Final Design Report
For
Residential Drop-off Center

Prepared for:
Cinder Lake Landfill
City of Flagstaff, Arizona

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1.0 Project Description

A Residential Drop-Off Center (RDC) will be designed at the Cinder Lake Landfill (CLL). The CLL provides services to the 68,000 residents of the City of Flagstaff. It will remain in service for its expected lifetime extending to the year 2054 with a thirty year rehabilitation period after closure.

CLL is located northeast of Flagstaff and two miles east of US Highway 89 in Coconino County. The site is located in Township 22 north, range 8 east and section 11. The location of this site can be seen in Figure 1 and 2 below. A vicinity map is also included in Appendix A.

Figure 1 Cinder Lake Landfill Location www.google.com/maps/

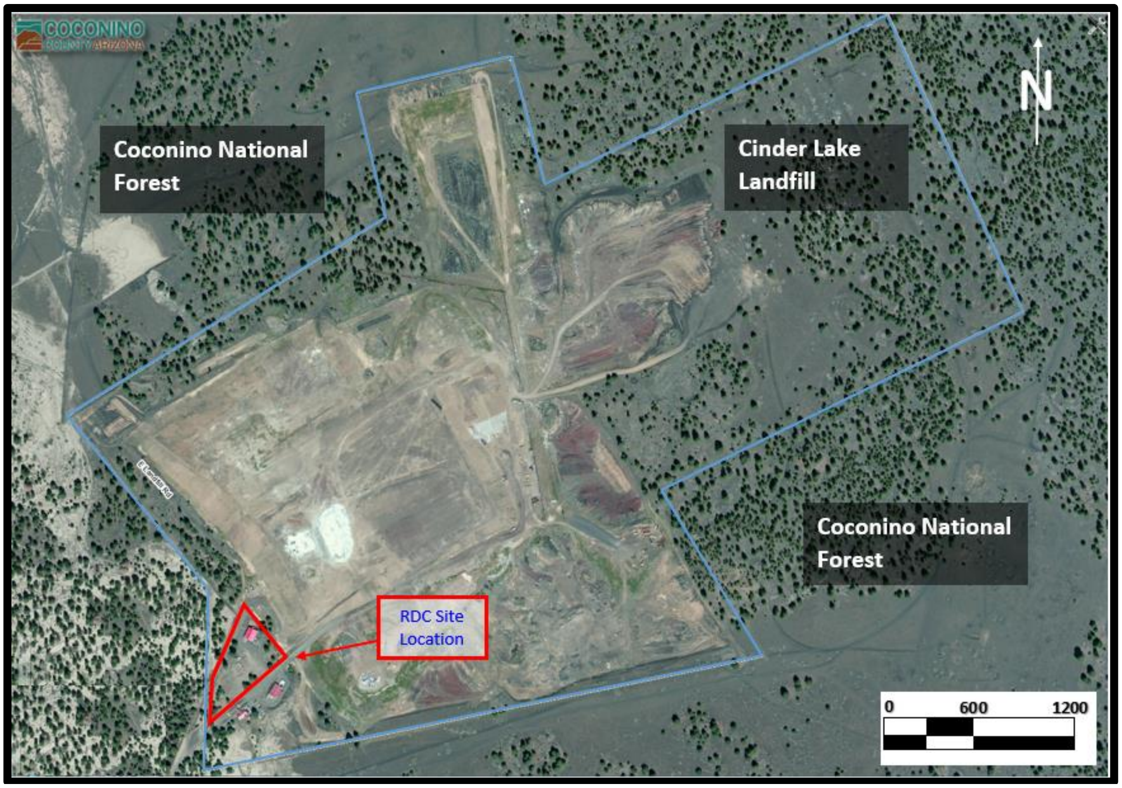

Figure 2 Cinder Lake Landfill Property **http://gismaps.coconino.az.gov/parcelviewer/**

The general traffic that flows through CLL is the municipal solid waste collector trucks belonging to the City of Flagstaff, city residents, Coconino County residents, contractors, and commercial/industrial businesses. All vehicles, excluding residential customers, must be weighed prior to entering the landfill and a fee is given per tonnage of landfill waste.

Both residential and commercial users enter the landfill through the same access road. Traffic control, therefore, is a crucial design aspect within the landfill as it changes daily due to the decreased airspace over time. The waste drop-off location is currently located at the working face of the landfill, which leaves it exposed to high speed winds. High profile vehicles and the waste compactors, therefore, pose a risk to the residential customers due to the possibility of tipping. To mitigate the hazards present to the residents, an on-site Residential Drop-Off Center will be designed.

Cinder Lake Landfill currently accepts several types of waste which can be found on the City of Flagstaff website http://www.flagstaff.az.gov/. For the convenience of the customers the proposed Residential Drop-Off Center will accept the following types of waste:

- -MSW
- -Recycling (Paper, Plastic, etc.)
- -Wood/Green Waste
- -Glass waste
- -Ashes

These items will be separated into a total of six different 40 yard roll-off bins. The proposed location for this drop-off center will be at the current entrance just north of the access road. This can be seen in Figure 3 below.

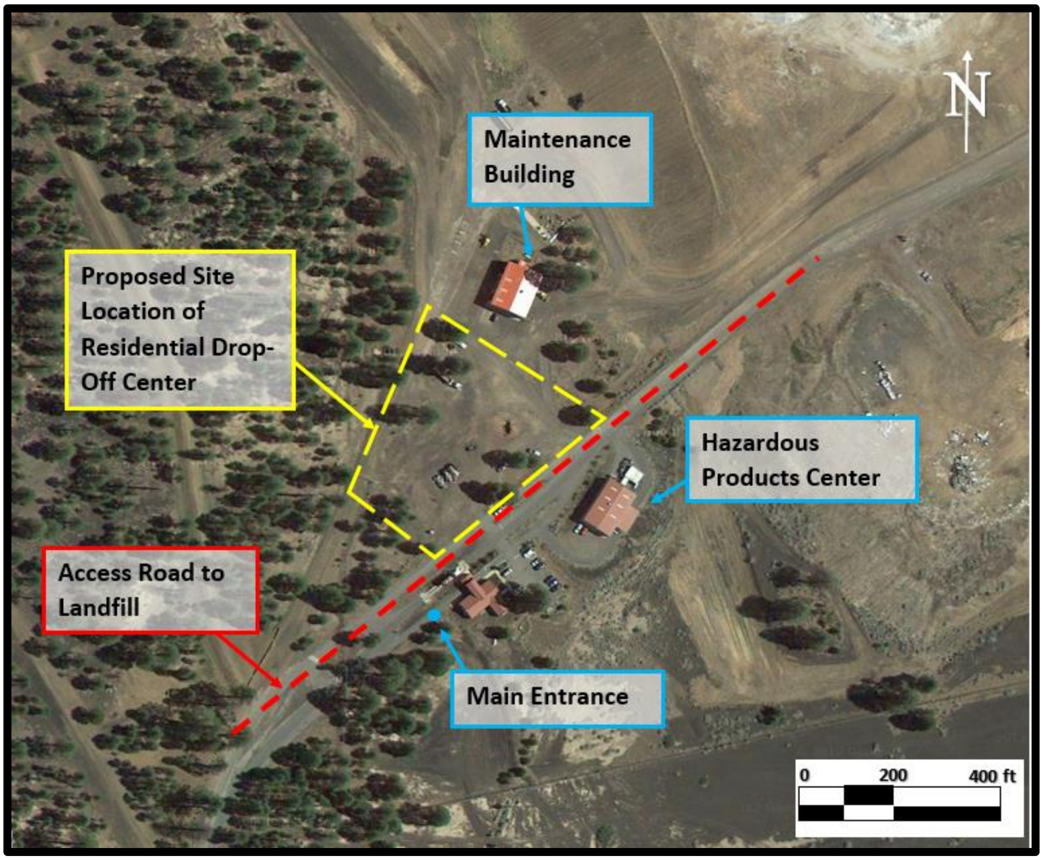

Figure 3 Proposed Site of Residential Drop-Off Center

1.1 Existing Conditions

There are several aspects of the existing location that will affect the design of the RDC. These conditions include the hydrology of the land, existing vegetation, and the entrance.

1.1.1 Hydrology

Due to the Shultz fire in 2010, the drainage characteristics have changed in the land surrounding the Cinder Lake landfill. The path of flow for the storm water has the potential to affect the RDC. In measures to prevent offsite runoff from entering the landfill property, berms have been placed near the entrance of the landfill.

This prevents the contamination of offsite runoff due to contact with the landfill surface. All onsite runoff is conveyed through three culverts that connect to a nearby retention basin. One culvert is sized at 48 inches with nearly two feet of sediment. The other two culverts are sized at 18 inches. All hydraulic features can be seen in Appendix B.

1.1.2 Existing Vegetation

There are approximately 15 existing pine trees located in the general area of the RDC. In a forest restoration project in Northern Arizona, all trees with a diameter of 16 inches or greater must not be removed without proper consideration. This project will also require considerations for existing plant units and future accommodations for landscaping.

1.1.3 Entrance

The entrance to the landfill was designed to service the general public, industrial/commercial businesses etc. Typically residents enters the landfill on the south side while commercial customers enter on the north, see Figure 4. The entrance shall remain the same and shall not be affected by the creation of the RDC. All entering vehicles merge into the same access road leading to the working face of the landfill. Traffic control is, therefore, necessitated at this location.

