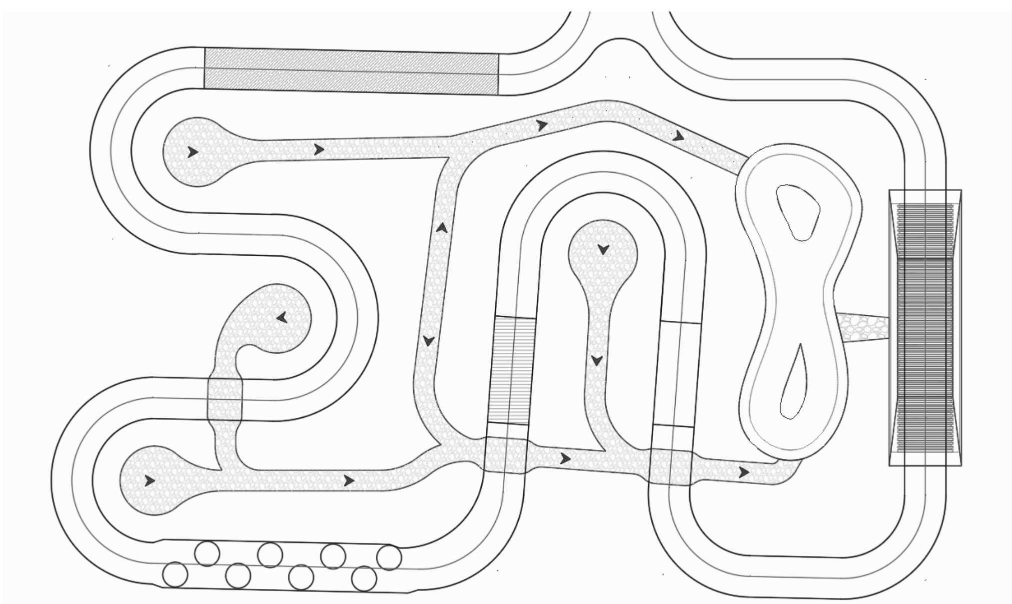

*Figure 8: Drainage Channels (flow direction follows arrows)*

A preliminary hydrological analysis of the project site was completed by the team in order to develop a stormwater drainage plan. The team completed an initial hydrological analysis of the project site, calculating the pre-development peak flow of stormwater off of the parcel. Variables that are assumed in the calculation of the pre-development peak flow of stormwater include a parcel area of 3.11 acres, an average slope of .00465 ft/ft (derived from the topographic map), a water flow length of 375', and a surface material of open space/range. Using the rational method depicted in the Stormwater Management Design Manual provided by the City of Flagstaff [1], the peak flow resulting from a 25-year storm is calculated to be .876 cfs. Stormwater systems in Flagstaff, AZ are required to handle the peak flow resulting from a 100-year storm, so the use of a 1.25 multiplier as per the Stormwater Management Design Manual is used to adjust the peak flow to 1.095 cfs [1].

Due to time constraints regarding the amount of work needed to accomplish the hydrological analysis, the team was unable to complete the entire analysis and additional work will need to be completed. The additional portions of the analysis that need to be completed include the volume calculations for the detention of the stormwater that is not related to the LID standards, the outflow design and routing of stormwater to the appropriate facilities, and a post-development hydrologic analysis.

# 4.0 Project Design

This section discusses each task associated with the design of the course. This includes the site layout, parking lot design, Ingress/Egress design, feature design as well as a safety plan.

## 4.1 Site Layout

The site location and building envelope of the proposed track design and its required parking lot have been provided and are visible in Figure 9. This shows an aerial view of the site, and the surrounding area

The site layout has been decided and can be seen below, in Figure 9. The figure shows the final layout decision along with the required parking, as well as the location and general size of each of the features. The parking lots were designed using the code requirements above, both for the City of Flagstaff and ADA. Lanes widths were designed with both safety and cost effectiveness in mind. While having smaller lanes would mean less cost, it would also decrease safety and people who are driving unfamiliar cars may be more likely to cause an accident. To mitigate the risk of an accident and therefore any possible lawsuits resulting in a payout by Findlay Toyota, larger lanes were selected for safety, even with the increased cost. These lanes were decided to be 12 feet wide instead of the smaller, yet acceptable, 10 feet wide.

Ultimately, the team decided upon the selected layout based off overall safety, economy, and features per area. The visibility is how visible each track would be from the street, as well as how easy to drive. Overall safety takes into consideration the amount of turns, the rate at which drivers would have to turn and space that drivers would have. Economy is essentially how much it would cost to build based on track area. Access point is the place where a vehicle would be able to get onto the track; which would have only one entrance/exit. Features per area is the amount of test features, ie. the boulder garden, hills etc., as a ratio compared to the total track area. The location of the features along the track can be seen in *Figure 9: Feature Placement*

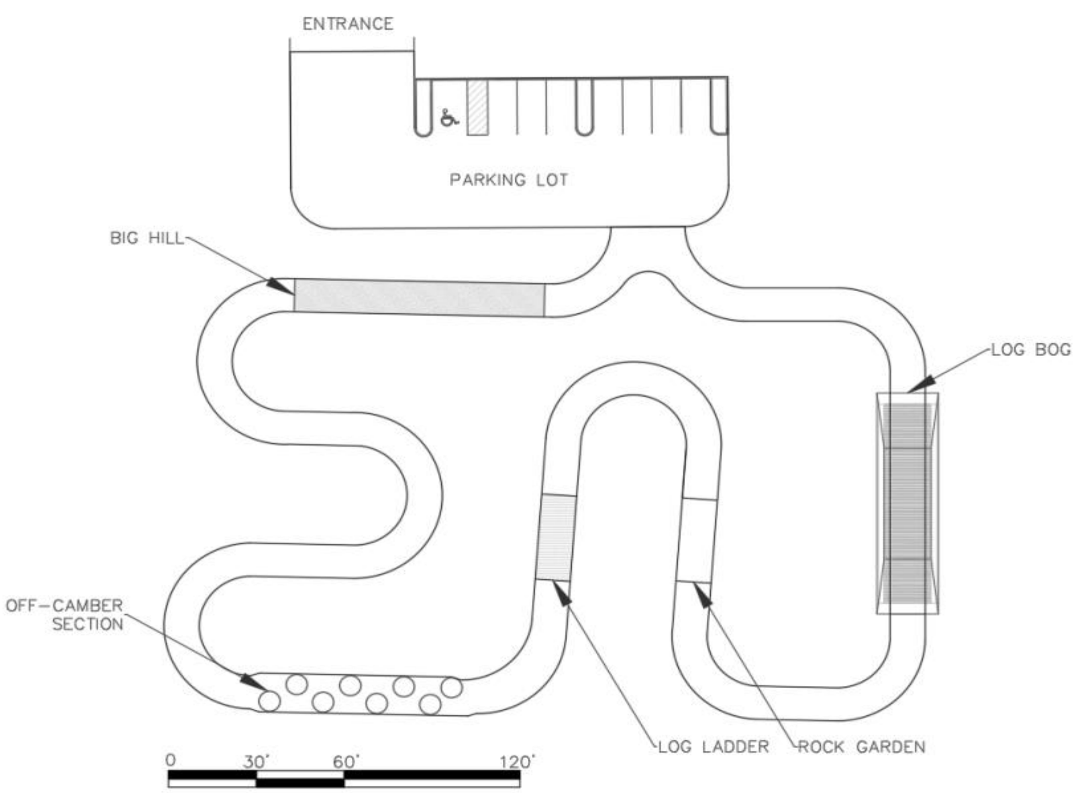


*Figure 9: Feature Placement*

## 4.2 Parking Lot Design

Using the city of Flagstaff's code, in combination with the knowledge that our site is a highway commercial zone, it was determined that the parking required with for our site would be one parking space per every 1500 gross square feet. This essentially was the area taken up by our course; however, the city allows for a regular reduction of up to 10% of parking spaces, and rounding to the nearest number of parking spaces. Ultimately it was determined that our chosen course will have 8 parking spaces, one of those being ADA compliant. They will measure 10 ft in width and 20 ft in length. The same is true of the ADA space, however, it also has an 8 ft by 20 ft area to allow for access by a wheelchair and wheelchair lift [3].

## 4.3 Ingress/Egress Design

This plan includes removal or addition of current sidewalk, curb, and wheel stops. Design and locations for the new driveway and the accompanying curb have been completed, and can be seen in *Figures 3,4, and 5*.

## 4.4 Feature Design

This section discusses the design of features to be seen on the course. To be sure that the features demonstrate the capabilities of both the Toyota 4Runner and Tacoma, the features were designed using the limiting vehicle specifications of the two vehicles.

