AEES

CINDER LAKE LANDFILL RE-SEQUENCING CELL D

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Sincerely,

Aspen Engineering and Environmental Services

Environmental Engineering Senior Capstone Design Team, Northern Arizona University

1.0 Project Description

Cinder Lake Landfill requires a plan for landfill mining and excavation to achieve the design of future Cell D.

1.1 Background

Cinder Lake Landfill is 343-acre municipal solid waste landfill located in East Flagstaff, Arizona. The landfill services residential, commercial and industrial waste throughout a 70-mile radius around Flagstaff. The City of Flagstaff Cinder Lake Landfill is proposing a re-sequencing of Cell D in order to expand available airspace for future waste. This project can provide various economic benefits to the City of Flagstaff. This project could provide an additional of 5 to 30 years of landfill life, which would delay the anticipated closure date of 2050. The project also has the potential to save money spent on future landfill cover. It is estimated that in 2031, the landfill will run out of cover material, 19 years prior to its expected closure in 2050. The mined materials could be processed and used as a cover material, which would reduce the need to purchase material. Additionally, the excavated rock has the potential to be sold as an aggregate for construction projects and roadways. The extension of the closure date, and the recovery of cover and sellable materials has the potential to save millions of dollars for the City of Flagstaff.

1.2 Future Design

The re-sequencing Cell D includes expanding the cell, by volume and area. In order to accomplish this task, adjacent cells and area must be excavated, which include Cell C, the South Thumb and the North Pit. Figure 1.1 shows the target cells for this project.

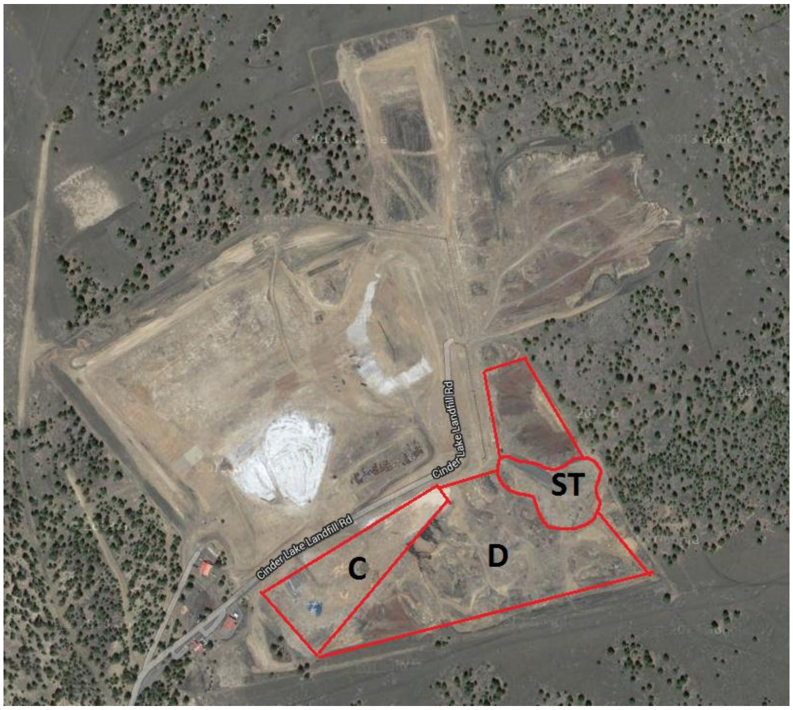


Figure 1.1: Cells of concern for re-sequencing Cell D: the current Cell D, Cell C and the South Thumb (ST). Source: Google Earth (Annotated).

A portion of Cell C will be excavated which currently contains 20-30 year old which is predicted to contain primarily construction waste. The South Thumb currently contains 20 year old municipal solid waste (MSW). Cell D currently has no waste and contains rock and soil. Overall, the expansion of Cell D creates a non-uniform shape with an area of 50 acres, as shown in Figure 1.2.

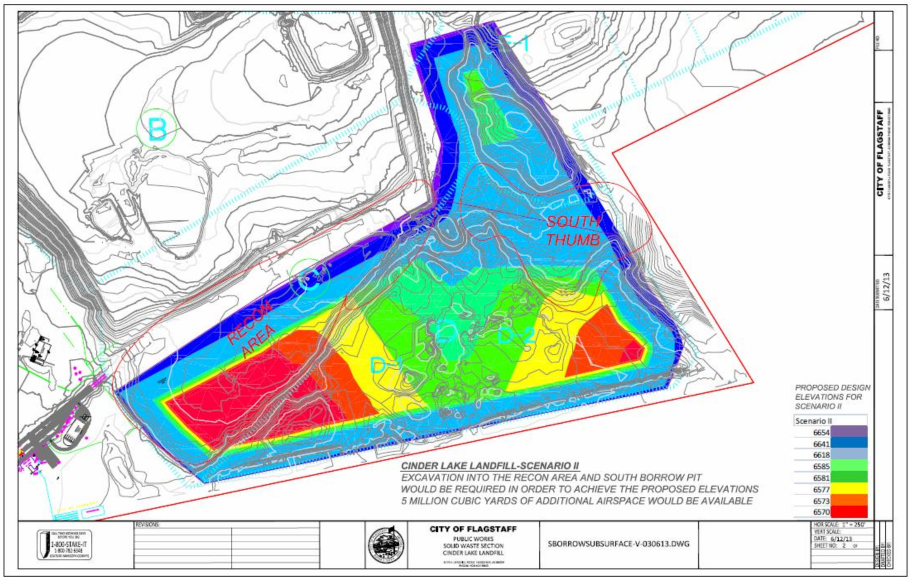


Figure 1.2: Proposed design of the future Cell D. Source: Matt Morales (City of Flagstaff).

2.0 Landfill Mining

2.1 Background

Landfill mining is a relatively new concept due to the recent introduction of engineered landfills in the 1970's. Landfill mining involves the excavation of municipal solid waste (MSW) or other materials from engineered landfills. Approximately 50 landfill mining projects have occurred since 1953, the first project being in Israel (Eklund, Mats). The purpose and benefits of landfill mining varies depending on the condition of the landfill. Reasons for landfill mining include:

- Recovering materials
- Recovering landfill airspace
- Reducing the size of the landfill
- Transferring material from an unlined to a lined landfill (US EPA, 1993)
- Reduction of closure costs
- Reclamation of land for other uses (US EPA, 1997)

Three landfill mining case studies have been evaluated for this project. The three case studies are Naples Landfill (Florida), Endinburg Landfill (New York) and Perdido Landfill (Florida). The landfill and excavation plan, environmental controls and budget from these case studies will be considered. Lastly, this project must abide by all city, state and federal regulations. Various regulations were researched for this project.

2.2 Case Studies

2.2.1 Naples Landfill, Collier County, Florida

A landfill mining demonstration project was performed at Naples Landfill in Collier County, Florida that began in 1991 and was completed in 1993. The demonstration project was established under the EPA Municipal Solid Waste Innovative Technology Evaluation (MITE) Program. The purpose of the demonstration project was to reclaim various materials such as soil, plastics, steel and aluminum. The removal of toxic and leachable materials was targeted for this project as well.

There were various environmental and safety concerns for this demonstration project. These concerns included soil contamination from chemicals, asbestos, odors, leachable toxins, hazardous materials, heavy metals, and explosions from methane. During the mining and ground moving, the project resulted in minimal odor and methane emissions. It was noted that there were only sight "garbagy" odors, which quickly dissipated. Methane did not prove to be an issue during landfill mining and also dissipated quickly into the atmosphere. At times of excavation and ground moving, it was calculated that 0.25% of the volume of atmospheric air was methane and it took no more than 5 minutes for there to be no measureable quantity of methane in the air. There were no asbestos or dangerous chemicals found in the mined material or soil. (Cobb).

The equipment that was used to perform the excavation and processing for the project was a front end loader, dozer, excavator, trommel and a magnetic separator. The excavated material in the landfill was stockpiled prior to processing. The trommel, air knife/de-stoner and magnetic separators consisted of the equipment used for processing. A flow diagram of the waste processing is shown below in Figure 2.1.