Figure 4 Cinder Lake Landfill Entrance

2.0 Background

The background information for this project consists of the present site conditions as well as the technical background needed to begin this project. The first portion of the background and the basis to all analysis is the surveying of the project site. The site of the Residential Drop-Off Center (RDC) requires survey data so the slopes and elevations can be recorded. The surveying was performed with GPS with a base station located at the landfill managing offices on site. GPS equipment gives accurate readings that are determined by the satellites within range. The more satellites that are present, the more accurate the data. The collected survey points exhibited the shallow drainage paths of the onsite runoff. With the collected 300+ survey points, the design of the RDC could commence and the current site conditions could be analyzed. These survey points were put into AutoCAD to obtain all the needed components.

With the surveying complete, new tasks were able to begin. Some of these components required background research utilizing the following:

1. International Building Code (IBC)
2. RS Means
3. Federal Highway Administrative Headwater Depth Nomographs

2.1 International Building Code

The IBC has not yet been referenced but will be used in the upcoming weeks. This code shall be used to find proper safety regulations for the RDC. This code consists of 35 chapters and 13 appendices with content needed for the safety. This code will be used for all aspects of the RDC in order to preserve the safety of the residential customers.

2.2 RS Means

RSMeans is a reference book that is employed to determine the construction costs of various aspects of the project. This reference book aided in the costs for the different surface alternatives. The price that was used for every single surface was the cost of compaction of the soil. This pricing included the labor and installation costs as well as the maintenance costs. These calculations are not completely accurate due to the outdated version of the RSMeans available.

2.3 Federal Highway Administrative Headwater Depth Nomographs

These nomographs were used to find the headwater over diameter ratio. This ratio is required to be less than 1 in order to have no potential overbanking. These calculations were performed for both the 48 inch concrete culvert and the 18 inch corrugated metal pipe culvert in order to ensure that they can maintain the current flow and expected future flow created from the RDC design.

3.0 Identification of Alternatives

It is necessary to consider all options in choosing the details of the final design for the residential drop-off center. Design alternatives were chosen for the surface pavement to be implemented on-site. It was additionally necessary to consider the elevation of the bin top elevations.

3.1 Surface Alternative

There are several design alternative options considered for the surface type of the Residential Drop-Off Center. A flexible pavement was considered in choosing the design alternative. The design alternatives considered were impervious asphalt, modular block pavers, gravel paving, and compacted fill.

3.1.1 Impervious Asphalt

Impervious asphalt is the standard material used for roadways, and parking lots, as seen in Figure 5. This is the ideal roadway surface because of its durability, lifespan, and ease of maintenance. The cost of the asphalt along with the required subgrade is $2.43 according to RSMeans [2]. It has a lifespan of 20 years with a maintenance every 5-7 years [3].

Figure 5 Impervious Asphalt Parking Lot

3.1.2 Modular Block Pavers

Modular block pavers is an acceptable alternative to be considered. This option is ultimately in consideration due to the ease of installation. This alternative is typically utilized within driveways, and not in roadways. It can, however, be used in parking lots. The cost of the pavers is $2.21/ft^2 along with the cost of subrade at $1.20/ft^2. [4] Modular block pavers have the same lifespan as asphalt: 20 years. It has required maintenance of every five years along with frequent inspection and debris removal.

Figure 6 Modular Block Paved Parking Lot

3.1.3 Gravel

Gravel is the use of compacting the soil and placing approximately 12 inches of gravel on top of the soil. Gravel consists of placing large rocks at the bottom of the gravel and placing smaller rocks on top until the top layer consists of pebble sized rocks. The benefits of this is that it is reasonably cheap. Gravel needs to be replaced about every 10 years and requires much maintenance. [5]

Figure 7 Gravel Lot

3.1.4 Compacted Fill

Compacted fill consists of soil currently located in the landfill acting as the parking lot surface. This soil would need to be compacted a great deal in order to make it useable as a road without much erosion. This alternative would be a very cheap alternative but would need much upkeep with the amount of rain/snow that Flagstaff receives. [5]

Figure 8 Compacted Fill Lot

3.2 Height Alternatives

Two different alternatives for the height of the 40-roll-off bins above the ground surface were considered to ensure the safety of the residential customers. One option is to reduce the needed fill so that the bins would be 2.5 ft. above the ground surface. This would provide an adequate barrier to prevent harm to the customers. The second option is to have the bins level to the surface of the ground. This would allow the residents to dispose of their waste on a concrete pad in front of the bins and keep them away from the disposal bins.

3.2.1 Above Ground Level

As seen in the picture below, the bin is located at a predetermined height above the ground surface. This alternative considered for the Residential Drop-Off Center has the bin at a height of 2.5 feet higher than the ground surface. This would be advantageous to reduce the cut needed for the project, thereby reducing costs. A 2.5 feet height also enhances the safety of the residential customers by creating a barrier to the open bin.

Figure 9: Above Ground Bin Elevation

3.2.2 Surface Elevation

This alternative requires the top of the roll-off bin to be located at the ground surface elevation. This allows customers to drop off their waste in a designated safe zone and allow a skid steer loader push it into the provided roll-off bins. This will allow for a more controlled and safe environment for the customers. This concept has been set into place by other landfills as seen in the picture located below.

Figure 10 Bins at Surface Elevation

4.0 Analysis

4.1 Hydrology

4.1.1 Objective

The objective of the analysis is to determine the impact the proposed development will have on the runoff characteristics of the site. Mitigation measures will be provided for adverse impacts to the runoff conditions. The design of the proposed drainage control structures will be in accordance with the Coconino County Drainage Design Criteria.

4.1.2 Existing Conditions

The existing drainage area consists of; maintenance garage, asphalt and gravel road, rolling open land, ponderosa pine forest, widely spaced shrubs and currant, and a sparse cover of grasses.

The CLL is located in the Rio de Flag drainage area. There are no washes evident in the Cinder Lake. The offsite run-on will not be considered in the analysis because there are 6 foot berms located outside the perimeter of CLL to mitigate flooding. The area is relatively flat and has a high infiltration capacity, see Reference 7.

The project is located in Zone X of the FEMA Flood Insurance Rate Map, number FM04005C6470G, and September 3, 2010. Zone X is described as an area determined to be outside the 500-year floodplain. Appendix A contains a copy of the FIRM map with the location of the project site, see Appendix B. There are no floodplains located near the CLL site. The closest floodplain is 4 miles south of the site.

4.1.2.1 Offsite Drainage Area

In the summer of 2010 a large fire burned more than 15,000 acres on the east side of the San Francisco Mountains which are located west of the CLL site [8]. As a result of this fire the drainage patterns of the areas located upstream to the west of the site were changed causing them to be more susceptible to runoff and flooding events of greater frequency and volume (Reference 2). In response to the increased flooding in these areas Coconino County expanded and deepened a system of roadside ditches to move water away from residential areas and into the Cinder Lake area [8].

4.1.2.2 Onsite Drainage Area

The CLL was divided into six sub-basins. Drainage basin 1 is the north east portion of the site, consisting of municipal waste, paper mulch used as cover, and native soils. The storm water runoff from sub-basin 1 consists of sheet flow which exits to a ditch to a ditch on the side of gravel road and conveys to 48 inch concrete pipe.

Sub-basin 2 and 3 are mid-north east portion of site and consists of majority paper mulch used for cover, native soil, municipal waste, and steep slope. The storm water runoff from sub-basin 2 and 3 consists of sheet flow which exits to a ditch on the side of gravel road and conveys to 48 inch concrete pipe.

Sub-basin 4 is east portion of site and consist of; native soil, gravel roads, concrete pads, shrubs, trees and roofed surface. The storm water runoff from sub-basin 4 consists of sheet flow which are conveyed by channels to parts to 48 inch concrete pipe and 18 inch corrugated metal pipe.

Sub-basin 5 and Sub-basin 6 are the west portion of the site, consisting of trees, shrubs, gravel road, recycle bins, and native soil. The storm water runoff from sub-basin 5 and 6 consist of sheet flow and flow to two different located 18 inch CMP's.

4.1.3.1 Results

The Rational Method parameters for the existing conditions are summarized in Table 1. Rational 'C' coefficients were weighted based on quantities of existing cover and impervious areas.

Table 1. Rational Method Parameters

Basin	C coefficient	T_c (min)	Area (acres)
1	0.21	23.62	9.45
2	0.21	21.04	3.05
3	0.21	19.54	9.91
4	0.33	18.26	2.76
5	0.23	17.76	1.02
6	0.26	14.70	1.00

The peak flows for the pre-development conditions are summarized in Table 2.

Table 2. Existing Condition Peak Flows (cfs)

	Q (cfs)					
Basin	**2 yrs.**	**5 yrs.**	**10 yrs.**	**25 yrs.**	**50 yrs.**	**100 yrs.**
1	2.80	3.79	4.61	6.38	8.15	9.83
2	0.90	1.23	1.49	2.06	2.63	3.18
3	2.94	3.98	4.83	6.69	8.55	10.31
4	1.30	1.76	2.14	2.96	3.78	4.56
5	0.34	0.46	0.56	0.78	0.99	1.20
6	0.37	0.50	0.61	0.85	1.08	1.30

4.2 Hydraulic

4.2.1 Objective

The objective of the analysis is to determine the impact the proposed development will have on the existing culverts of the site. The design of the proposed drainage control structures will be in accordance with the Coconino County Drainage Design Criteria.

4.2.2 Existing Conditions

The Sub-basins all drain to a 48 inch concrete culvert (Fig. A) and two 18 inch culverts (Fig. B). These culverts were already installed at the site, and the current conditions of the culverts (Pre-development) were calculated. According to our hydrology analysis, a 100 year 24 hour storm event produces a runoff of 30.38 cubic feet per (cfs) for our basin. Sub-basins 1 through 4 all drain to the 48 inch concrete culvert which will accumulate 27.88 cfs, also for the 100-year 24-hour event. The concrete culvert would be the main source of drainage, which has a length of 69 ft., at an upstream invert elevation of 6622.47 and a downstream invert elevation of 6621.74, and making a slope of 1.06%. After calculating the capacity of the concrete culvert using nomographs (refer to Chart 1B), it is found to withstand a runoff of 77 cfs (headwater to depth ratio HW/D=1.00). With the current of 27.88 cfs the concrete culvert only fills 26.40" (HW/D=0.55).