### 4.4.1 Steep Hill

The hills for the course were designed using basic geometry in combination with the vehicle specifications, in particular the approach/departure angles as well as the ground clearance and wheelbase [3]. The approach and departure angles were used to determine the maximum angle that the vehicles would be climb and descend from, respectively. However, to ensure that the vehicles would be able to ascend and descend from either side, the maximum angle used in the hills was the departure angle. To be safe, it was slightly reduced from 23.5 degrees to 23. This also ensured that the hill would not be too steep for the vehicle to climb. Additionally, it was determined that the breakover angle, of 19 degrees (Determined using Equation 1), would cause the vehicle to get stuck while moving from the incline onto the peak of the hill, which resulted in the angle being changed halfway through the ascent of the hill. Lastly, to prevent anyone from driving off the sides, 24 inch boulders will be lined on both sides of the lane all across the hill. The final design and specific measurements can be seen in Appendix A.

$$B = 2\arctan(2G/W) \qquad \text{(Eq 1)}$$

*Equation 1:* B= 2arctan(2G/W) (Eq 1)

*B=Breakover angle (degrees)*
*G=Ground Clearance (inches)*
*W=Wheelbase (inches)*

### 4.4.2 Off-Cambers

The off-camber section of the course was designed to allow for demonstration of the suspension travel as well as the limited-slip differential and Active Traction Control system of the vehicles. This section consists of small hills with 3 foot diameter and 2 foot heights. The hills are spaced laterally per the average width of both primary test vehicles (4Runner and Tacoma) at 6.25 feet [12], [13]. The longitudinal spacing (along the centerline), was designed with the wheelbase specifications of the vehicle with the shortest wheelbase. This length is approximately 9 feet and was determined to be the limiting factor and thus was chosen for the longitudinal spacing. The height of the hill was chosen based on the suspension travel of vehicles. While the vehicle drives over the hills, alternating front and rear wheel suspension will be compressed, allowing for the other wheels to lift from the ground surface. In doing this, the power going to the wheels will be diverted to the wheels still in contact with the ground effectively demonstrating the traction control features of the vehicles [12], [13].

### 4.4.3 Log Ladder

The log ladder feature for the course represents washboard road situation which may experience in off-road courses. The purpose of the log ladder is to test the vehicle suspension. The entire feature of the log ladder is 30’ long, with a 6”-12” diameter (See appendix A figure 3.0 and 3.1).

### 4.4.4 Log Bog

The log bog for the course was designed to simulate someone driving through water. This feature will be filled using water with 1’ of freeboard. Additionally, it will have traction logs at the bottom of the log bog so the car won’t get stuck. However, to prevent the feature from overflowing and damaging the vehicles, there will be an outflow channel which leads into the detention basin using a riprap lined channel. (See Appendix A Figure 4.0, 4.1 and 4.2).

### 4.4.5 Boulder Garden

The hills for the course were designed using basic geometry in combination with the vehicle The boulder garden is designed using dimensions from the track and the vehicles. The width of the track will also be the width of the boulder garden, which is 12 feet wide. The length of the boulder garden will be longer than the vehicles, which are approximately 18 feet; this is to ensure that the vehicle completely fits within the boulder garden and the driver has an opportunity to actually drive on the boulders. To do this, the team recommends a length of 30 feet for the boulder garden. The team also considered using a 40 foot length but decided against due to increased cost. Lastly, the approximate diameters of these boulders should range between 18 inches and 24 inches (See appendix A figure 5.0 and 5.1). This allows for a bumpy ride that showcases the vehicle's ability to drive through a rocky terrain without putting the driver at risk by using larger boulders. Furthermore, using boulders/rocks any smaller than that would make it feel like the driver is simply driving through gravel.

## 4.5 Safety Plan

The safety plan has been completed and all materials required are included in the materials schedule. Specific instructions on setup for the safety features are included for each feature in the plan set. These include heights for sight poles on the hill, as well as entrance and exit signs.

# 5.0 Final Project Design

The final site design developed by the team can be seen below in *Figure 10: Final Design Layout*

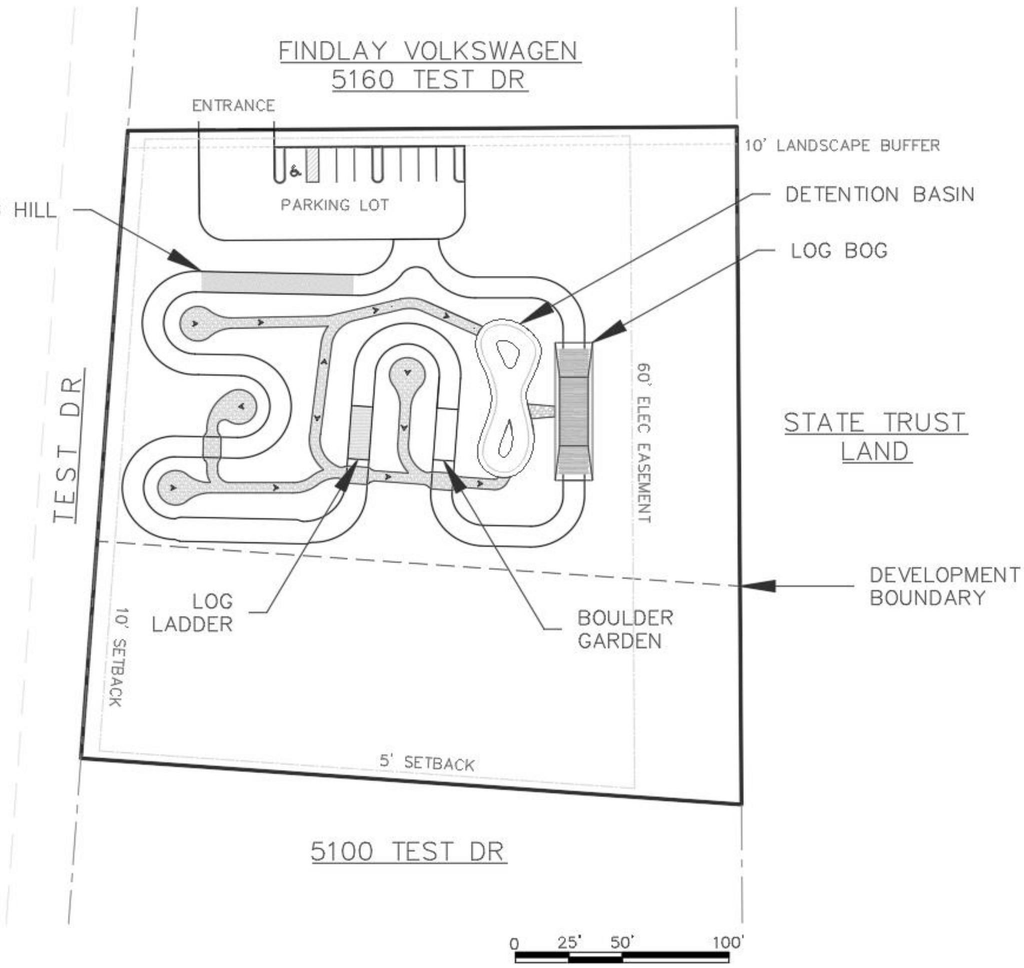


*Figure 10: Final Design Layout*

The final design includes the layout, features and drainage discussed in previous sections. The course uses the northernmost two acres as per client request (indicated by the Development Boundary line). The design will demonstrate a variety of vehicle capabilities including Hill Ascent/Descent, Traction Control, and 4 Wheel Drive.

# 6.0 Summary of Project Costs

The totals costs for the project consists of costs from two different sources, the materials and installation for the course and the actual cost of design. The breakdown for material and installation costs can be seen in Appendix D while staffing costs can be seen in Appendix E. Material-only costs were approximately $117,000 while material and installation costs were around $169,000. The costs for staffing were initially estimated to be around $70,000 but turned out to be only around $60,000 due to the team taking less time to design the course than originally anticipated. With this, the total project costs for design, materials and installation, is approximately $230,000.

# 7.0 Scheduling

Below, a simplified schedule can be seen, showing the original and actual end dates of the project tasks. The finish dates in green are dates that were finished on time, while the dates in red are tasks that were not completed in time. The Site Analysis and Geotechnical Analysis took much longer than expected due to issues with the weather and getting the equipment rented and paid for, which caused everything else to be behind. The other tasks were started but could not be completely finished until those two were done, which explains their later finish dates. The original Gantt Chart with the breakdown for each of the major tasks can be seen in Appendix F. The simplified schedule can be viewed on the next page in *Table 5: Simplified Schedule*

*Table 5: Simplified Schedule*

| # | Title | Due Date | Finish Date | Team Lead |
|---|---|---|---|---|
| 1.0 | Site Analysis | 2/15/17 | 2/24/17 | Malik |
| 2.0 | Code Review | 2/13/17 | 2/13/17 | Trandon |
| 3.0 | Geotechnical Testing/Analysis | 2/13/17 | 3/30/17 | Miranda |
| 4.0 | Drainage Analysis | 3/6/17 | 3/31/17 | Miranda |
| 5.0 | Project Site Design | 4/1/17 | 4/21/17 | William |
| 6.0 | Park Feature Design | 4/1/17 | 4/21/17 | Trandon |
| 7.0 | Deliverables and Project Management | Varies | 5/9/17 | William |

# 8.0 References

[1]"FLAGSTAFF CITY CODE", Flagstaff.az.gov, 2017. [Online]. Available: http://www.flagstaff.az.gov/DocumentCenter/Home/View/39021.

[2]"City of Flagstaff LID Manual", Flagstaff.az.gov, 2017. [Online]. Available: http://www.flagstaff.az.gov/DocumentCenter/Home/View/8401.

[3]"ADA Design Guide", Accessible Parking Spaces, 2017. [Online]. Available: https://www.ada.gov/restripe.pdf.

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[7]"Soil Classification | NRCS Soils", Nrcs.usda.gov, 2017. [Online]. Available: https://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/survey/class/.