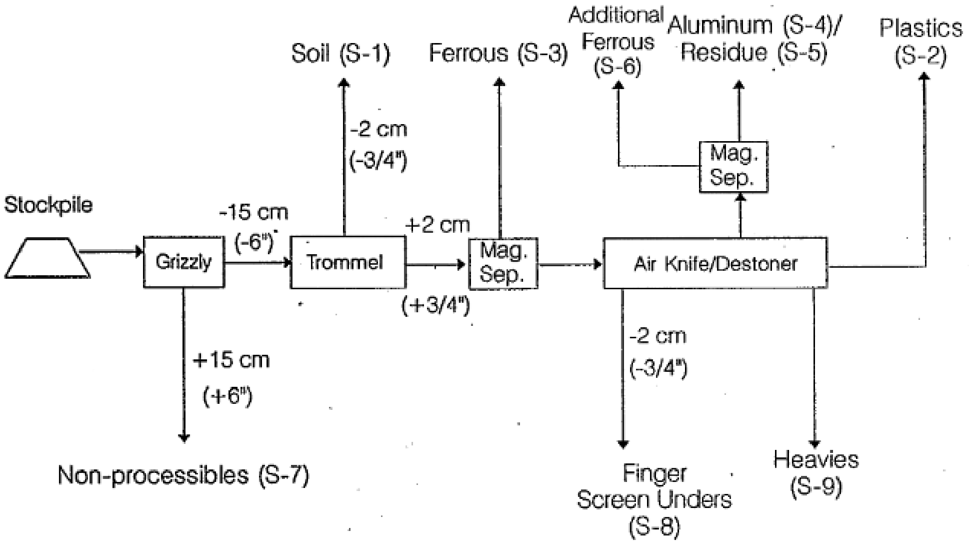


Figure 2.1: Processing block flow diagram from Naples Landfill mining demonstration project. (EPA, 1993)

In the waste processing, materials were hand-sorted into 14 categories, and outputs of the system included soils, plastics, ferrous materials, aluminum/residue, and non-processibles. The ferrous, film plastics and aluminum materials were classified to have a potential use for recovery. Certain precautions were taken into consideration such as soil testing and air quality control. Bacterial colony-forming units, pH, nitrogen, lead content, and mercury content were tested in the soil. (EPA, 1993).

A feasibility study was performed on two separating equipment pieces, an impact separator and a vibratory screener. The impact separator was evaluated first and it was used to separate and screen highly decomposed landfill material. It performed well and separated 3 sizes of materials as the waste was sieved through three different sized holes. The processing rate of the impact separator was approximately 3 tons per hour. The impact separator was not efficient at processing plastic bags, glass, wood and rocks of large size. The vibrating screen separator was the second piece of processing equipment for the feasibility study. This separator was chosen to recapture the cover soil. The separator successfully recovered soil, however other materials such as wood, metal, glass and stones were often found in the recaptured soil. The processing rate of the vibrating screener was approximately 60 tons per hour. (Cobb).

Approximately 292 tons of waste was excavated and processed for the demonstration project. Of the 292 tons of waste that was excavated, 171 tons was recovered as a soil fraction to be used future landfill cover, which is about 58% of the excavated material. An evaluation was performed on the waste composition that was mined from the landfill. The majority (81.1% by weight) of the waste was classified as "other." "Other" consists of soil, textile, rubber and other undefinable materials. The remaining 20% (by weight) of waste consisted of paper (3%), glass (21%), plastic (4.3%), metal (2.4%) and food and wood wastes (7.2%). (Cobb).

Overall, the project proved successful in recovering landfill cover, but was not successful in recovering recyclable materials. The recyclable materials would need to upgrade their quality for sale and marketable quality. From the 10 acres that was mined, 50,000 tons of reclaimed soil was recovered for future landfill cover and as a soil for supporting plant-growth. (US EPA, 1997).

2.2.2 Endinburg Landfill, Endinburg, New York

The New York State Energy Research and Development Authority (NYSERDA) and the New York State of Environmental Conservation performed a feasibility landfill mining reclamation project. There were two areas in the landfill that were mined for the project, a 1-acre and 1.6-acre area. The operation for the 1-acre was completed in June 1991 and the operation for the 1.6-acre was completed in September 1992. The soil was used for construction fill. The objectives of this project were to determine an alternative to landfill closure and to reduce the footprint of the landfill. The first phase of this project was to excavate 5,000 yd^3 of 12 year-old waste from a depth of 20 feet. The second phase of this project included the excavation of 10,000 yd^3 of 20 year-old waste from a depth of 8 feet. The unit cost for the two phases was $5 per cubic yard including excavation and processing. 75% of the excavated materials were soil and 25% of the excavated were waste. 12.5% of the waste was recyclable and they were tires, white goods, and ferrous materials. The remaining materials of the waste were sent to the nearby landfill. The health and safety plan provided for a project contingency plan, a segregated disposal area, and special waste handling procedures for the hazardous waste. (US EPA, 1997).

2.2.3 Perdido Landfill, Escambia County, Florida

The Escambia County Division of Solid Waste Management performed a pilot-scale landfill mining project of an unlined portion of Perdido Landfill. The purpose of the pilot project was to evaluate the economic and technical feasibility of a full-scale mining project. Perdido Landfill has 45 acres of closed unlined disposal containing waste from 1981 to 1989. The pilot project lasted from June to November 2008, and involved mining 2.5 acres of an unlined site. Approximately 54,000 yd^3 of material was mined during the project; 70% of which was soil.

Since about 70% of mined material was soil, it was determined that the landfill mining project would create 70% more airspace than not completing the project. Mining cost for this project, including waste excavation, screening and hauling, and hazardous material management, was estimated to be \$8.6/yd^3. However, based on a compilation of other case studies presented in the Perdido Landfill report, the average cost of landfill mining was \$5/yd^3.

Waste composition was not recorded during the project, however, test pits were analyzed prior to the project to determine what time of waste can be expected. Figure 2.2 is a size distribution of excavated waste.

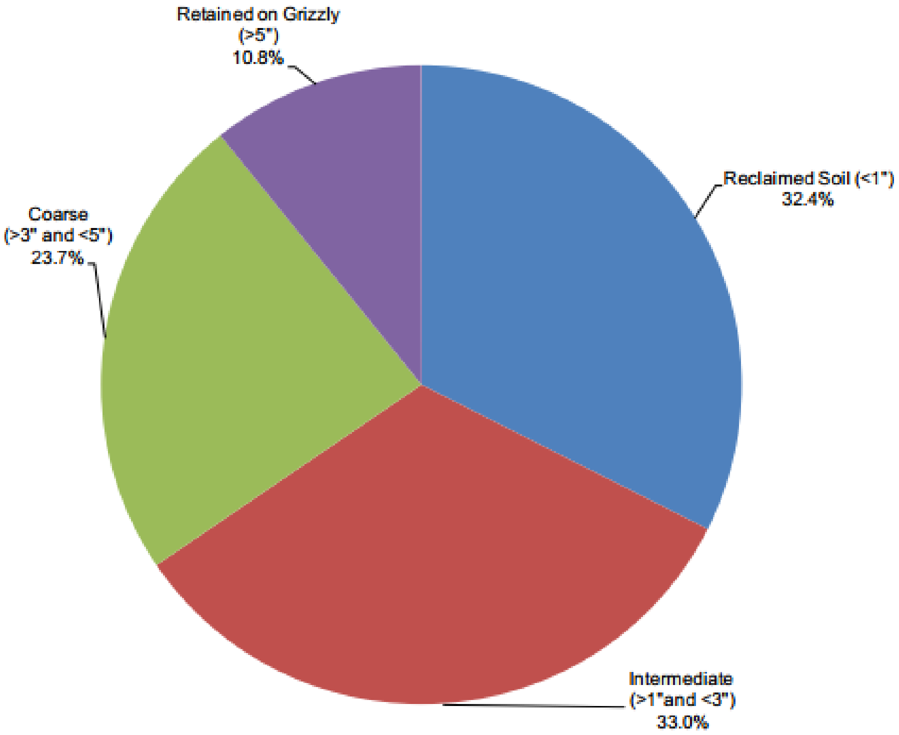


Figure 2.2: Perdido landfill, Average waste size distribution. Source: (Perdido Landfill, 2009).

A large portion of the waste retained on the Grizzly were tires, but past that observation, no characterization of this waste was performed. Waste characterization of the coarse and intermediate size waste was performed. Figure 2.3 provides the estimated composition, by weight, of the coarse and intermediate waste.