Figure 11 48 inch Concrete Culvert *Figure 12 18 inch CMP Culvert*

Sub-basins 5 and 6 produce a runoff of 1.20 cfs and 1.30 cfs, respectively. Sub-basins 5 and 6 have an 18 inch CMP culvert, which has a length of 105', at an upstream invert elevation of 6624.74 and a downstream invert elevation of 6621.74, and making a slope of 2.86%. After calculating the capacities of the CMP culverts using nomograph (refer to Char 2B, it is found to withstand runoffs of 5.5 cfs (@ HW/D=1.00). The current runoff 1.20 cfs and 1.30 cfs from the two sub-basins wouldn't overwhelm the culverts. The runoff produced does not reach a headwater to depth ratio of 0.50.

4.3 Traffic Analysis

After analyzing the traffic counts for Saturday, January 25, 2014, from 11:00 AM to 2:45 PM and Monday, January 27, 2014, from 10:30 AM to 2:30 PM a peak fifteen minute and peak hour volume were found. The peak fifteen minutes for both days was 11 vehicles and the peak hour was 29 vehicles. With winter not being the peak season for landfill use, the use of parking spots could be beneficial for the RDC. The peak season for landfill usage is during the summer so the amount of vehicles coming through would be much greater.

4.3.1 Parking Space Analysis

After some discussion and research about putting parking spaces into the RDC, the decision to not include them was made. The spots would have to be at a location that would require the vehicles to drive out of their way in order to park in it. Most cars will want to wait in a line right behind the bins to dispose of their waste. Since it is also a RDC, the vehicles should not be unloading waste for too long so the vehicles can get through at a reasonable speed. The research that was done for the parking spaces can still be used to create spaces by the bins themselves. With spaces right in front of the bins where the vehicles would dispose of their waste it creates less confusion. The vehicles know where to pull up and the space can be used to its full capabilities.

4.3.2 Traffic Flow

The figure located below this section shall be referenced throughout this portion to discuss the flow of the vehicles. As is stands right now, vehicles turn into the RDC area, outlined in blue, where the orange arrow is located currently. This is a problem because these vehicles turn in front of the large commercial vehicles driving by. The proposed new turn in shall be moved up in roadway, shown with a red arrow on the figure, and will be given a yield sign, the upside down orange triangle, so the commercial vehicles have the right of way. This would be an ideal turn in because the curve into to make it into one lane is a smoother way of having a turn. Also, the commercial vehicles would have a better view of the vehicles with the toll booth not blocking their view. As well as the yield sign placed at the entrance, one would be placed at the exit as well. The green arrow signifies the exit of the RDC, which is a different turn out then the entrance. This design of traffic flow will eliminate the possibility of vehicles running into each other and will bring about a travel path for the vehicles rather than entering and exiting where they please.

Figure 13 Aerial Photo of RDC Area

4.4 Cut/Fill

The cut and fill calculations were done using surveying points plugged into Civil 3D for the location of the RDC. The cut and fill was done to either raise or lower the existing ground based off of the RDC layout. It was determined that the RDC is to be raised in order to accommodate for the height of the bins. Because the bins are to be flush with the drop off area, a fill is required for the RDC. The table below shows the amount of fill needed in order to have the drop-off area flush with the top of the bins.

Table 3. Cut/Fill Volume Summaries

Volume Summary							
Name	**Type**	**Cut Factor**	**Fill Factor**	**2d Area** (Sq. Ft.)	**Cut** (Cu. Yd.)	**Fill** (Cu. Yd.)	**Net** (Cu. Yd.)
Proposed RDC Surface	full	1.000	1.000	11650.49	0.00	1929.72	1929.71<Fill>
Proposed Bin Pad	full	1.000	1.000	2697.64	3.18	24.20	21.02<Fill>
Proposed Side Slopes	full	1.000	1.000	5249.97	0.00	395.74	395.74<Fill>

Totals				
	2d Area (Sq. Ft.)	**Cut** (Cu. Yd.)	**Fill** (Cu. Yd.)	**Net** (Cu. Yd.)
Total	19598.10	3.19	2349.66	2346.47<Fill>

As this summary table shows, the amount of fill needed to be used is about 2400 yd^3. With our client saying we have up to 14000 yd^3 of fill useable on site for the RDC, the amount of fill needed falls below this amount. With this knowledge, the fill price will only incorporate the compaction and transportation prices, not bringing off site fill as well.

5.0 Identification of Selected Design

With the selected alternatives, a decision matrix was used to determine a preferred option. Only one decision matrix was used throughout this process which aided in the decision for which surface type should be implemented within the RDC. A decision matrix was used here due to the many advantages and disadvantages of each surface type. Within this design matrix there were seven different design factors that were taken into consideration. These factors can be found in the following section. Other design decisions were based off of different design parameters given within the site as well preference given by the client.

5.1 Defining Design Factors

Each of the following design factors were chosen to make a decision matrix for both the surface type and height of the bin as discussed before. Each of these design factors will be given a score between 1 and 5, with 5 being the highest and desirable score and 1 being the lowest and least desirable score. The explanation of each of these factors is discussed below:

5.1.1 Aesthetics

This design factor will be based off the visual appearance which will make the Residential Drop off Center more appealing to the general public. In terms of aesthetics, a score of 1 will be highly undesirable and a score of 5 will be considered appealing to the visual sense.

5.1.2 Cost

The cost of pavement, both short-term and long-term, will be considered in deciding the final surface type. The short-term cost includes installation and material costs. The long-term-costs include the costs of maintenance and general life costs. A score of 1 will create difficulties in maintaining within balance of budget. A score of 5 will aid in maintaining within budget.

5.1.3 Operations

This design factor will be defined as the convenience of travel in terms of the Cinder Lake Landfill personnel. A score of 1 will be given if alternative will create difficulty in the productivity of the residential drop off center. A score of 5 will be given if no problem can be foreseen with the alternative.

5.1.4 Accessibility

This design factor will be defined as the convenience of travel in terms of the Cinder Lake Landfill customers. A score of 1 will be given if the alternative creates poor flow into and through the RDC for the customers. A score of 5 will be given if an ideal traffic scenario is created.

5.1.5 Maintenance

This design factor will be defined as the work needed to preserve an acceptable surface condition and the frequency of such action. A score of 1 will be given if an undue amount of maintenance will be required. A score of 5 will be given if the upkeep of the alternative is minimal.

5.1.6 Lifespan

This design factor will be defined as the expected duration of the surface material. A score of 1 will be given if the alternative lifespan is incomparable to the lifespan of the landfill. A score of 5 will be given if the alternative lifespan will equal that of the landfill.

5.1.7 Safety

This design factor will be defined as the safety as it pertains to the customers and the landfill personnel. A score of 1 will be given if danger to all persons is of high risk. A score of 5 will be given if no dangers are foreseen with the alternative.

5.2 Weighting Design Factors

Each of the design factors listed above was given a weighted score based upon the importance of that design factor in choosing our alternatives. The weighting of each design factor for surface type is determined and explained below:

5.2.1 Aesthetics

The weighting percentage determined for the aesthetics of the surface type decision matrix is 5%. This was given the lowest percentage out of all of the design factors because it is the least important of all of them. The surface type will not have a large effect on the aesthetics because it is just the roadway but it will make people want to enter the site based off of how it looks.

5.2.2 Cost

The weighting percentage determined for cost of the surface type is 30%. This was given the highest percentage because of the importance of cost to this project. The costs of these surfaces incorporate installation costs and O&M costs. With a budget given to the team by our client, it is important to make sure the costs stay near reasonable pricing.

5.2.3 Operations

The weighting percentage determined for the operations of the surface type is 15%. This was given a percentage closer to the middle. The operations are important because the CLL personnel need to have easy flow into and out of the RDC. The surface type is important in this aspect because the high profile vehicles are very heavy and the surface material needs to withstand this weight.

5.2.4 Accessibility

The weighting percentage determined for the accessibility of the surface type is 15%. This was given a percentage closer to the middle. The accessibility is important because the customer needs to be able to smoothly dispose of their waste in a timely manner.

5.2.5 Maintenance

The weighting percentage determined for the maintenance of the surface type is 15%. This was given a percentage closer to the middle. Maintenance of the surface incorporates how much upkeep is necessary to keep the surface in good shape and the amount of labor to do repairs when the surface becomes damaged.

5.2.6 Lifespan

The weighting percentage determined for the lifespan of the surface type is 20%. This is important because the ideal surface will last the remaining time of the landfill. If it does not last that long, then the fewer times that it is needed to be replaced the better.

5.2.7 Safety

Safety was decided to not be included in the decision matrix for the surface type. The team decided all the components of safety for the surface type were already covered in all of the other sections.

5.3 Decision Matrix

The following matrix lays out the surface alternatives, provides a basis for the surface type decision.