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[9] University of California Division of Agriculture and Natural Resources, "Rural Roads: A construction and Maintenance Guide for California Landowners", Oakland, 2007.

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[12]"2017 Toyota 4Runner Engine & Mechanical Features", Toyota.com, 2017. [Online]. Available: http://www.toyota.com/4runner/features/mechanical_performance/8642/8646/8670/8672.

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# 9.0 Appendices

APPENDIX A: FEATURES

APPENDIX B: LID DESIGN

APPENDIX C: MATERIAL SCHEDULE

APPENDIX D: SCHEDULING AND STAFFING

APPENDIX E: GANTT CHART

APPENDIX F: BORING LOGS

APPENDIX G: SIEVE ANALYSIS RESULTS

Appendix A: Features

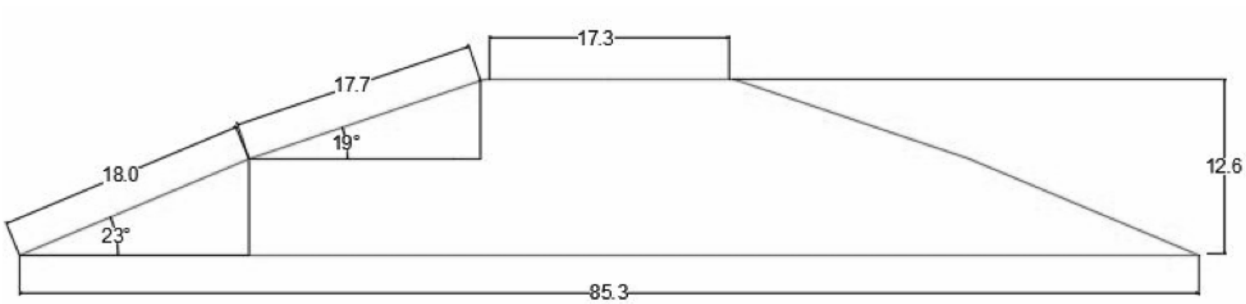



*Figure 1.0: A side view of steep hill design.*

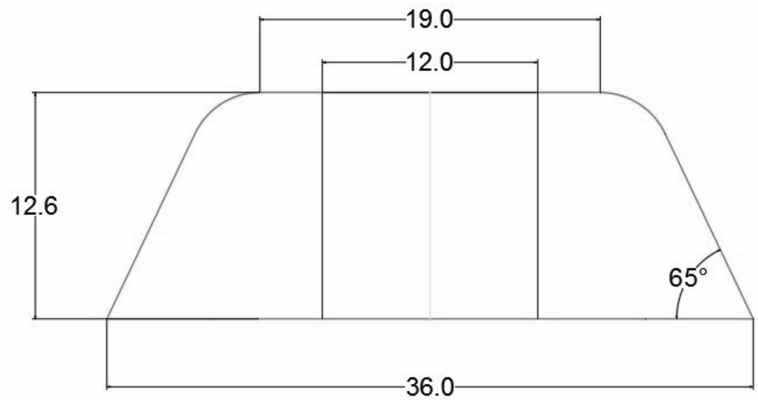



Figure 1.1: A front view of the steep hill.