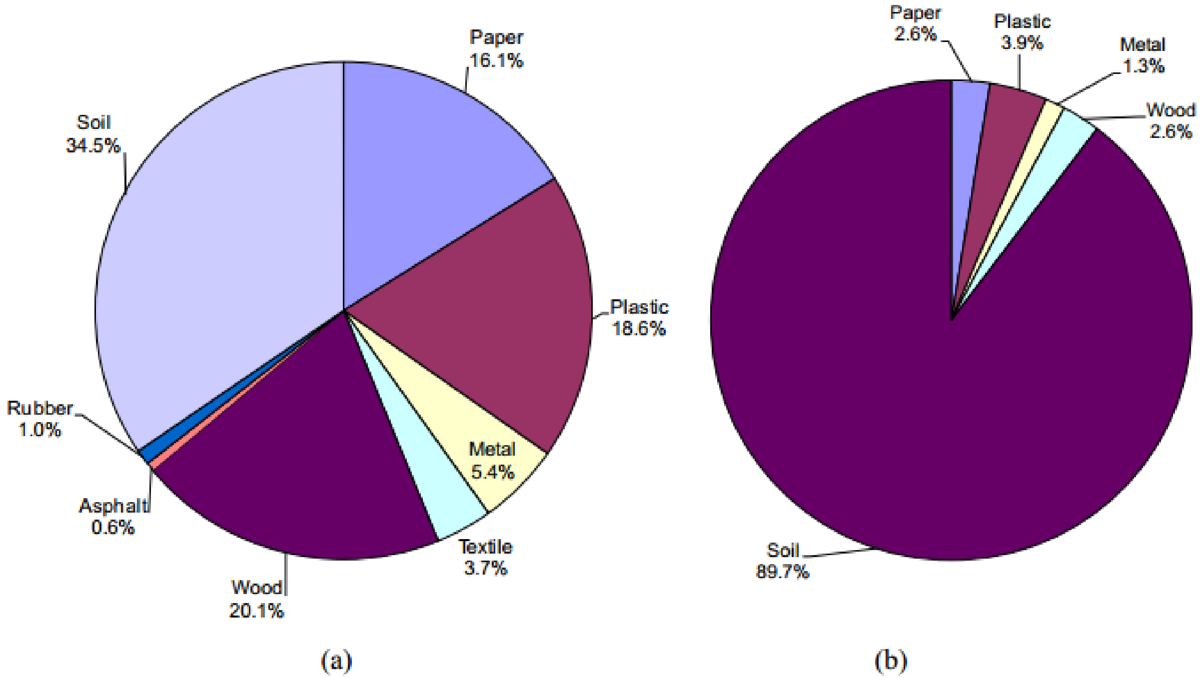


Figure 2.3: Perdido Landfill, Composition of (a) Coarse and (b) Intermediate Fractions of Waste. Source: (Perdido Landfill, 2009).

The majority of soil in the coarse fraction existed in lumps so the ability to recover this soil was questioned by those involved in the Perdido project.

The Perdido Landfill mining project documented the effectiveness of different equipment, including, excavators, dozers, and separation equipment. Trials were completed to test the effectiveness of a trommel screen versus shredded waste and vibratory screen. For the separation of fines, a trommel screen was more effective than a combination of shredding and vibratory screener. The approximate excavation rate was 540 yd^3/day, though it was expected to be higher once shredding was stopped. It was also determined that the excavation rate was more efficient with the use of only an excavator, as opposed to an excavator aided by pre-scrapping of waste.

The Perdido project prepared for possible health and environmental impacts caused by landfill gas, dust, hazardous waste, and stormwater. Landfill gas, odor, and dust issues were not encountered during waste excavation and processing, however, blowing litter from waste piles was an issue. Hazardous waste was not an issue either. No hazardous waste was encountered during the project, however, a large number of tires were encountered in some areas. Stormwater management was achieved primarily by covering waste and diverting stormwater. When significant precipitation was expected waste piles were covered by a polyethylene liner to reduce exposure to rain. Stormwater that came in contact with waste was diverted to retention ponds so to not mix with not contaminated stormwater. (Perdido Landfill, 2009)

2.2.4 Case Study Comparison to Flagstaff

The case studies have demonstrated that the amount of soil recovery that can be expected is largely dependent on the past operations of the landfill. However, they have provided a basis to conservatively assume about 50% (by weight) of excavated waste will be soil. A conservative estimate of 50% soil is appropriate because Flagstaff is located in a dryer climate than the three case studies. Therefore, it can be expected that decomposition of waste has occurred more slowly than the waste in each case study. It is likely that less waste has decomposed enough to a similar size as soil. Based on the case studies, it is apparent that an excavator and trommel are likely necessary of the efficient excavation and processing of mined landfill waste. Though landfill gas and hazardous waste were not issues in these case studies, it is still necessary to address the possibility of their occurrence during the Cinder Lake Landfill project.

2.3 Regulations

Local, Arizona nor federal regulations have been written for landfill mining. There are, however, regulations that are applicable to the activities involved in this project. Relevant regulations address hazardous waste handling, testing, worker safety and typical landfill operations. In this section, the state and federal role in municipal solid waste management will be discussed. These regulations include the Code of Federal Regulations (CFR), Resource Conservation and Recovery Act (RCRA), Clean Air Act (CAA) and Clean Water Act (CWA).

2.3.1 Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act (RCRA) was passed by congress in 1976. RCRA is classified into two main categories, Subtitle C – Hazardous Waste and Subtitle D – Non-Hazardous Waste. The regulations of RCRA are located in the CFRs under 40 CFR Part 257. An additional section was added to the CFR's addressing landfill criteria as Part 258. Part 258 is titled "Criteria for Municipal Solid Waste Landfills." Part 257 and Part 258 of the CFRs comprise of the Resource Conservation and Recovery Act. Part 257 addresses potential landfill environmental issues such as floodplains, groundwater, air, endangered species and surface water. Safety and disease vectors are also addressed in this Part. Part 258 addresses the design concept of landfills. These design considerations includes location restrictions, operation criteria, groundwater monitoring and corrective action, financial assurance and closure and post closure care. It is the duty of the employer to identify the system of failed protector to ensure that all suitable criterion are met. (Kreith).

2.3.2 Clean Air Act (CAA)

The Clean Air Act was (CAA) was passed by congress in the 1970s. This act introduced guidelines for control of gases and other compounds in the air. 1n 1990, the Clean Air Act was amended to regulate emissions from a variety of sources including those from solid waste management. Landfill gases must be regulated under this act. (Kreith).

2.3.3 Clean Water Act (CWA)

The Clean Water Act (CWA) is also applicable to the operation solid waste management. The CWA protects surface waters and prevents pollutants from being discharged into waterways. Under the CWA is the program, National Pollution Discharge Elimination system (NPDES). Various facilities are covered under the NPDES program. These include hazardous waste treatment, storage and disposal facilities, landfills, and material recycling facilities. These facilities must obtain the CWA 301 best available technology/best control technology (BAT/BCAT). (Kreith)

2.3.4 New York Landfill Mining

New York is one of few states that provide regulations on landfill mining. New York regulations require plans and documentation of actions, such as emergency protocol and personal protection equipment to ensure worker safety is addressed. Though these regulations do not govern the project at Cinder Lake Landfill, they have been consulted for good practices. (US EPA, 1997).

3.0 Landfill Mining and Excavation Plan

A landfill mining and excavation plan has been developed for the target cells and areas to re-sequence Cell D. The landfill mining and excavation will be completed in four phases over a 60-month (5 year) duration. In the meanwhile, the processing of the excavated material will also be performed.

3.1 Overview

3.1.1 Current Cells

Cinder Lake Landfill covers an area of 343 acres. The landfill is comprised of five Cells including Cells A, B, C, D, and E, and a portion near Cell D containing waste called the South Thumb. Currently Cell B is the only active Cell, meaning the trash currently being brought into the landfill is buried in Cell B. Cell A is ready to accept trash, but currently receives no trash. Cell E is being used as a borrow pit from which the landfill takes soil to use as daily cover for the active portion of the landfill. Cells C, D, and the South Thumb are of main concern for this project. Cell C contains 10 to 30 year old construction and demolition waste. It covers an area of 13 acres and has an approximate depth of 54ft. Cell D contains no wastes except for in the South Thumb portion. The 33 acre Cell D was once used as a borrow pit, but landfill operators have reached the bottom of the soil layer, 20ft deep, and now cannot dig deeper into the basalt layer. The South Thumb contains 20 year old Municipal Solid Waste (MSW). It covers an area of 3 acres and has an approximate depth of 42ft.

3.1.2 Duration

The overall duration of this project, limited to the excavation of Cell C, Cell D, and the South Thumb, is planned to be 5 years. The excavation of Cell C waste is estimated to take 16 months;

the excavation of the South Thumb is estimated to take 5 months; and the excavation of Cell D is estimated to take 39 months. The project duration is based on assuming a standard of approximately 21.7 working days per month for 60 months. With a 20% buffer time to account for equipment breakdown or poor weather conditions, the project is expected to take a total of 6 years.

3.2 Excavated Volume

The excavated volume will be for Cell C, Cell D, and the South Thumb. Also, this part consists of the soil excavation, waste excavation, and the total processing rate. For more information see Appendix 9.1.