Table 4 Decision Matrix

	Weight	**Alternative #1- Impervious Asphalt**	**Alternative #2- Modular Block Pavers**	**Alternative #3- Gravel**	**Alternative #4- Existing Terrain**
Cost	30	3	2	4	5
Lifespan	20	4	4	3	1
Maintenance	15	4	4	1	3
Operations	15	5	4	2	2
Accessibility	15	5	5	3	3
Aesthetics	5	5	4	3	3
Total	100	4.05	3.55	2.85	3.05

5.4 Impervious Asphalt:

After implementing all of the alternatives into the decision matrix, the surface that was decided upon was the impervious asphalt. This alternative scored five's in the factors of operations, accessibility, and aesthetics and four's in maintenance and lifespan, scoring higher than all the others in these five categories. It scored high in operations because of the ease of flow for the CLL personnel. They will have an easier time driving on impervious asphalt with the high profile vehicles and snow present. Accessibility scored high because of the ease of flow for the customers using the RDC at Cinder Lake landfill. Impervious asphalt creates a typical roadway surface which will be the easiest to drive. Aesthetics scored high because impervious asphalt is the most appealing surface on the eyes. Since this surface is typically used for the roadways, it looks appealing to drive on because vehicles are meant to drive on it. The maintenance of the asphalt scored a score of four, which is not a perfect score but still tied for the highest score in that design factor. Maintenance for impervious asphalt consists of filling in cracks primarily and keeping the roadway clean. Cracks in the asphalt have a crack repair kit that will fill the cracks so it is an easy fix but still does require some maintenance to it. That is why this material did not score the highest score for maintenance. Impervious asphalt also scored a four on lifespan. The desired lifespan of this surface is the remaining life of the landfill, which lasts until 2054. The reason that impervious asphalt did not receive a score of five is because the impervious asphalt will need to be replaced roughly around ever twenty years. This means that the asphalt will need to be replaced at least once while the RDC is in place. For this reason, the lifespan did not receive a perfect score. All of the reasons listed above led to the impervious asphalt being chosen as the surface type for the RDC.

5.5 Height of Bin

The two design alternatives for the height of bin relative to ground surface (2.5 ft. above ground surface and at ground surface) were equally considered for implementation in the final design. Because the purpose of this design is to increase the safety of residential customers within the landfill, the option that promotes the greatest safety has been chosen—this is the preference of the client. Customers will enter the RDC and dispose of their waste in a designated safe zone. A skid steer loader will be used to push the waste into the assigned bins.

6.0 Final Design

6.1 Final Layout Design

The final design used for the layout is shown in the construction plans on sheet 6. There were a few considerations taken in the design of this RDC. The considerations taken were the ease of access, the safety, and the waste management. All three of those considerations were used when designing the RDC. This design was placed in the 2.5 acres given and needed to be paved. The two gray regions are both paved asphalt, the darker region where the high profile vehicles will drive and the lighter gray where the customer vehicles will drive. The lighter gray area has a slope towards the main office of 4% while the darker gray area is flat. The green and red areas located within the RDC design as concrete pads. The green area is where the customers will drop their waste and it has a 2% slope. The red area is where the six bins shall be placed, with only four of the bins used for the current design and the other two for the possible expansion of the RDC. These four bins will have different types of waste for each of them, with two being for municipal solid waste, MSW, one for recycling, and one for green waste. Along with these four bins there will be another bin placed on the upper portion of the RDC for the disposal of ashes. This bin will have the dimensions of 6’3”x6’8”x5’5” and will be placed in the back left corner of the RDC. With all the bins placed, safety was needed to be considered with the bins. Removable bollards and chains were placed outside of the bins in order to keep the customers and their vehicles away from the face of the bins. Attached to the chains will be signs in order to show what waste goes into what bin. Another safety precaution is the installation of Jersey barriers along the sides of the RDC 5 feet from the retaining walls. These are placed so the vehicles do not drive off the side of the RDC. Attached on the top of the retaining walls shall be railings for pedestrians walking between the railing and Jersey barriers. These safety precautions are necessary in keeping the customer safe inside of the RDC. A fire extinguisher shall be placed next to the ash bin for any precautionary fires that start. There will be stairs placed on both sides of the RDC for both the use of the resident and the employees. The stairs located on the left side will typically be used for the port-o-potty located near them while the right stairs will typically be used for the employees. With all of the high profile vehicles located on the right side, the employees will need to use those stairs to get to the high profile vehicles from the RDC. The details for the stairs were found from panel built and are located in the attached construction drawings, sheet C-3. A retaining wall will be added around the entire RDC. A retaining wall is necessary for the design in order to hold all of the compacted soil underneath the paved area. Since the RDC area and top of bins are needed to be flush, compacted soil must be used in order to raise the RDC to the desired elevation. All of these components of the layout are necessary in the completion of the design for this RDC.

6.2 Operations

An important aspect that was crucial to take into consideration in the design of the RDC is the operations of the new facility. Residential customers will continue to enter the landfill using the main entrance. Where the residential path merges with the commercial path, a stop sign will be placed. The commercial vehicle operations will not be affected. The residential traffic path will turn left when a sufficient opening is available. The entrance of the RDC is located on the east side of the facility. Customers will travel up the sloped entrance to the top where they will be able to dispose of their waste on the concrete pad located in front of the bins. Here, the customers will sort their waste into the designated area laid out for MSW, recycling, green waste, and ashes, located in a smaller bin on the top. Throughout the day, landfill personnel will operate a skid steer loader to push the waste into the respective bins. The removable bollards will be taken out during this movement of the waste into the bins. To prevent the pushed waste from falling between the RDC wall and the bin, a manual dock lever will be placed in front of each bin to cover the gaps. To ensure the safety of the customers during this time, a metal chain will be placed across the entrance located roughly 40 feet back from the main entrance roadway. This is so vehicles can drive into the RDC. This will prohibit the interference of the customers with the daily operations. About once every two days, a transporting vehicle will enter the authorized vehicle entrance and haul the bins to the working face of the landfill. The facility has been designed to account for the turning radius of the vehicles ((The paths can be shown in the drawing)). After disposing of their waste, customers will exit on the west side of the facility, where they will turn on to the current exit road.

6.3 Retaining wall

The retaining wall design that was to be used was a precast concrete wall. This design was decided upon because a precast wall is much stronger than a gravity block wall. With such a large surcharge applied to the retaining wall, it was necessary that the wall be strong enough to hold up all of said surcharge. The properties for the retaining wall are necessary in order to determine if the retaining wall is strong enough for the forces. With so many different lengths and loads that the retaining wall would experience, it was important to do the worst case scenario for the walls. The worst case scenario will make the walls to the necessary strength in order to withstand the maximum active surcharge that could be applied. Another portion of the wall that was important was neglecting the passive surcharge. The passive surcharge would be applied to the lower portion of the retaining wall, where the bins will be placed. This surcharge was neglected in order to continue creating the worst case scenario. The passive surcharge would only decrease the active surcharge making the wall hold less loads. With knowing how to solve for the wall, the properties of the wall needed to be found.

6.3.1 Retaining Wall Dimensions

The properties of the retaining wall were found through either the geotechnical report of the site or the team's engineering intuition. The program that was used for the solving of the retaining wall was a program called ASDIP cantilever retaining wall. This program let the properties of the wall be plugged in and it would determine if the specifically sized wall could withstand the forces applied. With the use of this program, only certain properties were needed to be found. The first thing that needed to be determined was the sizing of the wall. With the wall needing to be flush against the bins due to the design, the exposed retaining wall could only be eight feet tall. A soil cover of two feet was used which made the backfill height ten feet tall accordingly. The stem's height was ten feet to make it level with the backfill and the thicknesses were one foot at the top and one and a half feet at the bottom. The heel and toe were one foot thick with lengths of four feet and one and a half feet respectively. All of these lengths were chosen in regards to the bin height which needed to be flush against the top of the retaining wall and the backfill. A key was not added to this design because the surcharge did not create enough sliding in order to need one. The backfill slope angle could only be set positively even though the slope for the RDC was a negative number. The slope was made 1.1 degrees because it created more soil on the retaining wall then there actually would be, making the surcharge against the wall greater through ASDIP. With all of the dimensions of the walls determined, the soil properties and surcharge loads could be determined.

6.3.2 Retaining Wall Soil Properties

A majority of the properties of the wall were found through the geotechnical report of the soils at Cinder Lake Landfill. The properties from the report that were given were the backfill moist density, 117.4 pound per cubic foot (pcf), and the backfill saturated density, 130 pcf. The Rankine active pressure was used with an internal friction angle of 35 degrees. This angle was assumed using the soil classification from the geotechnical report. The geotechnical report also said that the water table height was far away so a value of zero was used for it. The stem dead and live loads, the wind pressure, and the horizontal and vertical seismic coefficients were neglected because of how small these values would be. A uniform surcharge was applied to the backfill soil and that value was 200 psf. This value was used because the maximum weight that will be applied is the weight of a 962K medium wheel loader, which is 45,055 lbs. This had to be broken down into psf so the weight was divided by 25 feet, for the length of the vehicle, and 12 feet, the width of the vehicle. This gave a value of around 150 psf to be used. The value was increased by 50 psf, or 15,000 lbs., to account for any unseen forces that could be applied to the wall. With all of the properties laid out, the materials of the retaining wall could be determined.

6.3.3 Retaining Wall Materials

The materials of the wall were the most important components of the wall. If too weak of materials were chosen, then the wall would crumble and if too strong of materials were chosen, then the wall would be overpriced for what it needed to do. The concrete that was chosen had a compressive strength of 4,000 psi and the rebar strength is 60,000 psi. The allowable bearing pressure and friction coefficient were both found through the geotechnical report and were 15.2 ksf and 0.4 respectively. With the concrete material picked, the rebar used throughout the retaining wall was next to design. The construction plan, page C-4, contains the location of all the rebar as well as the number rebar used. For the vertical bars throughout the stem, #6 was used at a spacing of 12 inches on the right side to prevent shear failure. A #4 bar spaced at 24 inches was place on the left side of the stem, as shown in the construction drawings. This rebar was placed in the design in order to account for the possibility of seismic activity. The heel and toe horizontal rebar were #6 bars at a 12 inch spacing. The transverse bar size used for both the stem and footing were #4 bars spaced at 12 inches apart. All of these rebar were necessary so the wall would not fail due to shear failure. With all of the retaining wall properties, soil properties, and materials found, the retaining wall checks need to be classified as in the range.