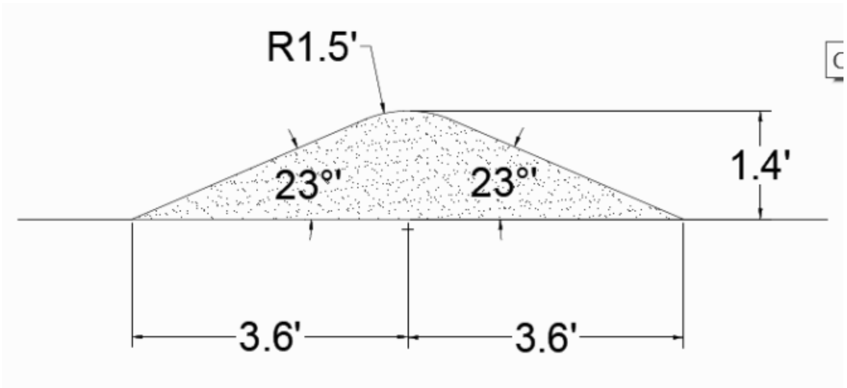



*Figure 2: Off-Camber Section Design*

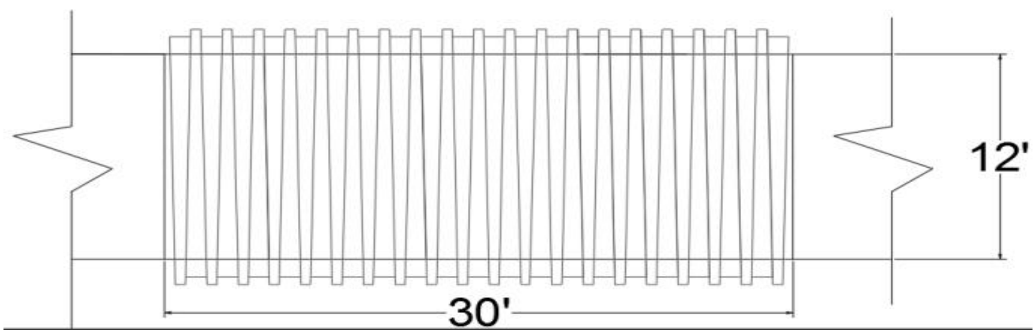


*Figure 3.0: Log Ladder feature showing length.*

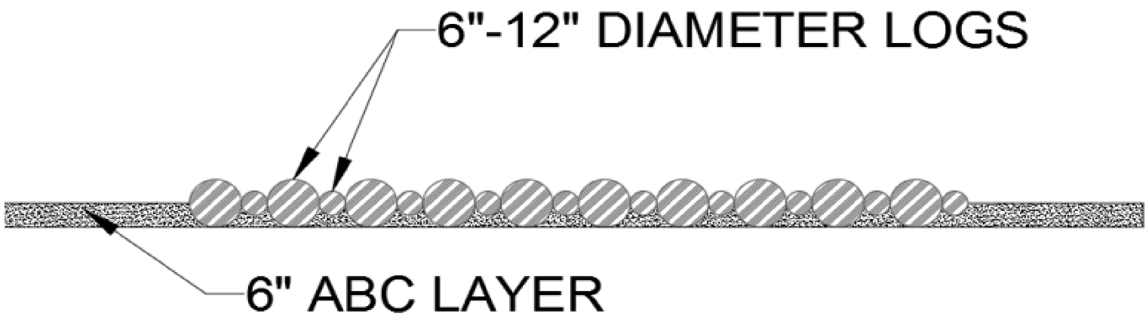



*Figure 3.1: Log Ladder feature showing log diameter.*

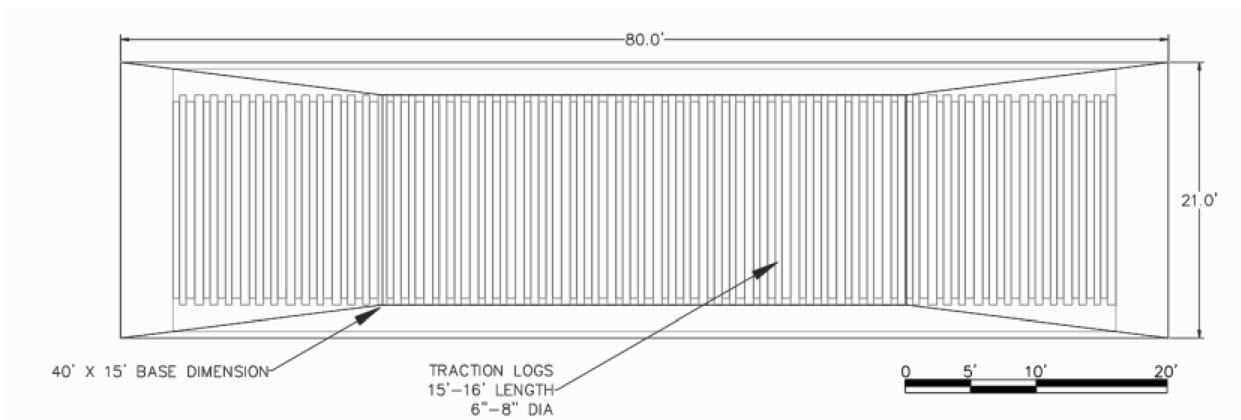



*Figure 4.0: Log Bog top view showing its dimensions.*

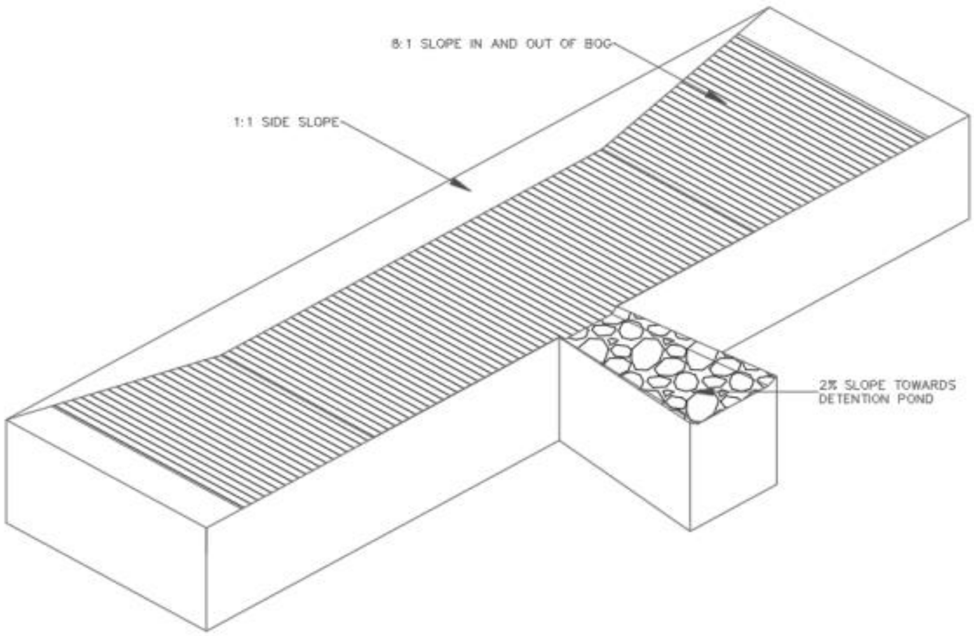



*Figure 4.1: Log Bog feature showing detention basin.*

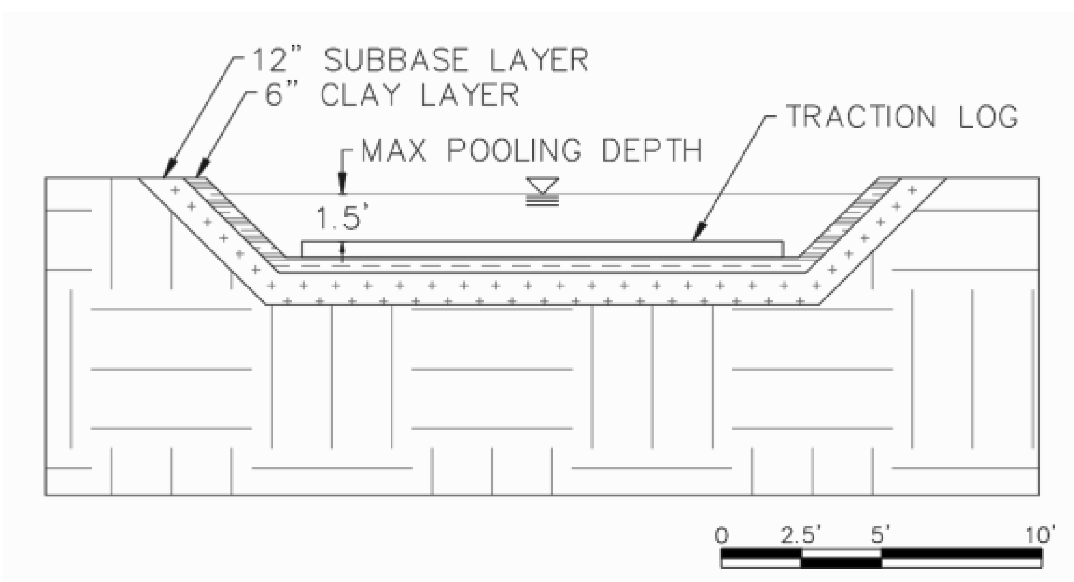



*Figure 4.2: A side view of Log Bog feature.*

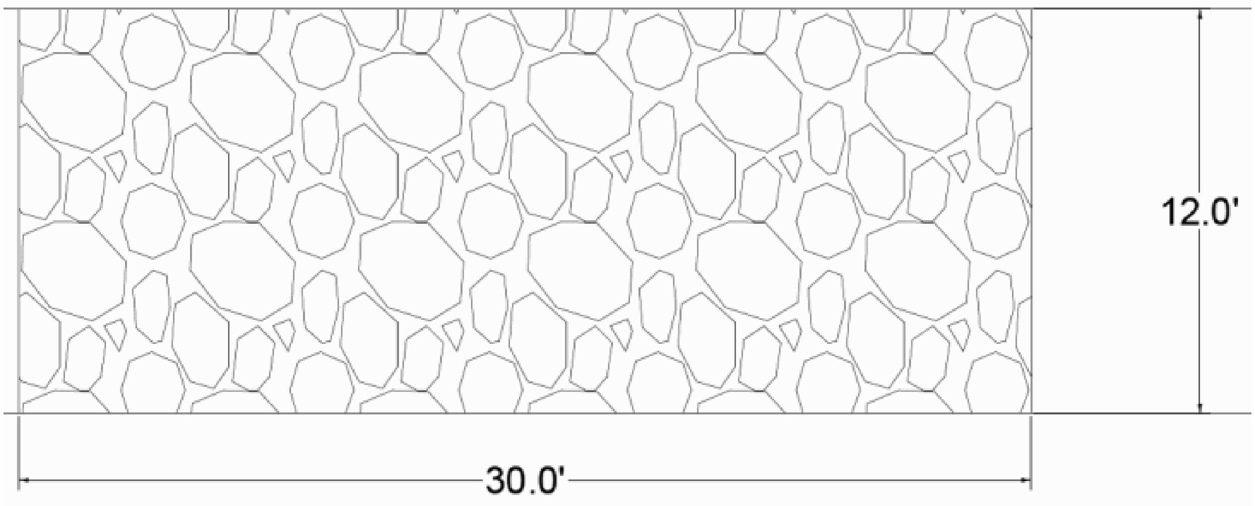


*Figure 5.0: Boulder Garden feature showing its dimensions.*

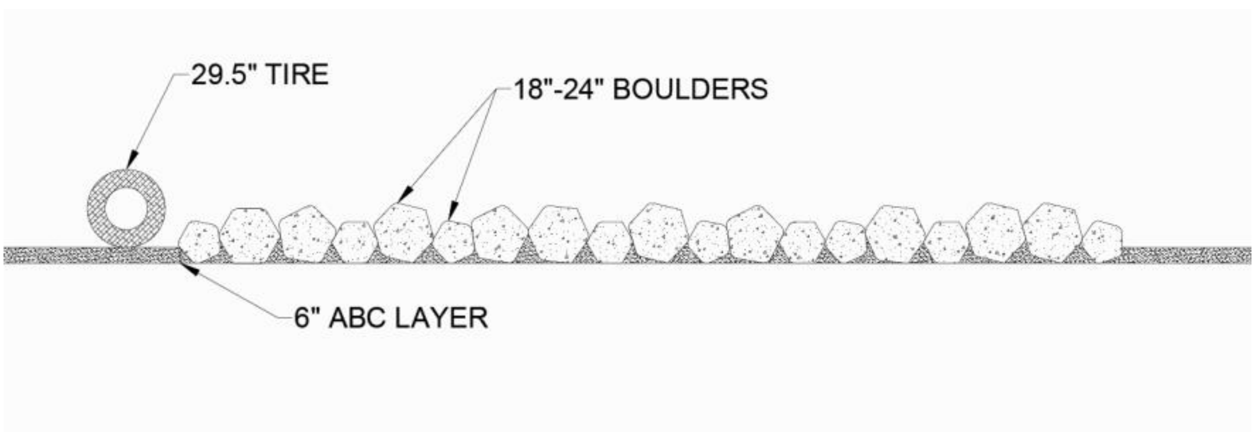


*Figure 5.1: Boulder Garden feature showing ABC layer.*

Appendix B: LID Design

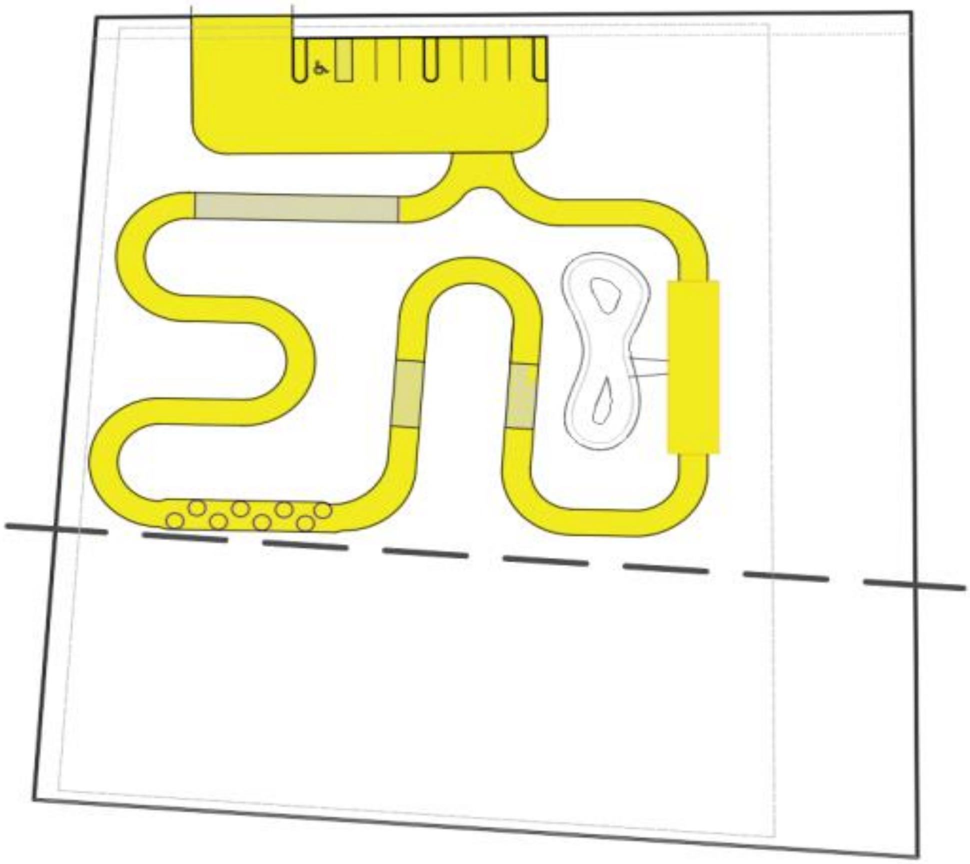


*Figure 1.0: LID Design which shows Impervious Surfaces in Yellow*

## Appendix C: Materials Schedule

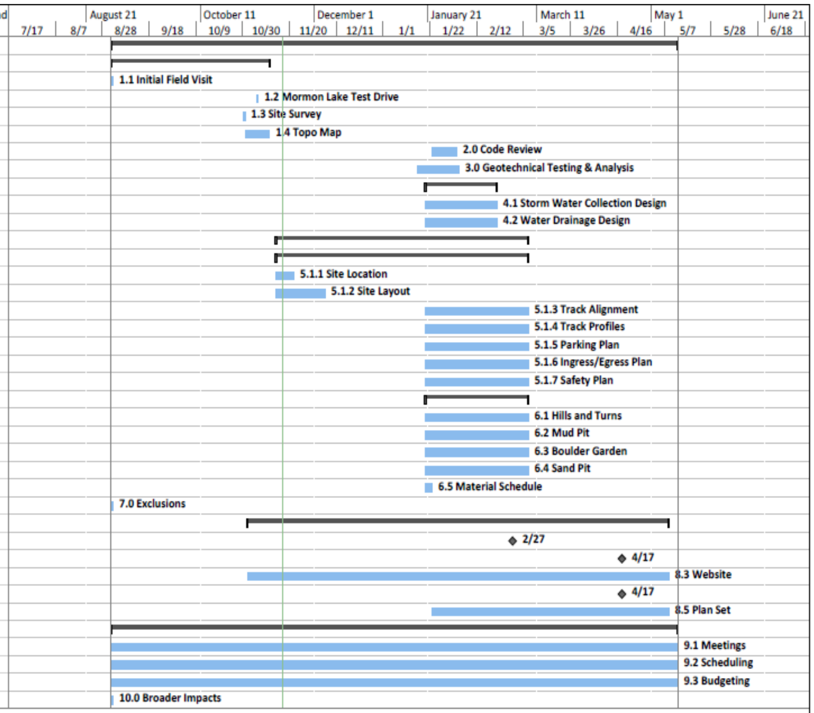
| Material | Use | Unit | Amount | Material only cost | Installed/Completed | Material Cost | Installed Cost |
|---|---|---|---|---|---|---|---|
| Driving Surface Aggregate | Off-Camber | ton | 132.20739 | $20.00 | $27.50 | $2,644.15 | $3,635.70 |
| Driving Surface Aggregate | Hills | ton | 1703.5095 | $20.00 | $27.50 | $34,070.19 | $46,846.51 |
| Driving Surface Aggregate | Surface Layer | ton | 333.9 | $20.00 | $27.50 | $6,678.00 | $9,182.25 |
| HMA | Parking | ton | 229.32 | $100.00 | X | $22,932.00 | $34,398.00 |
| Subbase | Track | ton | 1625.5 | $15.00 | $22.00 | $24,382.50 | $35,761.00 |
| Subbase | Parking | ton | 344.27 | $15.00 | $22.00 | $5,164.05 | $7,573.94 |
| Logs | Safety flag | Quantity | 5 | $110.00 | X | $550.00 | $825.00 |
| Logs | Log Features | Quantity | 110 | $110.00 | X | $12,100.00 | $18,150.00 |
| Riprap R-3 | Drainage | ton | 178 | $19.00 | $29.00 | $3,382.00 | $5,162.00 |
| Riprap R-5 | Boulder Garden | ton | 17.2 | $23.00 | $35.00 | $395.60 | $602.00 |
| Riprap R-6 | Boulder Garden | ton | 23.4 | $25.00 | $39.00 | $585.00 | $912.60 |
| Entrance/Exit Signs | Directions | sq ft | 16 | $18.00 | X | $288.00 | $432.00 |
| Square tubing | signs | LF | 28 | $15.00 | X | $420.00 | $630.00 |
| sign foundation | signs | Quantity | 4 | $175.00 | X | $700.00 | $1,050.00 |
| Concrete | Curb/Landscape | CY | 27.5 | $90.00 | X | $2,475.00 | $3,712.50 |
| | | | | | Total | $116,766.49 | $168,873.50 |

## Appendix D: Scheduling and Staffing

| Position | Actual Hours | Proposed Hours | Hourly Rate | Actual Cost | Proposed Cost |
|---|---|---|---|---|---|
| PM | 130.5 | 121 | $83.00 | $10,831.50 | $10,043.00 |
| INT | 182.5 | 240 | $51.00 | $9,307.50 | $12,240.00 |
| ENG | 145.5 | 228 | $106.00 | $15,423.00 | $24,168.00 |
| SENG | 141.25 | 146 | $167.00 | $23,588.75 | $24,382.00 |
| Total Hours | 599.75 | 735 | | $59,150.75 | $70,833.00 |

# Appendix E: Gantt Chart

| ID | Task Name | Duration | Start | Finish | Team Lead |
|---|---|---|---|---|---|