3.2.1 Soil Excavation

The soil excavation volume for Cell D is 2,080,000 yd^3 by applying 30% of soil expansion. The excavation rate for Cell D will be 2,458 yd^3/ day for the time period of 39 months

3.2.2 Waste Excavation

The waste excavation volume for the South Thumb is 206,858 yd^3. The waste excavation rate for the South Thumb will be 1,907 yd^3/day for the time period of 5 months. The waste excavation volume for the Recon area (Cell C) is 734,458 yd^3. The waste excavation rate for the Recon area (Cell C) will be 2,115 yd^3/ day for the time period of 16 months.

3.2.3 Total Processing Rate

The total processing rate for the project is 2,300 yd^3/ day for the time period of 60 months.

3.3 Required Equipment

An analysis of earthmoving equipment was performed in order to determine the necessary equipment for excavation. CAT® earth moving equipment will be used throughout the duration of the project. Each equipment piece will assist one another in the operations of excavation, processing and stockpiling, as further explained in Section 3.4.2. The list below contains the earthmoving equipment that will be used for this project.

1. 328D LCR Hydraulic Excavator
2. 966K Wheel Loader
3. D9T Dozer
4. 735 Articulated Dump Truck
5. 450F Backhoe

In addition to earthmoving equipment, the required screening equipment was determined to process the excavated waste from the South Thumb and Cell C. Screen Machines Industry screening equipment will be used for this project. The models of screening equipment is listed below.

1. Scalper 107D (Vibratory Screener)
2. 612W Trommel

3.3.1 Equipment Description

The earthmoving and processing equipment was selected based on three criteria: cost, efficiency and durability. The three criteria were incorporated into a decision matrix for each equipment piece. Within the decision matrix, the cost, efficiency and durability were weighted 40%, 30%, and 30% respectively. Cost considers the rental price of the equipment; this criteria was weighted slightly more because implementing a project at the lowest price is important considering that this project is funded by tax payers. Efficiency considers the handling rate that the equipment piece is expected to perform. Lastly, durability considers the horsepower of the machinery and its ability to perform the expected task without failure. The decision matrices for the excavator, dozer, loader, dump truck and screeners are located in Appendix 9.5.

328D LCR Hydraulic Excavator

The hydraulic excavator will be used to perform the excavation of soil and waste from the targeted cells. The hydraulic excavator has a power of 204 hp, which will effectively perform the necessary tasks. The tasks to be performed by the hydraulic excavators includes the removal of: solid waste from the South Thumb, construction debris from Cell C, and basalt from Cell D and the North Pit. Two hydraulic excavators are needed at a time for excavation. One excavator will have a 3 yd^3 bucket with a thumb while the other excavator will have one of three attachments. The three attachments include a hammer, contractors' grapple or trash grapple. The bucket with the thumb will be effective for picking up loose soil and rock as well as pieces of MSW that has a volume less than 3 yd^3. Whereas, the attachments will be able to perform specific tasks necessary for excavation.

Hammer

The hammer will be used to break up the bedrock soil in Cell D, basalt. A Cat® model hammer, H115E S Hammer was chosen because it has the ability to perform 370-800 blows per minute.

Contractors Grapple

The contractors grapple is a necessary attachment to excavate the waste from Cell C. Large pieces of concrete, lumber and rebar cannot be efficiently removed with a bucket due to the size and weight of the material. Therefore, the Cat® attachment model G130B Contractors' Grapple was selected to remove these large pieces when encountered upon in Cell C. The contractors grapple can lift up to 5,130 lbs and has a jaw opening of 10 feet.

Trash Grapple

The trash grapple attachment will ideally be used to excavate MSW in a more efficient manner than the bucket. The TG-C Trash Grapple model was selected based on the aggressive teeth that the attachment has. The teeth on the trash grapple will make the excavation of MSW more efficient based on the analysis that it will grab and hold onto the MSW better than the bucket. The trash grapple can lift up to 3,500 lbs and has a jaw opening less than 10 feet.

966K Wheel Loader

The 966K Wheel Loader will be used to transport the soil and/or waste into the articulated dump truck. The hydraulic excavators will initially excavate the waste from the ground and dump the waste and/or soil into piles. The wheel loaders will then transport the waste and/or soil from the pile into the articulated dump trucks. Two loaders are necessary to be on site for the project. One loader will be needed at the site of excavation and another loader will be needed at the MSW segregation processing site.

D9T Dozer

The D9T Dozer is a classified as a large dozer. A large dozer is necessary to maintain the site by keeping a clean workspace and area. The dozer will assist the loader, dump truck and excavator by sustaining the waste and/or soil in a confined area. Misplaced waste and/or soil will be moved by the soil into the correct piles. Two dozers will be necessary for this project. Similar to the placement of the loaders, one dozer will be needed at the site of excavation and one dozer will be needed at the MSW segregation processing site.

735 Articulated Dump Truck

The 735 Articulated Dump Truck will be used to transport the soil and/or waste from the excavation site to the MSW segregation area or to Cell E for stockpiling. The 735 model has a heaped SAE of 25.8 yd^3. A total of 8 trucks will be needed for this project in order to meet an average processing rate of 8,880 yd^3/day. Further truck logistics will be discussed in Section 3.4.2 Truck Cycles.

450F Backhoe

A backhoe will be needed at the waste segregation area to assist the dozer in sorting the waste from the initial piles to the sorted waste piles. The backhoe has the ability to transport waste in a similar fashion to loaders as well as to move waste in a similar fashion to excavators. This dual capability of the backhoe is the most efficient equipment piece to move waste around the segregation area.

Scalper 107D (Vibratory Screener)

The Scalper 107D is a vibratory screener which will be used to separate fines from the C&D waste coming from Cell C. This vibratory screener is capable of separating different material sizes associated with fines, rock, and concrete. The screener has two different size screens that allow fines to fall to the bottom, medium size materials to fall to the side, and large materials to remain on top. The vibratory screener will be located in the Waste Segregation Area.

612W Trommel

The 612W Trommel will be used to separate out fines from the excavated MSW from the South Thumb. Waste is put into the trommel where it is rotated like a tumbler. Fines fall out the bottom and are directed off to the side of the trommel through a conveyor belt. Material not small enough to pass through the screen is unloaded off the back of the trommel. This model also provides self-cleaning trommel drum brushes to reduce the chances of clogging. The trommel will be located in the Waste Segregation Area.

3.4 Logistics Plan

3.4.1 Project Phases

The team decided to have four phases for the logistics plan. Phase 1, which will include portion of Cell C. Phase 2, which will include the South Thumb. Phase 3, which will include Cell D. Phase 4, which will include the north pit and a portion of the South Thumb. Stock piles will be located in Cell E and the municipal solid waste segregation area will be located in the north west of Cell E.