6.3.4 Retaining Wall Checks

All of the retaining wall checks were important in determining if the wall designed above could withstand the loads applied. The checks that needed to be done were the overturning safety factor, the sliding safety factor, the shear force ratios, and the moment capacity ratios. Each of these checks had certain values that they needed to be less than or greater than in order to meet the requirements. The overturning and sliding safety factor's values needed to be greater than a value of 1.50. The overturning safety factor was 3.50 while the sliding safety factor was 2.21, showing that the wall will not fail from overturning or sliding. The shear force checks were done for the three portions of the retaining wall, the stem, toe, and heel. The values determined for each of these was 0.23, 0.26, and 0.79 respectively. These values needed to be under one so this wall will not fail based off of shear failure. The last checks were the moment capacity ratio checks which all needed to be less than 1. The moment capacity ratios for the stem, toe, and heel, respectively, were 0.43, 0.23, and 0.95. With all of these values less than 1, there will not be a failure based of off the moment applied on the wall. With all of the checks done and passed, the retaining wall is completed and prepared for implementation into the design.

6.4 Post Hydrology/Hydraulic

With the design finished, the proposed RDC was applied to the watershed basin (see Post Development Drainage map, appendix B1). Sub-basins 1, 2 and 3 runoffs were not affected by this change due to the placement of the RDC. Sub-basin 4 was slightly changed by the increase of impervious surface such as asphalt, concrete, and riprap in the sub-basin. The asphalt was placed for the convenience of the operation vehicles and was sloped to direct the runoff to the 48" culvert. Sub-basin 5 changed and became composed of a large area of asphalt and some natural terrain. Any runoff collected by sub-basin 5 will drain to the 18" culvert located within sub-basin 5. Sub-basin 6 basically remained the same, majority of the surface is the natural terrain with a small increase of impervious surfaces. The table below contains the details for each of the sub-basins with the new runoffs.

Table 5: 100 Year Event-Pre Development

100 year event – Post Development					
Sub-basin	C_f	C	i	A	Q (cfs)
1	1.25	0.21	3.96	9.46	9.83
2	1.25	0.21	3.96	3.06	3.18
3	1.25	0.21	3.96	9.92	10.31
4	1.25	0.35	3.96	2.77	4.56
5	1.25	0.66	3.96	1.04	1.20
6	1.25	0.20	3.96	1.01	1.30
				$\sum =$	30.38

Table 6: 100 Year Event-Post Development

100 year event – Post Development					
Sub-basin	C_f	C	i	A	Q (cfs)
1	1.25	0.21	3.96	9.46	9.83
2	1.25	0.21	3.96	3.06	3.18
3	1.25	0.21	3.96	9.92	10.31
4	1.25	0.35	3.96	3.39	5.87
5	1.25	0.66	3.96	0.62	2.03
6	1.25	0.20	3.96	0.82	0.81
				$\sum =$	32.03

After calculating the new discharge, the overall flow from the basin increased by a total of 5 percent. The tables above, have the calculated runoffs for each sub-basin; for both pre-development and post-development. This increase in runoff was due to the increase in impervious surface. With such a small increase of discharge throughout the basin, the culverts were not needed to be redesigned. With such a small increase in the discharge and the culverts designed for expansion in the landfill, it makes sense that a redesign of the culverts was not needed.

6.5 Grading/Drainage Plan

The grading and drainage plan is important in determining where the water will drain to during storms. The grading plan was determined in order to have the water drain to the desired culverts. Subbasin 5 was made to be the RDC upper portion. All of the runoff from this subbasin drained into the 18 inch culvert that was also located in this subbasin. With an impervious area added in the subbasin, all of the water that went into subbasin 5 would drain out through that 18 inch culvert. The other area that received impervious area within it was subbasin 4. This was a much large subbasin so this one all will drain into the 18 inch culvert located within this subbasin. An open channel was created to make the water flow from that 18 inch culvert to the large 48 inch culvert. From this culvert it shall flow into the retention basin located on the other side of the main offices. The grading plan for the lower asphalt region is not as drastic as the upper region but it still will make the water drain to the desired culvert. All of the grades that were used for these subbasins is shown in the construction plan, sheet 7.

6.6 Costs

The costs for this project can be broken down into both design costs and construction costs.

6.6.1 Design Costs

The design costs for this project has been broken down by tasks. The information can be seen in the table below. The total design hours came to 468 hours. This total number of hours is significantly less than what was estimated in the proposal with a total of 1182 hours. There are many reasons for this over-estimate. One of which is that, CLL provided a great deal of information that aided in the analysis for the design project of the RDC.

Table 7: Design Cost Breakdown

Task	Hours	Billable Rate	Total Cost
Meetings	68	$114.00	$7,752.00
Survey	14	$114.00	$1,596.00
Traffic Count	4.5	$114.00	$513.00
Hydrology/Hydraulics	37.5	$114.00	$4,275.00
Retention Wall	47.5	$114.00	$5,415.00
Layout Design	86.5	$114.00	$9,861.00
Construction Plans	40	$114.00	$4,560.00
Cost Analysis	4.5	$114.00	$513.00
Reports/presentations	101	$114.00	$11,514.00
Other	64.5	$114.00	$7,353.00
TOTAL	**468**		**$53,352.00**

6.6.2 Construction Costs

The costs for the construction of this project are included in the table below. All of the projects listed were the components needed to complete the design for the RDC. These components have corresponding units in accordance with how the projects were measured. The quantity was the amount of each unit that the project needed for the design. With the total price and quantity multiplied together, a total price for each project could be determined. The sum of these prices gave the total price for both labor and material of each project. All of these prices were taken from RS Means, which is where both the labor and materials costs came from. The table below shows all the values found.

Project	Material	Total Per Unit		QTY	TOT. $
Cut/Fill	Grade subgrade for base course	1.03	SY	4798	4941.94
	16.5 CY Truck, 15 MPH ave, cycle 0.5 mi, 15 min. Wait/Ld./Uld.	0.65	LCY	7027.879	4568.121
	Riding, Vibrating roller, 6" lifts, 4 passes	0.23	ECY	11596	2667.08
Asphalt Pavement	6" stone base, 2" binder course, 1" topping	2.453	SF	31510	77294.03
Concrete Pavement	Heavyweight concrete, Ready mix: 4000psi	114	CY	47	5358
	Reinforcement: Slab on grade, #3 to #7	1705	TON	0.05	85.25
	Placing concrete: Slab on grade up to 6" thick, direct chute	26	CY	47	1222
	6000 psi	124	CY	55	6820
Retaining Wall	2x Reinforced concrete cantilever, incl. excavation, backfill & reinf: 6' high, 33° slope embankment	267	LF	402	214668
Waste Collection	40 Roll Off Bin	5000	EA	6	30000
Barrier	Jersey Barrier	200	EA	12	2400
Railing	Aluminum, 2 rail, satin finish, 1-1/4" diameter	58.5	LF	402	23517
Pavement Marking	**Acrylic waterborne Arrow**	30	EA	3	90
Signage	Guide and directional signs, 12"x18", reflectorized	78	EA	5	390
Water protection	Polyester reinforced w/integral fastening system 11 mils thick	1.29	SF	960	1238.4
Regulatory Rqmts.	Permits: Rule of thumb, most cites, minimum	2000		1	2000
Chains	Everbilt #3x15ft Zinc-Plated Double Loop Chain	6.5	EA	8	52
Rip Rap	Dumped, 50 lb. average	30.5	TON	100	3050
Bollards	Metal parking bumper folding with individual padlock	200	EA	14	2800
Mechanical Ledge		200	EA	6	1200
Contingency				20%	76872.36

TOTAL 461234.2

Table 8: Construction Cost

All of the projects are explained in the design portion listed above except for the contingency. The contingency is defined as the unexpected prices that could occur during the actual implementation of the design. With a 20% contingency, all unknown prices are covered, giving a total right under $500,000. With a maximum budget of one million dollars, the total design budget was much less than the total budget used.

6.7 Benefit Cost Analysis

A benefit cost analysis was performed to compare the current landfill operations to the proposed operations with the implementation of the RDC. This comparison takes into consideration the operational gains and losses throughout a ten year time period for both of the alternatives. A discussion of each analyzed operations will be discussed below.

6.7.1 Existing Operations

The landfill currently dedicates 40% of operational time maintaining the working face of the landfill. It is necessary to maintain a safe environment for the residential customers present within the landfill. In order to create this safe environment, residential waste is buried several times throughout each working day. This constant effort of CLL consumes an excess amount of fuel, oil, time etc. which as a result, creates excess costs.

Recycling is another item which generates additional costs. CLL is required to recycle at least 60 tons each day. Any shortcoming of this goal is fined $32.25 per ton. According to the Environmental Protection Agency (EPA) Report of 2011, a total of 54% of collected MSW is recyclable items. Therefore, if short of required recycling goal, the MSW is sent to a material recovery facility (MRF) in order to attempt retrieval of recyclable items.

6.7.2 Proposed Operations

There will be many benefits with the implementation of the RDC. By keeping the residential customers away from the hazards of the working face of the landfill, the amount of time dedicated to maintaining a safe environment will be reduced from 40% to an estimated 10%. Residential waste will not necessitate constant burial.