| 1 | **Findlay 4x4 OHV Park** | **254 days?** | **Thu 9/1/16** | **Fri 5/12/17** | |
| 2 | **1.0 Field Work** | **71 days** | **Thu 9/1/16** | **Thu 11/10/16** | **Miranda** |
| 3 | 1.1 Initial Field Visit | 1 day | Thu 9/1/16 | Thu 9/1/16 | Miranda |
| 4 | 1.2 Mormon Lake Test Drive | 1 day | Sat 11/5/16 | Sat 11/5/16 | Miranda |
| 5 | 1.3 Site Survey | 1 day | Sun 10/30/16 | Sun 10/30/16 | Malik |
| 6 | 1.4 Topo Map | 11 days | Mon 10/31/16 | Thu 11/10/16 | Malik |
| 7 | **2.0 Code Review** | 11 days | Mon 1/23/17 | Thu 2/2/17 | Trandon |
| 8 | **3.0 Geotechnical Testing & Analysis** | 19 days | Mon 1/16/17 | Fri 2/3/17 | Miranda |
| 9 | **4.0 Drainage Analysis** | **32 days** | **Fri 1/20/17** | **Mon 2/20/17** | **William** |
| 10 | 4.1 Storm Water Collection Design | 32 days | Fri 1/20/17 | Mon 2/20/17 | William |
| 11 | 4.2 Water Drainage Design | 32 days | Fri 1/20/17 | Mon 2/20/17 | William |
| 12 | **5.0 Project Site Design** | **113 days** | **Mon 11/14/16** | **Mon 3/6/17** | **William** |
| 13 | **5.1 Site Development Design** | **113 days** | **Mon 11/14/16** | **Mon 3/6/17** | **Miranda** |
| 14 | 5.1.1 Site Location | 8 days | Mon 11/14/16 | Mon 11/21/16 | Miranda |
| 15 | 5.1.2 Site Layout | 22 days | Mon 11/14/16 | Mon 12/5/16 | Miranda |
| 16 | 5.1.3 Track Alignment | 46 days | Fri 1/20/17 | Mon 3/6/17 | Malik |
| 17 | 5.1.4 Track Profiles | 46 days | Fri 1/20/17 | Mon 3/6/17 | Malik |
| 18 | 5.1.5 Parking Plan | 46 days | Fri 1/20/17 | Mon 3/6/17 | Miranda |
| 19 | 5.1.6 Ingress/Egress Plan | 46 days | Fri 1/20/17 | Mon 3/6/17 | Malik |
| 20 | 5.1.7 Safety Plan | 46 days | Fri 1/20/17 | Mon 3/6/17 | Malik |
| 21 | **6.0 Park Features Design** | **46 days** | **Fri 1/20/17** | **Mon 3/6/17** | **Trandon** |
| 22 | 6.1 Hills and Turns | 46 days | Fri 1/20/17 | Mon 3/6/17 | Trandon |
| 23 | 6.2 Mud Pit | 46 days | Fri 1/20/17 | Mon 3/6/17 | William |
| 24 | 6.3 Boulder Garden | 46 days | Fri 1/20/17 | Mon 3/6/17 | Miranda |
| 25 | 6.4 Sand Pit | 46 days | Fri 1/20/17 | Mon 3/6/17 | Miranda |
| 26 | 6.5 Material Schedule | 3 days | Fri 1/20/17 | Sun 1/22/17 | Malik |
| 27 | **7.0 Exclusions** | 1 day? | Thu 9/1/16 | Thu 9/1/16 | |
| 28 | **8.0 Project Deliverables** | **189 days?** | **Tue 11/1/16** | **Mon 5/8/17** | **William** |
| 29 | 8.1 50% Report | 1 day? | Mon 2/27/17 | Mon 2/27/17 | William |
| 30 | 8.2 Final Report | 1 day? | Mon 4/17/17 | Mon 4/17/17 | William |
| 31 | 8.3 Website | 189 days | Tue 11/1/16 | Mon 5/8/17 | William |
| 32 | 8.4 Presentation | 1 day? | Mon 4/17/17 | Mon 4/17/17 | William |
| 33 | 8.5 Plan Set | 106 days | Mon 1/23/17 | Mon 5/8/17 | William |
| 34 | **9.0 Project Management** | **254 days?** | **Thu 9/1/16** | **Fri 5/12/17** | **Miranda** |
| 35 | 9.1 Meetings | 254 days? | Thu 9/1/16 | Fri 5/12/17 | Miranda |
| 36 | 9.2 Scheduling | 254 days? | Thu 9/1/16 | Fri 5/12/17 | Miranda |
| 37 | 9.3 Budgeting | 254 days? | Thu 9/1/16 | Fri 5/12/17 | Miranda |
| 38 | **10.0 Broader Impacts** | 1 day? | Thu 9/1/16 | Thu 9/1/16 | |