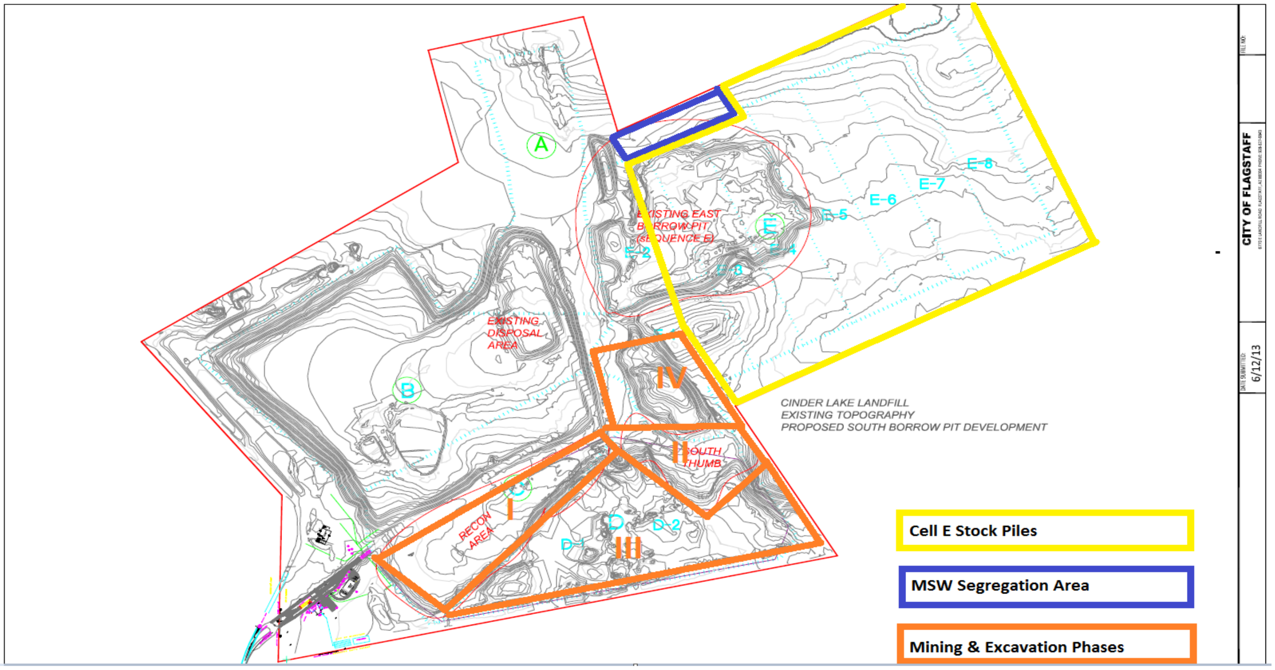
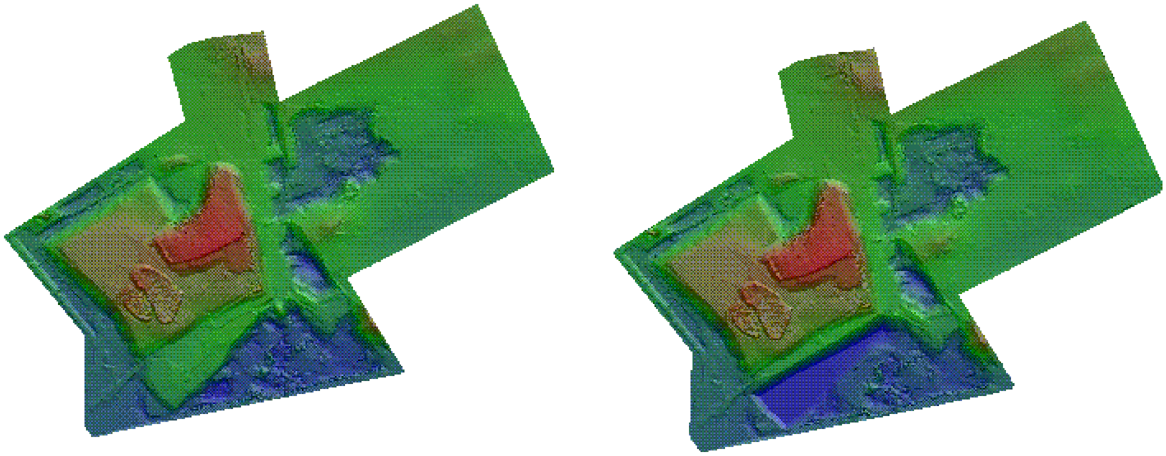


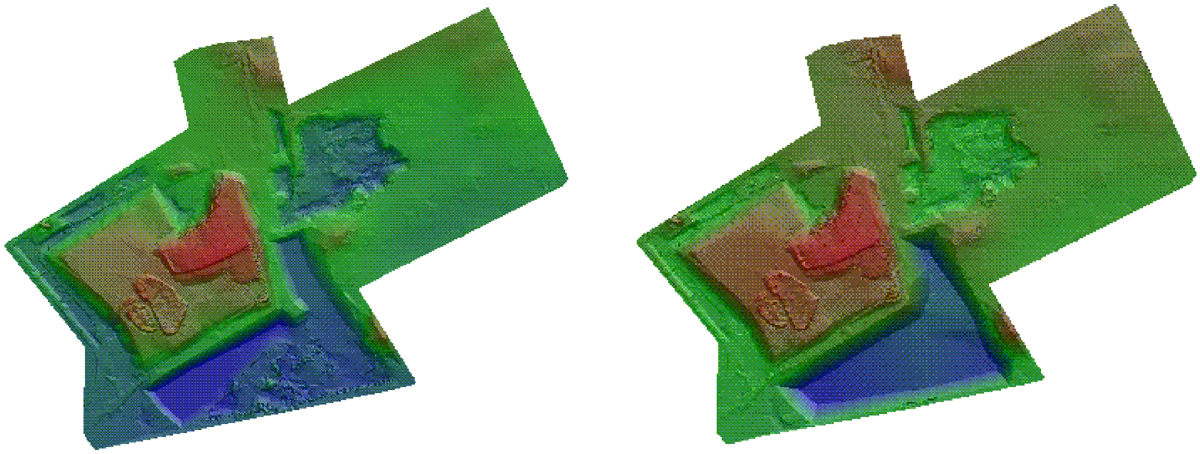
Figure 3.1: Project Schematics

Figure 3.1 is shown the location for mining and excavation phases in red color. The blue color shows the location for the municipal solid waste segregation area and the yellow color is shows the location for the stock piles.

Figure 3.2 shows the progression of the project over the excavation of Cell C, the South Thumb, and Cell D. These figures are 3D CAD renditions of the relative elevations of Cinder Lake Landfill. Dark blue indicates the lowest elevation while red indicates the highest elevation.



(a) Current Conditions *(b) Cell C Excavated*



(c) Cell C & South Thumb Excavated *(d) Final Design*

Figure 3.2: Progress of Cell D Source: Matt Morales

Figure 3.2 (a) depicts the current conditions at Cinder Lake Landfill. Notice that Cell C and the South Thumb are at a higher elevation than Cell D. In Figure 3.2 (b), the Recon portion of Cell C has been excavated. Figure 3.2 (c) shows the relative elevations after Cell C, the South Thumb, and the North Pit have been excavated. Figure 3.2 (d) shows the final elevations of the new Cell D, after everything has been excavated. The red indicates the active portion of the landfill, Cell B, and the blue in Cell E is a borrow pit. Note that despite the change in color of Cell E in the final conditions, Cell E is not being filled in.

3.4.2 Truck Cycles

Articulated Trucks will be cycling on a continual basis around East portion of the landfill for this project. The trucks will be traveling from the excavation area to the waste segregation area or to the stock piles in Cell E, and then back to the excavation area. In order to accommodate the necessary daily excavation rate of 2,300 yd^3/day, three (3) trucks are needed to cycle on a continual basis. Given that the heaped load per truck is 25.8 yd^3, each truck will need to make approximately 30 cycles per day.

The calculated time for a truck to perform one cycle is approximately 15 minutes. It will take 15 minutes to load waste into the truck, drive to the segregation area or Cell E, unload the waste, and then drive back to the excavation area. The anticipated loading time of 5 minutes includes the time for the excavator to mine 25.8 yd^3 of material, and then for the loader and dozer to load the excavated volume into the articulated truck. The anticipated unloading time is 2 minutes, where the truck will tip the waste to the waste segregation area. Given 9 minutes of loading and unloading, it will take the truck 6 minutes to travel 1.3 miles for a total time of 15 minutes. The maximum speed limit at Cinder Lake Landfill is 10 miles per hour.

3.4.3 Mass Balance

A mass balance was performed to determine the amount of expected materials to be excavated from Cell C, the South Thumb, and Cell D. In order to determine an estimated amount of waste to be excavated from Cell C and the South Thumb, typical waste compositions were applied to the estimated volumes of trash in both waste areas. Matt Morales provided values of typical uses of rock types for estimating the amount of materials that can be sold or used by the landfill. The mass balance is important in determining the area needed for each segregation pile in the processing areas.

Cell C

Waste Composition

Cell C waste is composed of construction and demolition debris. Typical characteristics of construction and demolition (C&D) debris entering landfills were used to determine what materials and their corresponding amounts that can be expected to be encountered during waste excavation. Figure 3.3 shows the waste characteristics of construction and demolition (C&D) debris that can typically be found in the waste stream.

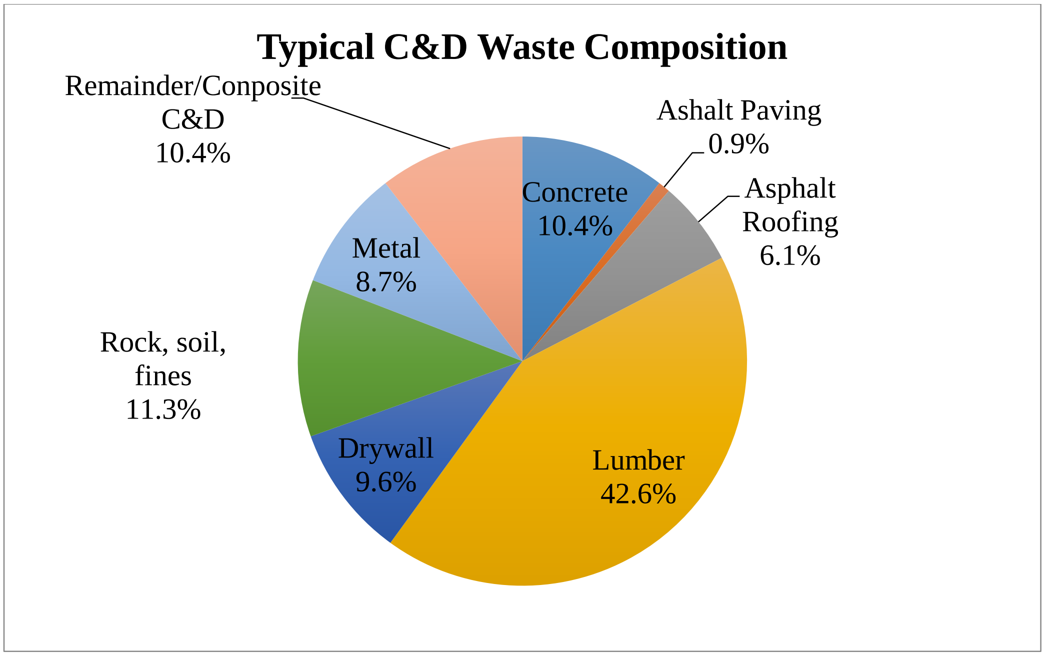


Figure 3.3: Typical composition of C&D waste entering the landfill. Source: (CIWMB).