An RDC creates a safe environment in which there are several locations for residents to separate their waste. The residents will no longer have to make several stops to dispose of their waste. It is estimated that the amount of recyclables buried alongside the MSW can be reduced by 10% for CLL. This can significantly save money spent using the MRF.

6.7.3 Results

The total net present value of the current operations comes to a loss of $5,803,603 at the end of a 10 year time period. This includes the prices of commodities (fuel, oil, vehicle parts etc.), labor costs, recycling short fall etc. An inflation rate of 2.4% was used in this analysis.

The total net present value of the proposed operations with an RDC comes to a loss of $185,525. This number is dependent on the amount of increased recycling compared to the existing operations.

The benefit for each alternative was weighed against the cost giving a ratio that can easily show the feasibility factors. The benefit cost ratio for the existing operation comes to 0.43 whereas the benefit cost ratio for the proposed operations is 1.43. This shows that the proposed RDC is much more beneficial to CLL than what is currently in operation. While the implementation of the RDC will continue to create loss for the landfill, it is less of a cost than leaving everything as is.

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8.0 Image Credit

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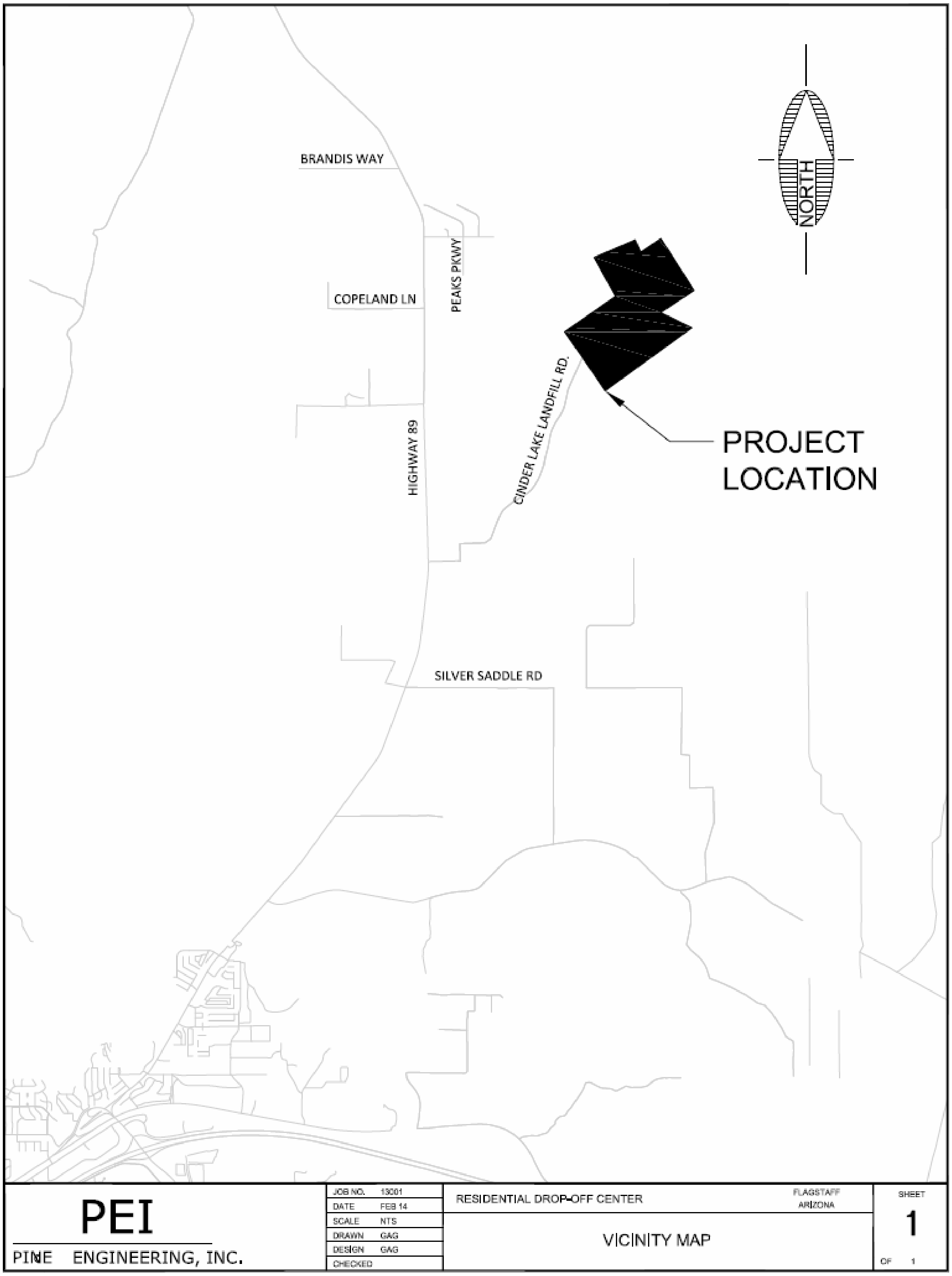
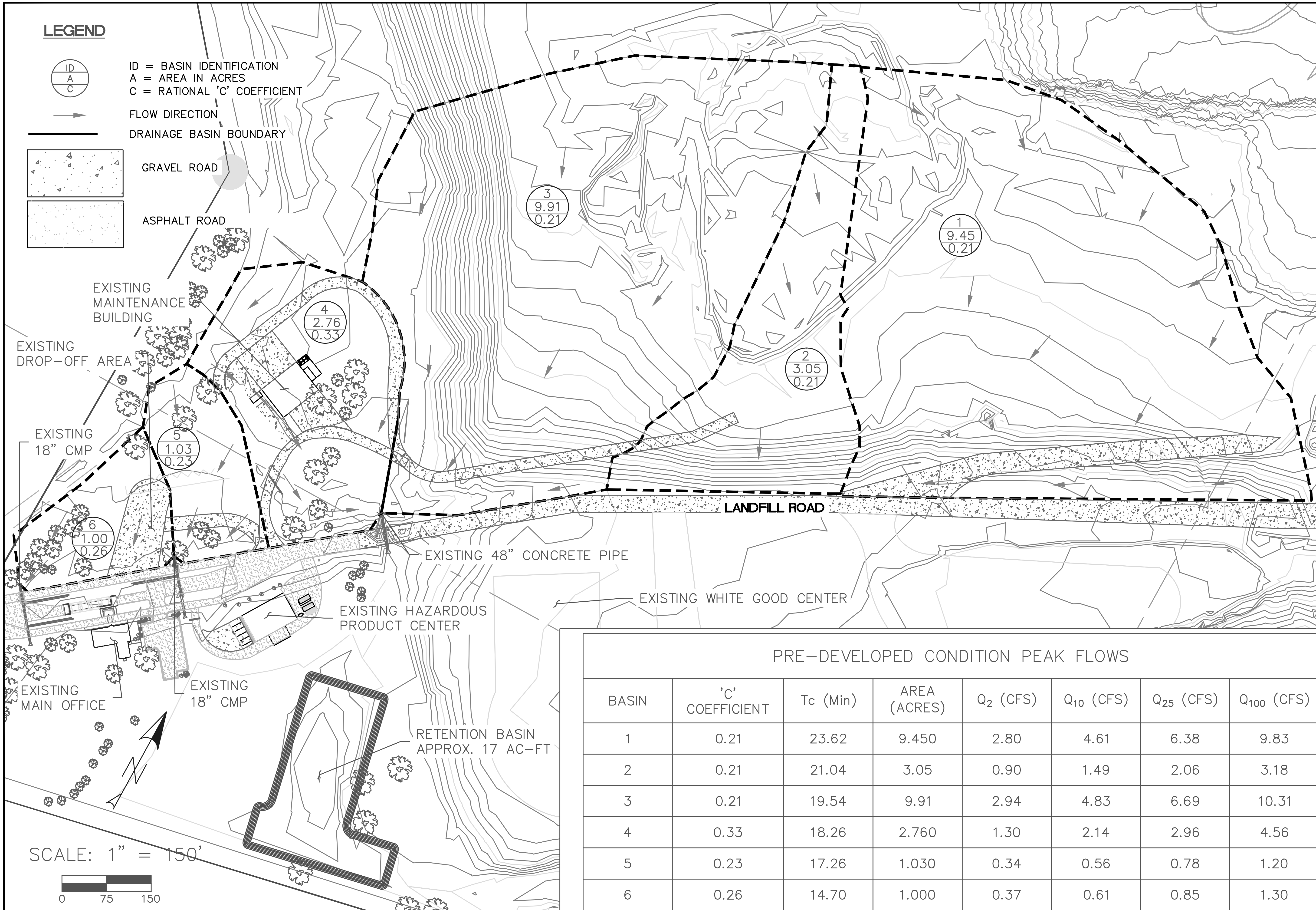
Appendix

Appendix A: Vicinity Map



Appendix B: Hydrology



PRE-DEVELOPED CONDITION PEAK FLOWS

BASIN	'C' COEFFICIENT	Tc (Min)	AREA (ACRES)	Q_2 (CFS)	Q_{10} (CFS)	Q_{25} (CFS)	Q_{100} (CFS)
1	0.21	23.62	9.450	2.80	4.61	6.38	9.83
2	0.21	21.04	3.05	0.90	1.49	2.06	3.18
3	0.21	19.54	9.91	2.94	4.83	6.69	10.31
4	0.33	18.26	2.760	1.30	2.14	2.96	4.56
5	0.23	17.26	1.030	0.34	0.56	0.78	1.20
6	0.26	14.70	1.000	0.37	0.61	0.85	1.30