Project: Findlay OHV Park
Date: Thu 11/17/16

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Task | | Project Summary | | Manual Task | | Start-only | | Deadline | |
| Split | | Inactive Task | | Duration-only | | Finish-only | | Progress | |
| Milestone | ◆ | Inactive Milestone | ◇ | Manual Summary Rollup | | External Tasks | | Manual Progress | |
| Summary | | Inactive Summary | | Manual Summary | | External Milestone | ◇ | | |

Page 1

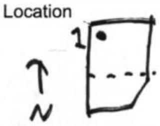
Appendix F: Boring Logs

Project No. ______ Project Name Findlay OHV Park  Date 2-25  Sheet 1 of 1

| | |
|---|---|
| Location | 5100 N Tuft Dr |
| Inspector | M AaRme A Alayan |
| Contractor | * Speedie & Associates |
| Driller | * Jon DeGeyter |
| Rig Type | * Case 580 N |
| Sample Types | |

Elevation ______ Datum ______

Boring Location




Tp-1

| WATER LEVEL INFORMATION | | | | |
|---|---|---|---|---|
| Depth of Hole | | | | |
| Depth to Water | | | | |
| Date & Time | | | | |

Notes: Proposed Parking Lot
Surficial Trash
Low grass

| Sample Number | Depth Interval | Inches Driven | Amount of Sample | Blows/6" | Percent Moisture | Wet Density | Dry Density | Depth, ft | Description Relative Density; Color; Soil Type; Moisture Content; Subordinates e.g. Hard Brown Sandy Clay Dry w/ Trace Gravel, Cementation, Air Voids etc.. | Graph | Well Diagram |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AS-1 | 1-3' | / | 2:p | | | | | 1 | 1-3' → 2-4 TSF, Medium Dense Brown, Silty Sand, Moist w/ trace Gravel Concrete @ 12", 4 ft (Asphalt). | | |
| | | | | | | | | 2 | | | |
| | | | | | | | | 3 | 3-5' Increasing clay content | | |
| BS-2 | 3-5' | / | 5g | | | | | 4 | | | |
| | | | | | | | | 5 | End TP at 5' | | |
| | | | | | | | | 6 | | | |
| | | | | | | | | 7 | | | |
| | | | | | | | | 8 | | | |
| | | | | | | | | 9 | | | |
| | | | | | | | | 0 | | | |
| | | | | | | | | 1 | | | |
| | | | | | | | | 2 | | | |
| | | | | | | | | 3 | | | |
| | | | | | | | | 4 | | | |
| | | | | | | | | 5 | | | |
| | | | | | | | | 6 | | | |
| | | | | | | | | 7 | | | |
| | | | | | | | | 8 | | | |
| | | | | | | | | 9 | | | |
| | | | | | | | | 0 | | | |

**Field Boring No.** B- TP-1

SPEEDIE AND ASSOCIATES

Project No. ______ Project Name Findlay Toyota OHV Park. Date 2-25 Sheet 1 of 1

| | |
|---|---|
| Location | TP-2 |
| Inspector | M Arton A Alaylan |
| Contractor * | Speedie & Associates |
| Driller * | J DeGraylor |
| Rig Type * | Case 580N |
| Sample Types | |

Elevation ______ Datum ______

Boring Location


WATER LEVEL INFORMATION

| | | | | | |
|---|---|---|---|---|---|
| Depth of Hole | | | | | |
| Depth to Water | | | | | |
| Date & Time | | | | | |

Notes: Superficial Trash - see photos
Low Brush

| Sample Number | Depth Interval | Inches Driven | Amount of Sample | Blows/6" | Percent Moisture | Wet Density | Dry Density | Depth, ft | Description: Relative Density; Color; Soil Type; Moisture Content; Subordinates e.g. Hard Brown Sandy Clay Dry w/ Trace Gravel, Cementation, Air Voids etc.. | Graph | Well Diagram |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AS-1 | 1-3' | / | Zip | | | | | | 1-3' 2.5-4.5 TSF, Medium Dense | | |
| | | | | | | | | 1 | Brown, sandy clay, ~5% gravel (Trace) | | |
| | | | | | | | | | Concrete @ 12" ), trace Cobble | | |
| | | | | | | | | 2 | | | |
| RS-2 | 3-4' | 12" | Rings | | | | | | | | |
| | | | | | | | | 3 | Orange-Brown | | |
| | | | | | | | | 4 | | | |
| AS-3 | 3-6' | / | Zip | | | | | | | | |
| BS4 | 3-6 | | Bulk | | | | | 5 | | | |
| | | | | | | | | 6 | | | |
| | | | | | | | | 7 | | | |
| | | | | | | | | 8 | | | |
| | | | | | | | | 9 | | | |
| | | | | | | | | 0 | Brown | | |
| | | | | | | | | 1 | End TP | | |
| | | | | | | | | 2 | | | |
| | | | | | | | | 3 | | | |
| | | | | | | | | 4 | | | |
| | | | | | | | | 5 | | | |
| | | | | | | | | 6 | | | |
| | | | | | | | | 7 | | | |
| | | | | | | | | 8 | | | |
| | | | | | | | | 9 | | | |
| | | | | | | | | 0 | | | |

**Field Boring No.** ~~B~~- TP-2

SPEEDIE AND ASSOCIATES

Project No. ____ Project Name ____ Date 2-25 Sheet 1 of 1

| | |
|---|---|
| Location | TP-3 |
| Inspector | M Aakne |
| Contractor | * Speedie & Associates |
| Driller | * J. Degeytar |
| Rig Type | * Case 580N |
| Sample Types | |

Elevation ____ Datum ____

Boring Location


**WATER LEVEL INFORMATION**

| | | | | |
|---|---|---|---|---|
| Depth of Hole | | | | |
| Depth to Water | | | | |
| Date & Time | | | | |

Notes: Superficial gravel & cobble
Mushy/Wet surface

| Sample Number | Depth Interval | Inches Driven | Amount of Sample | Blows/6" | Percent Moisture | Wet Density | Dry Density | Depth, ft | Description: Relative Density; Color; Soil Type; Moisture Content; Subordinates e.g. Hard Brown Sandy Clay Dry w/ Trace Gravel, Cementation, Air Voids etc.. | Graph | Well Diagram |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AS-2 | 0-4" | / | Zip | | | | | 1 | 3-4" → Asphalt millings, Black<br>4"-1.4" → Red, cindery | | |
| AS-3 | 4"-1'4" | / | Zip | | | | | 2 | 1'4" → 3'6" → Yellow Brown<br>↳ 3.5-4.5 TSF<br>Very stiff-Hard clay | | |
| BS-1 | 1'4"-3.5' | / | Bulk | | | | | 3 | Metal Plate @ 3' | | |
| | | | | | | | | 4 | | | |
| | | | | | | | | 5 | | | |
| AS-4 | 3.5'-6' | / | Zip | | | | | 6 | Dark Brown + Gravel, Some Cobble | | |
| | | | | | | | | 7 | Wire/Pipe debris @ 7' | | |
| | | | | | | | | 8 | Large Cobble (Fill) Concrete/Wood | | |
| | | | | | | | | 9 | End TP | | |
| | | | | | | | | 0 | | | |
| | | | | | | | | 1 | | | |
| | | | | | | | | 2 | | | |
| | | | | | | | | 3 | | | |
| | | | | | | | | 4 | | | |
| | | | | | | | | 5 | | | |
| | | | | | | | | 6 | | | |
| | | | | | | | | 7 | | | |
| | | | | | | | | 8 | | | |
| | | | | | | | | 9 | | | |
| | | | | | | | | 0 | | | |

**Field Boring No. B- TP-3**

SPEEDIE AND ASSOCIATES

| Project No. | Project Name Findlay Toyota OHV Park | Date 2-25 | Sheet 1 of 1 |
|---|---|---|---|

| | |
|---|---|
| Location | TP-4 |
| Inspector | M Aakre |
| Contractor | *Speedie & Associates |
| Driller | *J DeCraynter |
| Rig Type | *Case 580N |
| Sample Types | |

Elevation ______ Datum ______

Boring Location


| WATER LEVEL INFORMATION | | | | | |
|---|---|---|---|---|---|
| Depth of Hole | | | | | |
| Depth to Water | | | | | |
| Date & Time | | | | | |