These proportions were applied to the volume of waste expected to be in Cell C in order to estimate the composition of waste being excavated from Cell C. Based on the case studies discussed in Section 2.2 Case Studies and adjustments made due to the different type of waste, it has been estimated that 20% (by weight) of the excavated material in Cell C is soil. Using this information, a mass balance of excavated C&D waste from Cell C was developed.

Block Flow Diagram

Estimating the composition of excavated Cell C waste provides insight into the amount of recoverable materials and material that are likely to be put back into the landfill. The excavated waste will be placed in an initial pile in the segregation area and then separated into piles of concrete, lumber, metals, rock, fines, and waste to be reburied. Figure 3.4 is a block flow diagram showing the processing plan for excavated waste from Cell C and a mass balance corresponding to the waste separation.

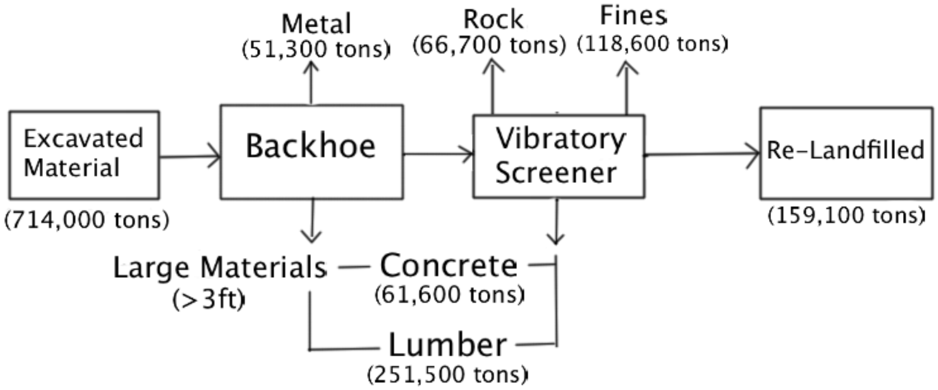


Figure 3.4: Block Flow Diagram of Cell C waste processing.

Large materials, greater than 3ft in any dimension and likely to be concrete, lumber, or metals, will be removed from the pile using a backhoe. Remaining waste will be put through the vibratory screener to separate out fines. Using a backhoe, the waste will then be picked over for valuable materials, such as concrete, and the remaining waste be reburied in the landfill. Cell C composition calculations can be found in Appendix 9.3.

South Thumb

Waste Composition

An estimated waste composition of South Thumb waste was determined based on analysis of the three cases studies discussed in Section 2.2 Case Studies and typical composition of landfilled Municipal Solid Waste (MSW) from the same time period as the waste to be excavated from the South Thumb. The waste in the South Thumb is approximately 20 years old.

Figure 3.5 shows the national average percent composition of MSW entering the landfill in 1994. (US EPA, 1995).

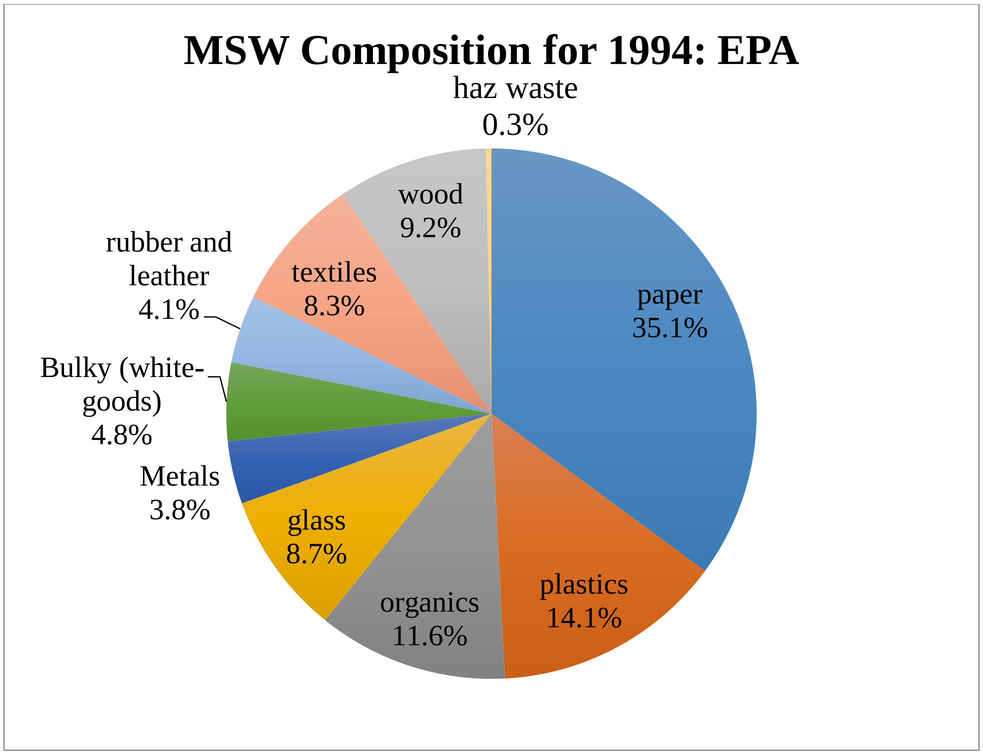


Figure 3.5: MSW entering the landfill in 1994. Source: (US EPA, 1995).

From the case studies previously discussed in Section 2.2 Case Studies, it was estimated that there is about a 50% ratio (by weight) between excavated soil and MSW. It was also assumed that 50% of the organic material has degraded and become a part of the soil fraction. In estimating the composition of excavated materials from the South Thumb, an analysis of the density ratio of soil and waste (4480 lb/yd^3 soil and 1350 lb/yd^3 MSW) and the waste composition explain above was performed to develop a mass balance.

Block Flow Diagram

Similar to the mass balance of Cell C waste, estimating what materials will be processed from the South Thumb will provide insight into what waste and processing techniques the workers will need to be prepared for. The equipment discussed in Section 3.3.1 Equipment Description will be used to separate the incoming South Thumb waste into piles of bulky waste, hazardous waste, fines, metals, and waste to be reburied. Bulky waste consists primarily of white goods, such as refrigerators and washing machines. Hazardous waste is considered dangerous or potentially harmful to person’s health or the environment (EPA). Specifics of hazardous waste classification and testing is discussed in Section 4.0 Environmental Controls. Fines will consist of particles able to pass through the trommel screen and will likely be used as cover material for the active portion of the landfill. Ferrous metals, primarily steel, will be sold for profit. The remaining waste will be reburied in the active portion of the landfill. Figure 3.6 is a block flow diagram showing the processing plan for excavated waste from the South Thumb and a mass balance corresponding to the waste separation. South Thumb composition calculations can be found in Appendix 9.2.

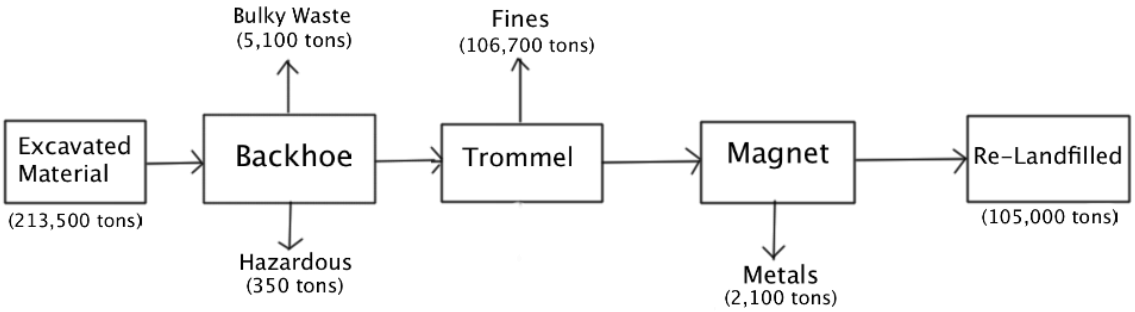


Figure 3.6: Block Flow Diagram of South Thumb waste processing.