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SHEET 1 OF 2

COCONINO COUNTY ARIZONA

RESIDENTIAL DROP-OFF CENTER

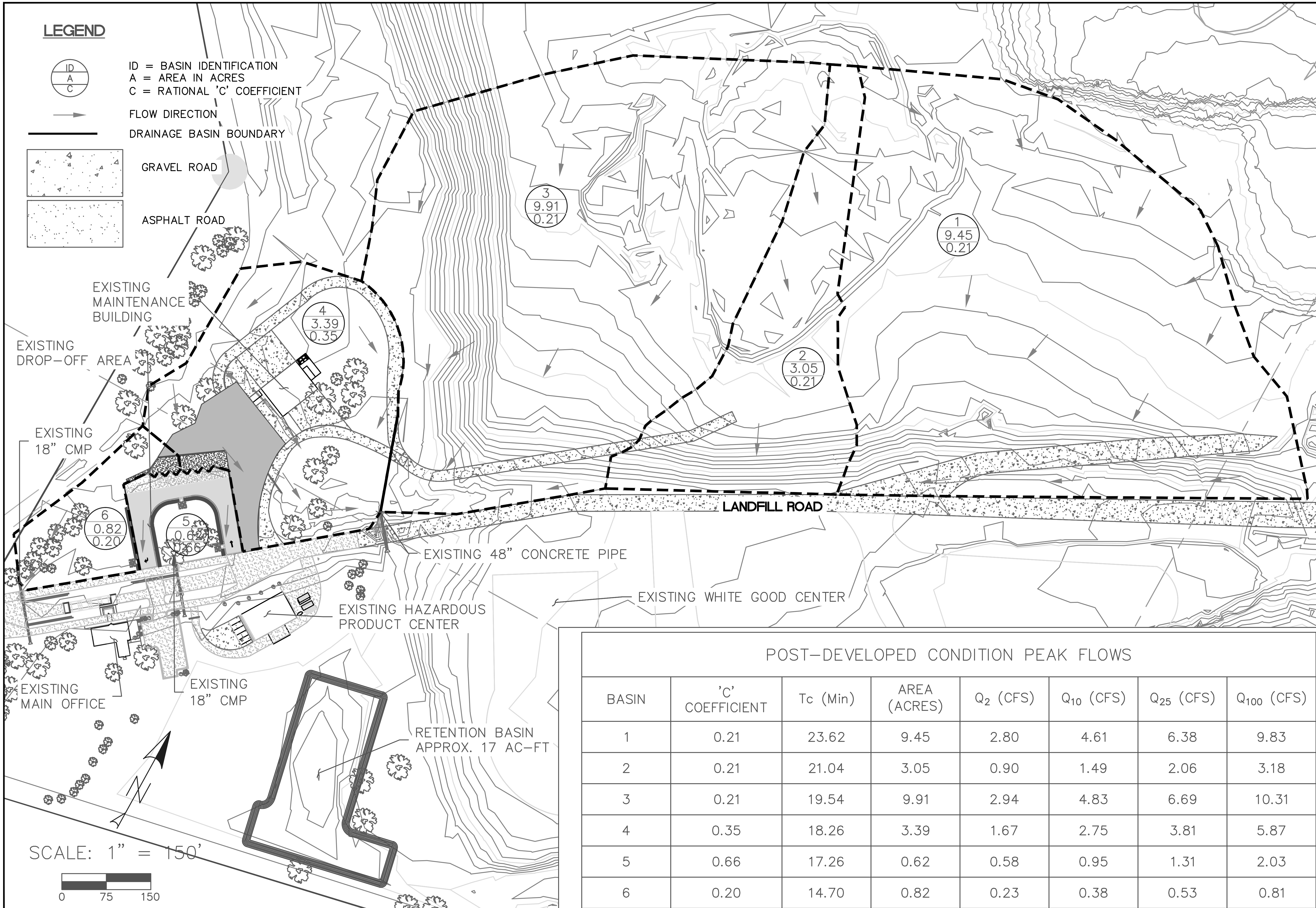
DRAINAGE REPORT
PRE-DEVELOPED DRAINAGE MAP

JOB NO: 0001
DATE: MAY 14
SCALE: 1" = 150'
DRAWN: GAG
DESIGN: GG,FP,TD,JF
CHECKED: TD

PEI
PINE ENGINEERING, INC.
1756 E. Villa Drive
Suite C-17
Cottonwood, AZ 86326
928.639.2712
928.639.2713 fax
www.swioz.com

CALL TWO WORKING DAYS BEFORE YOU DIG
1-800-STAKE-IT

PLOTTED: Apr 29, 2014-9:02pm
FILE: S:\Capstone\CENE\CENE-Cap-08\DWG\Hydrology\HYDROLOGY.dwg <<C3D_Imperial>>



POST-DEVELOPED CONDITION PEAK FLOWS

BASIN	'C' COEFFICIENT	Tc (Min)	AREA (ACRES)	Q_2 (CFS)	Q_{10} (CFS)	Q_{25} (CFS)	Q_{100} (CFS)
1	0.21	23.62	9.45	2.80	4.61	6.38	9.83
2	0.21	21.04	3.05	0.90	1.49	2.06	3.18
3	0.21	19.54	9.91	2.94	4.83	6.69	10.31
4	0.35	18.26	3.39	1.67	2.75	3.81	5.87
5	0.66	17.26	0.62	0.58	0.95	1.31	2.03
6	0.20	14.70	0.82	0.23	0.38	0.53	0.81

SHEET 2 OF 2

COCONINO COUNTY ARIZONA

RESIDENTIAL DROP-OFF CENTER

DRAINAGE REPORT
POST-DEVELOPED DRAINAGE MAP

JOB NO: 0001
DATE: MAY 14
SCALE: 1" = 150'
DRAWN: GAG
DESIGN: GG,FP,TD,JF
CHECKED: TD

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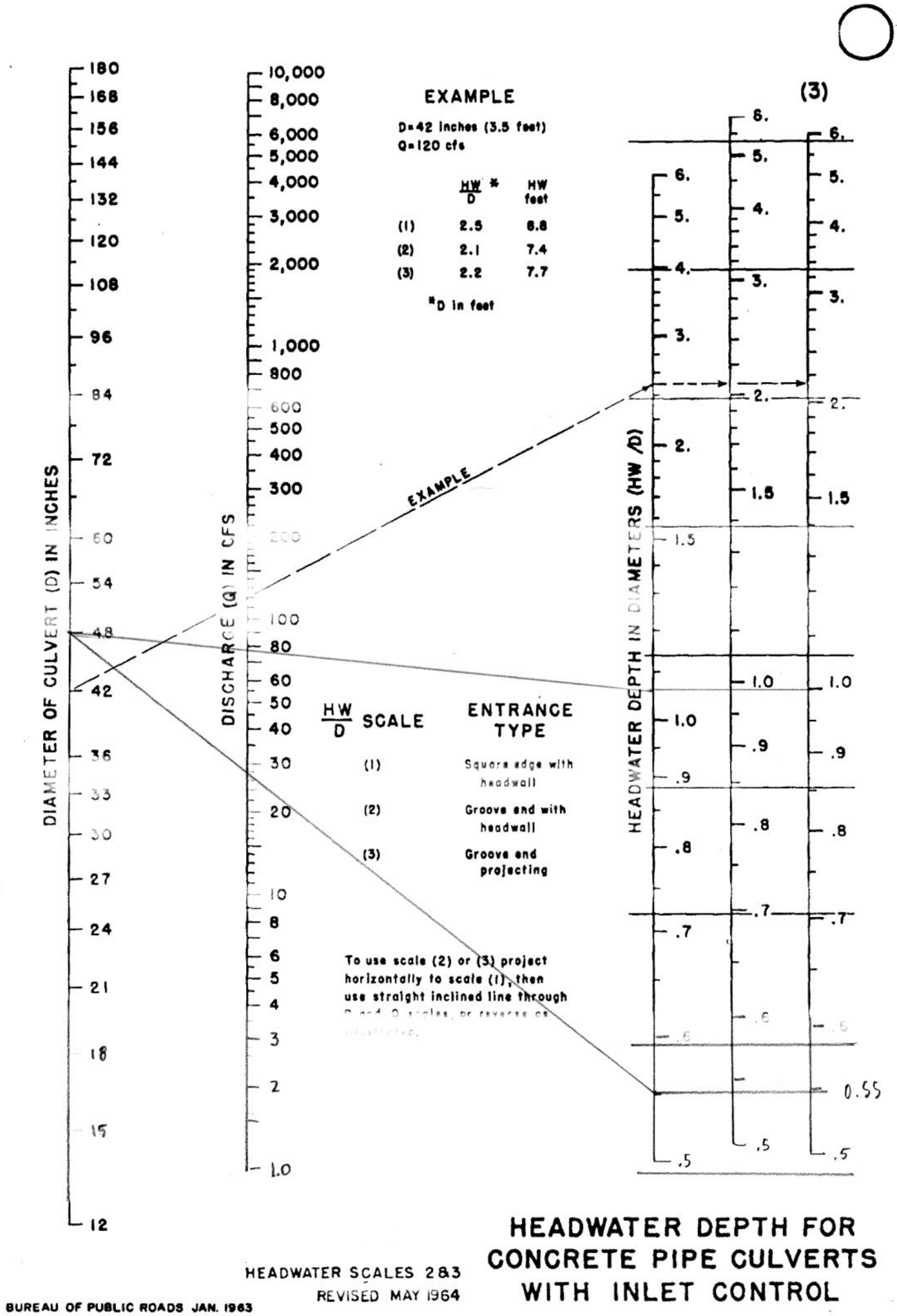
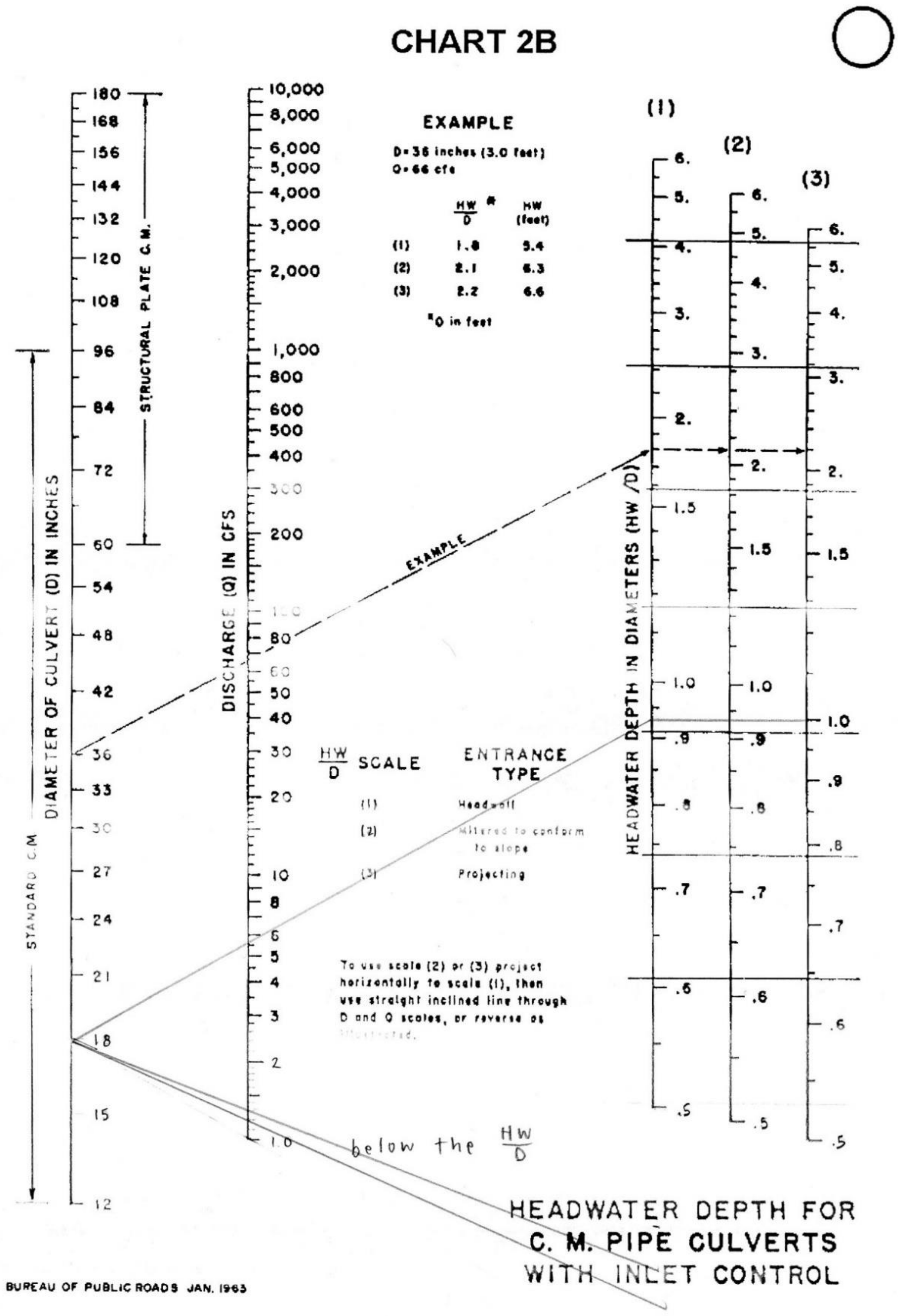
Appendix C: Chart 1B – Concrete Pipe Culvert Inlet Control