Notes: Low Grass / Shrub

| Sample Number | Depth Interval | Inches Driven | Amount of Sample | Blows/6" | Percent Moisture | Wet Density | Dry Density | Depth, ft | Description<br>Relative Density; Color; Soil Type; Moisture Content; Subordinates<br>e.g. Hard Brown Sandy Clay Dry w/ Trace Gravel, Cementation, Air Voids etc.. | Graph | Well Diagram |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BS-1 | 1-3' | / | Bulk | | | | | 1 | 0-3' Reddish-Brown Concrete base 2-3" down / ~2-3" thick 1.75-3.5 TSF - Silty sand | | |
| | | | | | | | | 2 | | | |
| | | | | | | | | 3 | | | |
| RS-2 | 3-4' | 12" | Rings | | | | | 4 | | | |
| AS-3 | 3-5' | / | Zip | | | | | 5 | dark Brown w/ Black streaks | | |
| | | | | | | | | 6 | | | |
| | | | | | | | | 7 | | | |
| | | | | | | | | 8 | | | |
| AS-4 | 8-10' | | Zip | | | | | 9 | Black Sandy Pockets | | |
| | | | | | | | | 0 | | | |
| | | | | | | | | 1 | | | |
| | | | | | | | | 2 | | | |
| | | | | | | | | 3 | | | |
| | | | | | | | | 4 | | | |
| | | | | | | | | 5 | | | |
| | | | | | | | | 6 | | | |
| | | | | | | | | 7 | | | |
| | | | | | | | | 8 | | | |
| | | | | | | | | 9 | | | |
| | | | | | | | | 0 | | | |

**Field Boring No.** ~~B-~~ TP-4

SPEEDIE AND ASSOCIATES

| Project No. | | Project Name | | Date 2-25 | Sheet 1 of 1 |
|---|---|---|---|---|---|

| | | | |
|---|---|---|---|
| Location | TP-5 | Elevation | Datum |
| Inspector | M Anton WGil Tstruck | Boring Location | |
| Contractor | *Speedie & Associates |  | |
| Driller | *J DeGreyter | | |
| Rig Type | *Case 580N | | |
| Sample Types | | | |

| WATER LEVEL INFORMATION | | | | | Notes: Low grass / shrubs |
|---|---|---|---|---|---|
| Depth of Hole | | | | | |
| Depth to Water | | | | | |
| Date & Time | | | | | |

| Sample Number | Depth Interval | Inches Driven | Amount of Sample | Blows/6" | Percent Moisture | Wet Density | Dry Density | Depth, ft | Description<br>Relative Density; Color; Soil Type; Moisture Content; Subordinates<br>e.g. Hard Brown Sandy Clay Dry w/ Trace Gravel, Cementation, Air Voids etc.. | Graph | Well Diagram |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BS-1 | 1-3.5' | / | Bulk | | | | | 1 | Brown Sandy Clay Moist<br>Trace Gravel 1.25-2.5 TSF | | |
| | | | | | | | | 2 | | | |
| RS-2 | 3.5-4.5' | 12" | Ring | | | | | 3 | | | |
| | | | | | | | | 4 | 2.5' Dia Boulder @ 4' | | |
| | | | | | | | | 5 | Concrete @ 5' | | |
| | | | | | | | | 6 | | | |
| AS-3 | 7-10' | / | Zip | | | | | 7 | | | |
| | | | | | | | | 8 | | | |
| | | | | | | | | 9 | | | |
| | | | | | | | | 0 | end TP | | |
| | | | | | | | | 1 | | | |
| | | | | | | | | 2 | | | |
| | | | | | | | | 3 | | | |
| | | | | | | | | 4 | | | |
| | | | | | | | | 5 | | | |
| | | | | | | | | 6 | | | |
| | | | | | | | | 7 | | | |
| | | | | | | | | 8 | | | |
| | | | | | | | | 9 | | | |
| | | | | | | | | 0 | | | |

**Field Boring No. B-**

SPEEDIE AND ASSOCIATES

# Appendix G: Sieve Analysis Results

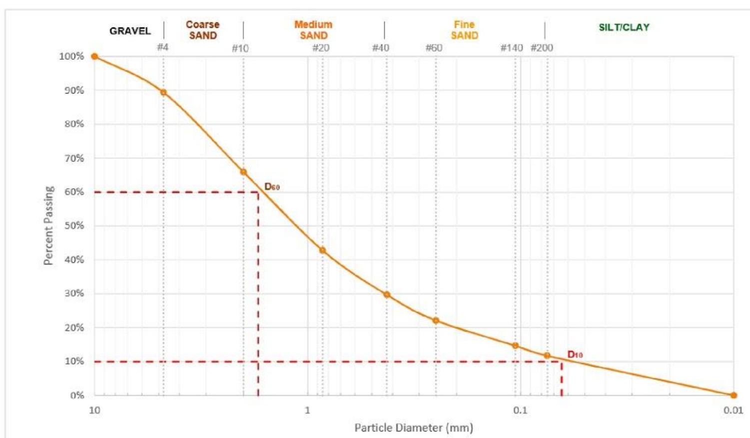
## Sieve Analysis Data Sheet

Project Name: Findlay 4x4 Boring No: TP1 Tested By: M Aakre
Location: 5130 N Test Dr Sample No: BS1 Date: 2/28/2017
Sample Depth: 1-3.5' Time: 1:10 PM

USCS Soil Classification:
AASHTO Soil Classification:

Initial Sample Weight (g): 501.05 g

| Sieve # | Sieve opening (mm) | Mass of sieve, A (g) | Mass of sieve and retained sample, B | Mass of sample, Wn (g) | Percent of mass retained, Rn | Cumalitive percent retained, ΣRn | Cumalitive percent passing, ΣRn |
|---|---|---|---|---|---|---|---|
| | 10 | | | | | | 100% |
| 4 | 4.75 | 774.21 | 827.37 | 53.16 | 10.63% | 10.63% | 89.37% |
| 10 | 2 | 409.59 | 527.08 | 117.49 | 23.49% | 34.12% | 65.88% |
| 20 | 0.85 | 393.40 | 509.12 | 115.72 | 23.14% | 57.26% | 42.74% |
| 40 | 0.425 | 384.85 | 450.19 | 65.34 | 13.06% | 70.32% | 29.68% |
| 60 | 0.25 | 367.57 | 405.45 | 37.88 | 7.57% | 77.89% | 22.11% |
| 140 | 0.106 | 338.28 | 375.48 | 37.20 | 7.44% | 85.33% | 14.67% |
| 200 | 0.075 | 319.16 | 334.06 | 14.90 | 2.98% | 88.31% | 11.69% |
| Pan | 0.01 | 366.23 | 424.7 | 58.47 | 11.69% | 100.00% | 0.00% |
| Σ | - | - | Wts= | 500.16 | 100.00% | - | - |



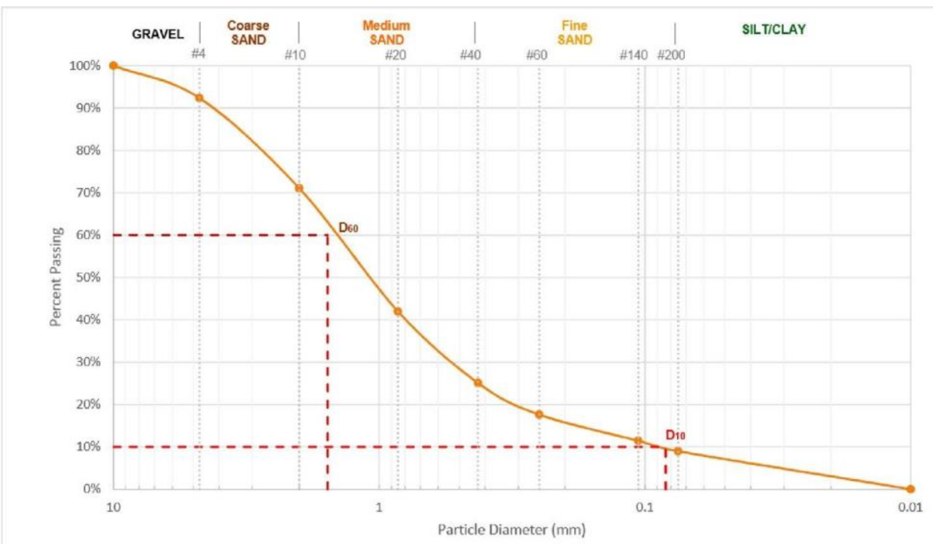
# Sieve Analysis Data Sheet

Project Name: Findlay 4x4 Boring No: TP2 Tested By: M Aakre, T Struck
Location: 5130 N Test Dr Sample No: BS4 Date: 2/28/2017
Sample Depth: 3-6' Time: 12:50 PM

USCS Soil Classification: ______
AASHTO Soil Classification: ______

Initial Sample Weight (g): 500.00 g

| Sieve # | Sieve opening (mm) | Mass of sieve, A (g) | Mass of sieve and retained sample, B | Mass of sample, Wn (g) | Percent of mass retained, Rn | Cumalitive percent retained, ΣRn | Cumalitive percent passing, ΣRn |
|---|---|---|---|---|---|---|---|
| | 10 | | | | | | 100% |
| 4 | 4.75 | 513.85 | 551.86 | 38.01 | 7.62% | 7.62% | 92.38% |
| 10 | 2 | 453.42 | 559.68 | 106.26 | 21.31% | 28.93% | 71.07% |
| 20 | 0.85 | 394.93 | 539.98 | 145.05 | 29.09% | 58.01% | 41.99% |
| 40 | 0.425 | 399.30 | 483.53 | 84.23 | 16.89% | 74.90% | 25.10% |
| 60 | 0.25 | 372.06 | 409.35 | 37.29 | 7.48% | 82.38% | 17.62% |
| 140 | 0.106 | 339.83 | 370.65 | 30.82 | 6.18% | 88.56% | 11.44% |
| 200 | 0.075 | 341.38 | 353.69 | 12.31 | 2.47% | 91.03% | 8.97% |
| Pan | 0.01 | 364.15 | 408.89 | 44.74 | 8.97% | 100.00% | 0.00% |
| Σ | - | - | Wts= | 498.71 | 100.00% | - | - |