Excavated waste from the South Thumb will be placed in the initial pile located in the segregation area. The bulky and potential hazardous waste will be separated from the initial pile with the backhoe. Potential hazardous waste will be handled and tested according to procedures discussed in the Environmental Controls section. The trommel will separate out fines from the waste and a magnet will separate out metals. The remaining waste will eventually be diverted to the active Cell.

Waste Segregation Area

Cell C and South Thumb waste will be processed in a 2.2 acre segregation area near the northwest corner of Cell E. Within the waste segregation area, waste coming from Cell C and the South Thumb will be separated into respective piles. Figure 3.7 shows the planned layout of the piles within the waste segregation area.

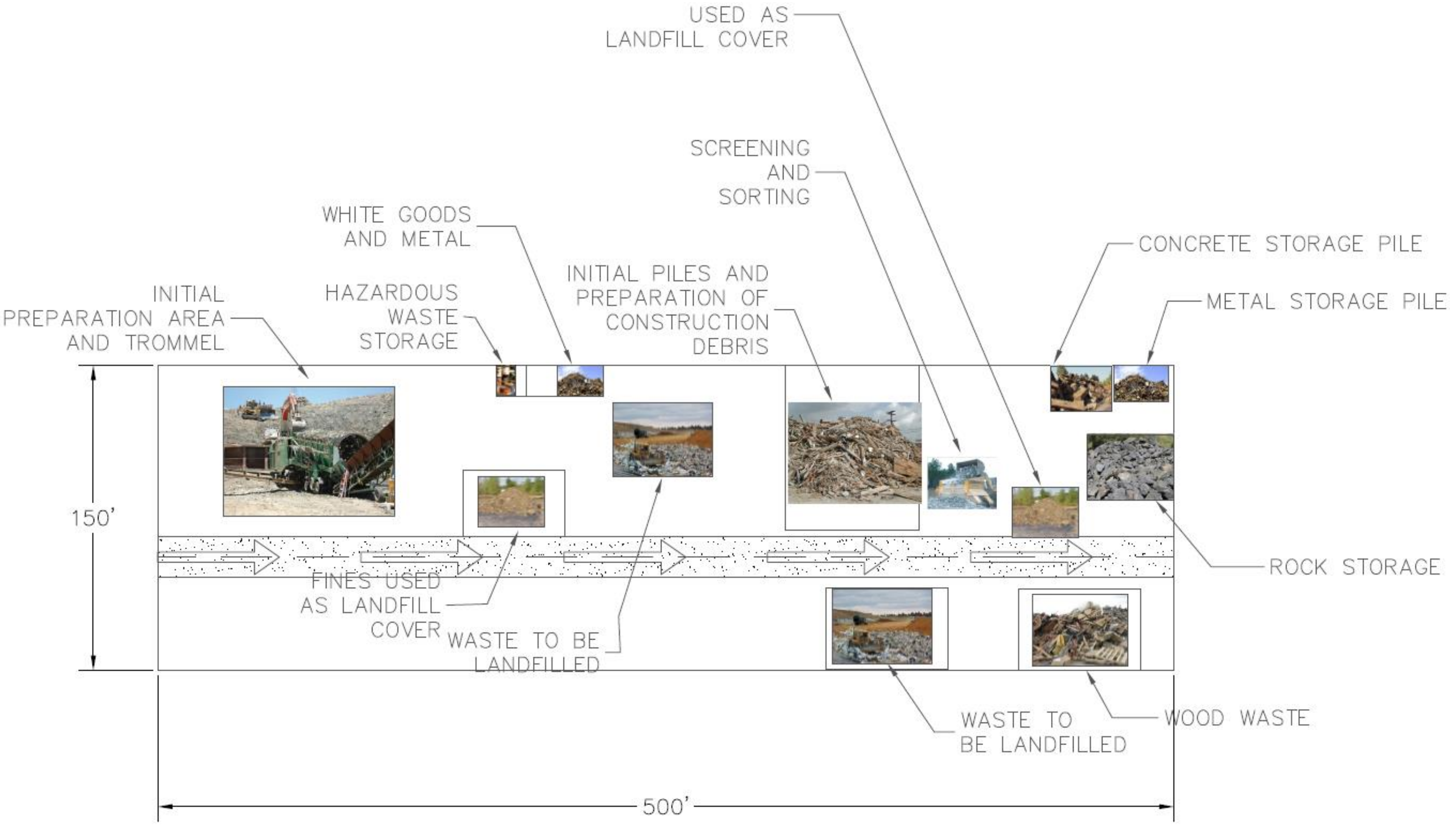


Figure 3.7: Waste Segregation Area (Rendered by Matt Morales).

Processing of South Thumb waste (MSW) will be located on the west side of the segregation area, while processing of Cell C waste (C&D) will be located on the east side of the segregation area. The sizes of each pile are scaled in proportion to the amount of waste expected for each pile. The dimensions of each pile can be found in Table 3.1.

Table 3.1: Waste Pile Areas

South Thumb	**Area (yd^2)**	**H (yd)**	**W (yd)**	**L (yd)**
Initial	179	1.67	12.5	14.3
Fines	89	1.67	11.0	8.1
Metals	2	1.67	3.0	1.0
Landfilled	88	1.67	6.3	14.0
Bulky	4	1.67	3.0	1.4
Haz Waste	1	1.67	1.0	1.0
Cell C	**Area (yd^2)**	**H (yd)**	**W (yd)**	**L (yd)**
Initial Pile	630	3.33	28.7	22.0
Concrete	61	3.33	6.3	9.7
Lumber	248	3.33	12.5	19.9
Rock, Soil, Fines	66	3.33	6.3	10.5
Metal	51	3.33	6.3	8.1
Landfilled	157	3.33	12.5	12.6
Cover Soil	47	3.33	6.3	7.5
Equipment	**Area (ft^2)**	**Area (yd^2)**	**W (yd)**	**L (yd)**
Trommel	6X12	17.8	3.3	5.3
Vibratory Screener	10X7	17.1	3.7	4.7

South Thumb piles are set to be 5ft high, while Cell C piles are set to be 10ft high. All waste is assumed to be processed within one day and removed from the segregation area and handled based on normal operations of the landfill. Stormwater management of the segregation area will be discussed in the Environmental Controls section.

Cell D

Material Available

Based on geotechnical reports of Cell D, the material that will be excavated consists of basalt rock, slightly weathered basalt rock, and decomposed rock (Speedie & Associates, 2013). Table 3.2 shows the amount of materials that are expected to be excavated from Cell D to a depth of approximately 30ft deeper than the current elevation.

Table 3.2: Expected volume of rock to be excavated from Cell D.

Basalt Rock	Slightly Weathered Basalt	Decomposed Rock
976,683 yd^3	246,487 yd^3	300,442 yd^3

Block Flow Diagram

The excavated rock will be separated into piles of cover material, landscape rock, and rip-rap. Approximate percentages of available material expected for each pile was provided by Matt Morales. Table 3.3 provides these values.

Table 3.3: Category of rock

Category of Rock Pile	Basalt Rock	Slightly Weathered Basalt	Decomposed Rock
Rip-Rap	30%	-	-
Landscape Rock	60%	80%	60%
Cover Material	10%	20%	40%

Based on these values the amount of materials in each piles was estimated and provided in Figure 3.8 below.

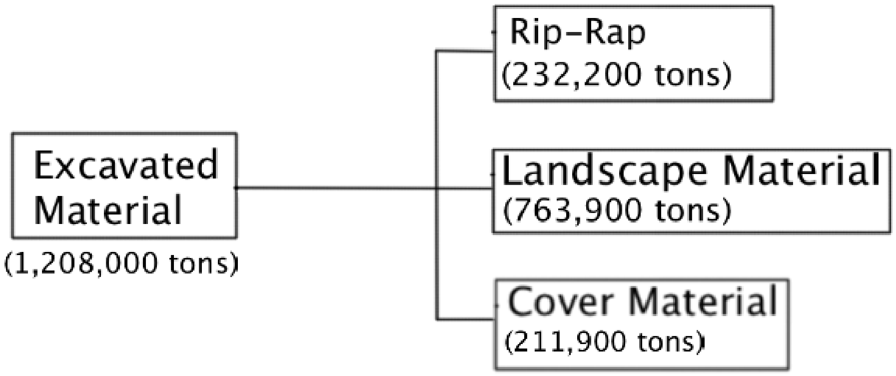


Figure 3.8: Block Flow Diagram of Cell D rock separation.