CHART 1B



Appendix D: Chart 2B – Corrugated Metal Pipe Culvert Inlet Control



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Appendix E: FEMA FIRM Map

Appendix F: Proposed Layout

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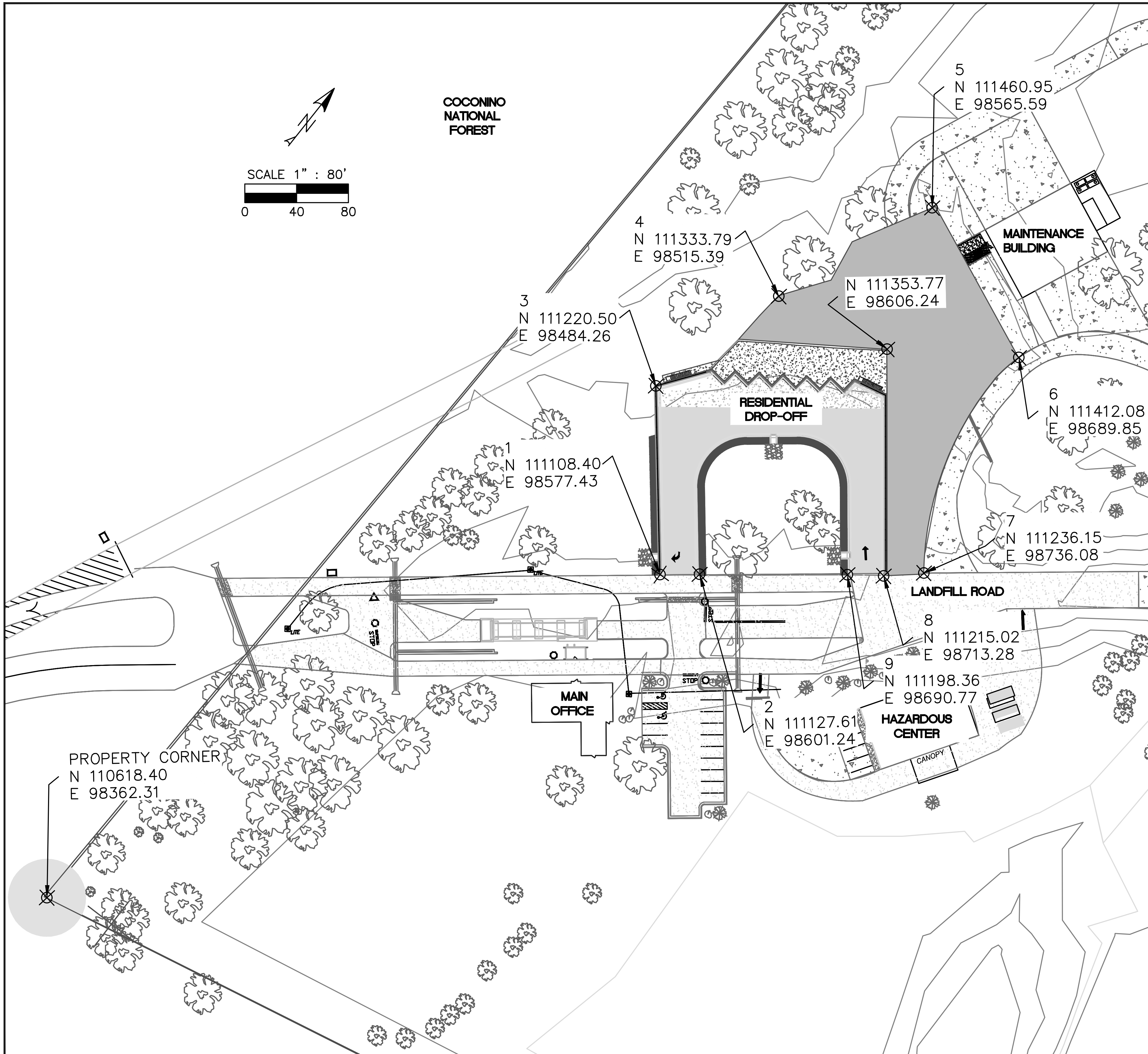

Point Table		
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4	111460.9544	98565.5940
5	111412.0770	98689.8537
6	111236.1514	98736.0838
7	111353.7653	98606.2439
8	111108.3996	98577.4263
9	111127.6101	98601.2357
10	111198.3554	98690.7709
11	111215.0182	98713.2813
12	111333.7919	98515.3884
1	110618.4000	98362.3100

SURVEY NOTES:

LINEAR UNIT: INTERNATIONAL FOOT
GEODETIC DATUM: NORTH AMERICAN DATUM 1983
SYSTEM: ARIZONA LDP (LOW DISTORTION PROJECTION)

PROJECTION: TRANSVERSE MERCATOR
LATITUDE OF GRID ORIGIN: 35° 00' 00" N
LONGITUDE OF CENTRAL MERIDIAN: 111° 37' 00"W
NORTHING AT GRID ORIGIN: 0.000 ft.
EASTING AT CENTRAL MERIDIAN: 70,000.000 ft.
CENTRAL MERIDIAN SCALE FACTOR: 1.000333 (exact)

BASIS OF BEARINGS IS GEODETIC NORTH. NOTE THAT GRID BEARINGS SHOWN HERON DO NOT EQUAL GEODETIC BEARINGS DUE TO MERIDINAL CONVERGENCE

THE BEARINGS SHOWN ON THIS DRAWING ARE GRID BEARINGS.

SHEET C5 OF 8

COCONINO COUNTY ARIZONA

RESIDENTIAL DROP-OFF CENTER

HORIZONTAL CONTROL POINTS

JOB NO: 0001
DATE: APR 14
SCALE: 1" = 80'
DRAWN: GAG
DESIGN: GG,FP,TD,JF
CHECKED: TD

PEI
PINE ENGINEERING, INC.

CALL TWO WORKING DAYS BEFORE YOU DIG
1-800-STAKE-IT

Appendix G: Gantt Chart