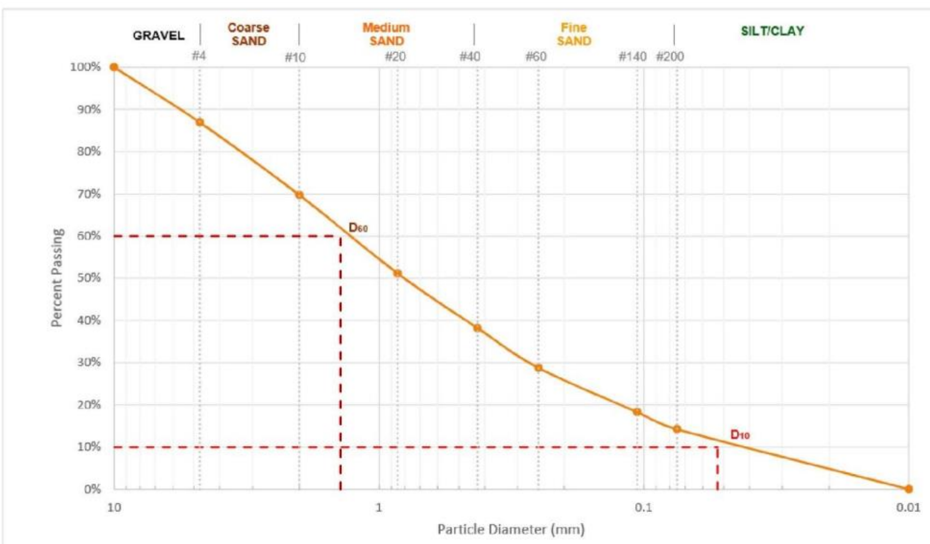
# Sieve Analysis Data Sheet

Project Name: Findlay 4x4 Boring No: TP3 Tested By: M Aakre, T Struck
Location: 5130 N Test Dr Sample No: BS1 Date: 2/28/2017
Sample Depth: 1'4"-3'6" Time: 2:32 PM

USCS Soil Classification:
AASHTO Soil Classification:

Initial Sample Weight (g): 500.5 g

| Sieve # | Sieve opening (mm) | Mass of sieve, A (g) | Mass of sieve and retained sample, B | Mass of sample, Wn (g) | Percent of mass retained, Rn | Cumalitive percent retained, ΣRn | Cumalitive percent passing, ΣRn |
|---|---|---|---|---|---|---|---|
| | 10 | | | | | | 100% |
| 4 | 4.75 | 774.24 | 839.58 | 65.34 | 13.07% | 13.07% | 86.93% |
| 10 | 2 | 409.63 | 495.61 | 85.98 | 17.20% | 30.28% | 69.72% |
| 20 | 0.85 | 393.44 | 486.31 | 92.87 | 18.58% | 48.86% | 51.14% |
| 40 | 0.425 | 384.85 | 449.58 | 64.73 | 12.95% | 61.81% | 38.19% |
| 60 | 0.25 | 367.64 | 414.76 | 47.12 | 9.43% | 71.24% | 28.76% |
| 140 | 0.106 | 338.26 | 390.71 | 52.45 | 10.49% | 81.73% | 18.27% |
| 200 | 0.075 | 319.18 | 339.43 | 20.25 | 4.05% | 85.78% | 14.22% |
| Pan | 0.01 | 366.20 | 437.25 | 71.05 | 14.22% | 100.00% | 0.00% |
| Σ | - | - | Wts= | 499.79 | 100.00% | - | - |



# Sieve Analysis Data Sheet

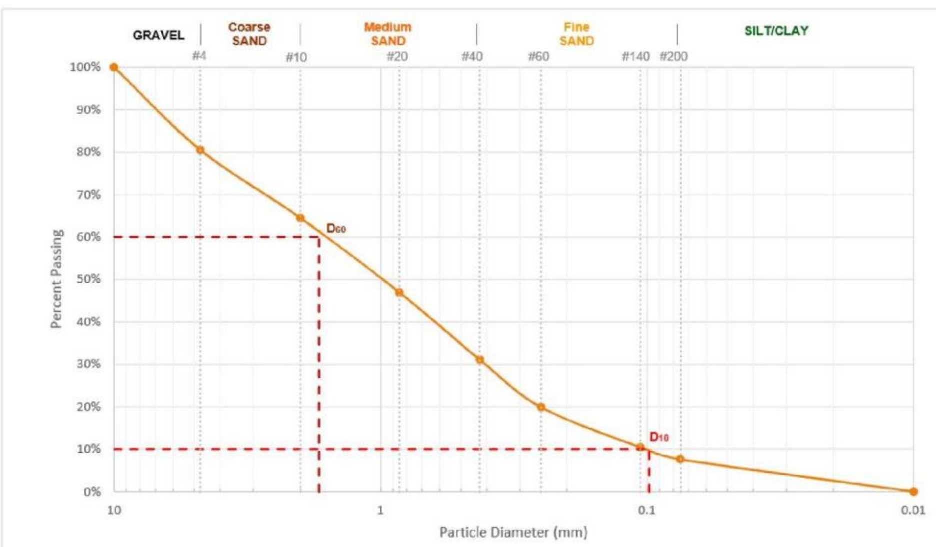
Project Name: Findlay 4x4 | Boring No: TP4 | Tested By: M Aakre
Location: 5130 N Test Dr | Sample No: BS1 | Date: 2/28/2017
Sample Depth: 1-3' | Time: 3:15 PM

USCS Soil Classification: ______

AASHTO Soil Classification: ______

Initial Sample Weight (g): 500.82 g

| Sieve # | Sieve opening (mm) | Mass of sieve, A (g) | Mass of sieve and retained sample, B | Mass of sample, Wn (g) | Percent of mass retained, Rn | Cumalitive percent retained, ΣRn | Cumalitive percent passing, ΣRn |
|---|---|---|---|---|---|---|---|
| | 10 | | | | | | 100% |
| 4 | 4.75 | 774.25 | 871.62 | 97.37 | 19.46% | 19.46% | 80.54% |
| 10 | 2 | 409.68 | 489.89 | 80.21 | 16.03% | 35.49% | 64.51% |
| 20 | 0.85 | 393.44 | 481.37 | 87.93 | 17.57% | 53.06% | 46.94% |
| 40 | 0.425 | 384.91 | 464.05 | 79.14 | 15.82% | 68.87% | 31.13% |
| 60 | 0.25 | 367.70 | 423.85 | 56.15 | 11.22% | 80.10% | 19.90% |
| 140 | 0.106 | 338.35 | 385.66 | 47.31 | 9.45% | 89.55% | 10.45% |
| 200 | 0.075 | 319.22 | 333.28 | 14.06 | 2.81% | 92.36% | 7.64% |
| Pan | 0.01 | 366.22 | 404.45 | 38.23 | 7.64% | 100.00% | 0.00% |
| Σ | - | - | Wts= | 500.40 | 100.00% | - | - |



# Sieve Analysis Data Sheet

Project Name: Findlay 4x4 Boring No: TP5 Tested By: M Aakre
Location: 5130 N Test Dr Sample No: BS1 Date: 2/28/2017
Sample Depth: 1-3' Time: 2:01 PM

USCS Soil Classification: ____________________
AASHTO Soil Classification: ____________________

Initial Sample Weight (g): 500.51 g

| Sieve # | Sieve opening (mm) | Mass of sieve, A (g) | Mass of sieve and retained sample, B | Mass of sample, Wn (g) | Percent of mass retained, Rn | Cumalitive percent retained, ΣRn | Cumalitive percent passing, ΣRn |
|---|---|---|---|---|---|---|---|
| | 10 | | | | | | 100% |
| 4 | 4.75 | 513.87 | 592.23 | 78.36 | 15.67% | 15.67% | 84.33% |
| 10 | 2 | 453.51 | 557.31 | 103.80 | 20.76% | 36.43% | 63.57% |
| 20 | 0.85 | 416.09 | 526.74 | 110.65 | 22.13% | 58.56% | 41.44% |
| 40 | 0.425 | 399.24 | 468.06 | 68.82 | 13.76% | 72.32% | 27.68% |
| 60 | 0.25 | 372.10 | 410.09 | 37.99 | 7.60% | 79.92% | 20.08% |
| 140 | 0.106 | 339.87 | 378.28 | 38.41 | 7.68% | 87.60% | 12.40% |
| 200 | 0.075 | 341.41 | 355.65 | 14.24 | 2.85% | 90.45% | 9.55% |
| Pan | 0.01 | 364.11 | 411.85 | 47.74 | 9.55% | 100.00% | 0.00% |
| Σ | - | - | Wts= | 500.01 | 100.00% | - | - |