The rock will be excavated from Cell D and transferred to the piles corresponding to the characteristics of the rock. Any processing of excavated rock will not be addressed by Aspen Engineering and Environmental Services.

Rock Segregation Area

The rock materials excavated from Cell D will be stockpiled in a 30 acre portion of Cell E. Figure 3.9 shows the proposed layout of the rock piles in the Rock Segregation Area.

Figure 3.9: Rock Segregation Area

The dimensions of each pile can be found in Table 3.4.

Table 3.4: Areas of Rock Piles

Category of Rock	Area/pile (acres)	H/pile (yd)	L/pile (yd)	W/pile (yd)
Rip-Rap	4.1	7	124	160
Cover	3.8	7	114	160
Landscaping	6.4	7	194	160

These areas are based on the assumption that the rock materials will be piled for one year. The piles can be removed prior to one year, but any longer than one year would result in needing more than the provided 30 acre area.

4.0 Environmental Controls

4.1 Air Quality

Dust control, dust monitoring, and air monitoring will be done for air quality in Cinder Lake Landfill. Dust control will be done by using water spraying. Dust monitoring will be done by using Digital Opacity Compliance System (DOCS II). Air monitoring will be done by using GEM2000 and MiniRAE3000.

4.1.1 Dust Control

Water spraying method confines and settles the dust from the air by dust and water particle adhesion. Water is sprayed through nozzles from the water truck over the working face in the excavation area. Three water trucks are needed for dust control, two of the water trucks will be in the working face and one water truck will be on the truck cycle. The capacity for each water truck is 3,800 gallons of reclaimed water. Each tuck will use up to 3000 gallons of reclaimed water every 25 minutes by using the water cannon for a distance of 25ft-30ft. In addition, the truck will spray water at the bottom over road in which the dump trucks cycle. The price for every 1,000 gallons of reclaimed water is $3.64 and the daily price for the reclaimed water is $41.50 per day. The total price of the reclaimed water for 60 months is $54,028.

4.1.2 Dust Monitoring

Dust monitoring will be done by digital imagery and associated hardware and software for the excavation area, such as the Digital Opacity Compliance System (DOCS II). The image for the dust in the working phase must be captured in a JPEG format that adheres to the EXIF 2.1 (or higher) standard (Visual Technology). The image must be captured with the sun within a 140° sector directly behind the Image capture device and it should be perpendicular to the direction of plume travel. The images for the active area will be sent to the Virtual Technology Company to be analyzed. The cost for the instrument kit is $5,495/unit and the camera operator subsystem will cost $2,500/operator. The team recommends using Digital Opacity Compliance System (DOCS II) instead of EPA method 9 for the working phase. Figure 4.1 shows the equipment involved in the DOCSII method. This includes the camara to capture images, a handheld recording device, and the software used by Virtual Technology to analyze images.

Figure 4.1: DOCSII. Source: Visual Technology

4.1.3 Air Monitoring

Air monitoring will be done by using point sampling for air monitoring by measuring the gases in the working face area. The instruments for air monitoring are GEM2000 and MiniRAE3000, as shown in Figure 4.2. Air monitoring will be completed a minimum of three times per day during the project using the GEM2000. The MiniRAE3000 should be carried with every worker on site at all times during the project. The monthly rental rate for MiniRAE3000 is $765 and the monthly rental rate for GEM2000 is $1275. Air monitoring is done to measure the upper and the lower concentration of a gases in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat). The lower and upper limits are stated in Table 4.1.

Figure 4.2: Air monitoring equipment to be used on site, MiniRAE3000 on the left and GEM2000 on the right. Source: omniinstruments & equiposervices

Table 4.1: LEL & UEL for Common Landfill Gases

Gas	Lower Explosive Limit (LEL)	Upper Explosive Limit (UEL)
Methane (CH_4)	5%	15%
Hydrogen Sulfide (H_2S)	4.3%	46%
Carbon Monoxide (CO)	12%	75%

Source: The Engineering Toolbox

Table 4.1 shows the lower and upper explosive limit for the most three common gases at Cinder Lake Landfill. The percent levels refer to the amount of vapor present in air. Gas measuring between the LEL and UEL have explosive characteristics when exposed to an ignition source, such as a spark. Gas measuring below the LEL or above the UEL do not have the proper proportions of vapor and gas to be explosive.

4.2 Stormwater Management

The piles of excavated waste will likely be exposed to precipitation. Stormwater coming in contact with the exposed waste in the Waste Segregation Area could become contaminated and needs to be managed. To mitigate the potential hazards caused by contaminated stormwater, stormwater must be diverted to a retention basin for temporary storage. Asphalt will be laid as a tipping floor of the Waste Segregation Area in order to restrict infiltration of stormwater into the ground. A silt fence will surround the asphalt tipping floor to retain sediment and waste from flowing out of the Segregation Area. Stormwater will be diverted from the Waste Segregation Area through a drainage ditch to a retention pond. The retention pond will be lined with a polyethylene liner so water does not infiltrate the ground. Stormwater will be retained in the pond and tested. If the water quality passes the Clean Water Act regulations it can be transferred to the City of Flagstaff Wildcat Hill wastewater treatment plant. However, specifics of water testing and use will not be addressed by the team at Aspen Engineering and Environmental Services. Figure 4.3 shows the relative location of the retention basin in reference to the segregation area.

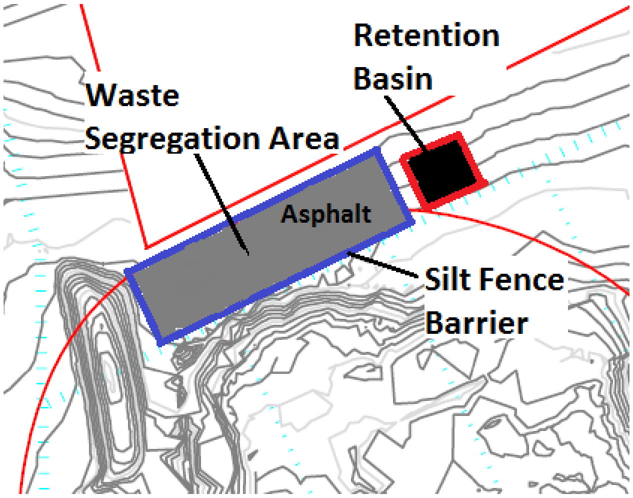


Figure 4.3: Stormwater Management Diagram.

4.3 Hazardous Waste & Soil

It is to be assumed that hazardous waste will be encountered during the excavation of waste from Cell C and the South Thumb. Therefore, hazardous waste management will be considered for this project. According to the EPA, “A hazardous waste is a waste with a chemical composition or other properties that make it capable of causing illness, death, or some other harm to humans and other life forms when mismanaged or released into the environment.” If encountered, hazardous waste must be handled and managed carefully following all RCRA regulations.

4.3.1 Hazardous Waste Identification Process

Step 1: Identification

The identification of hazardous waste will be determined by the worker who is performing the landfill mining. Key components for workers to identify hazardous waste include color, smell and identifiable containers that may be full of liquid. Any person who produces or generates waste must determine if the waste is hazardous under 40 CFR 262.11. Therefore, this project must follow a hazardous waste identification (HWID) process, as outlined below.

Hazardous waste that could potentially be found in the South Thumb and/or Cell C is Household Hazardous Waste (HHW), a subgroup of solid waste in the MSW stream. HHW products that contain hazardous ingredients include:

- Drain and oven cleaners
- Spot remover
- Oil-based paint
- Paint remover
- Garden insecticides
- Disinfectants
- Rubber cement
- Antifreeze

Mercury, lead and cadmium are elements found in various products which are found in the MSW stream. The most common sources of these elements are listed below in Table 4.2. (Kreith).

Table 4.2: Common Household Hazardous Waste Products

	Mercury	**Lead**	**Cadmium**
1	Household battery	Lead-acid battery	Household battery
2	Electric lighting	Consumer electronics	Plastics
3	Paint residue	Glass & ceramics	Consumer electronics
4	Fever thermometers	Plastics	Appliances
5	Pigments	Soldered cans	Pigments
6	Dental uses	Pigments	Glass & ceramics

Source: Kreith

The sources listed in Table 4.2, as well as the HHW products listed above, are more likely to be encountered in the South Thumb than Cell C, due to the assumption that Cell C contains primarily construction debris.

Step 2: Testing

The EPA categorizes four different hazardous waste types, which include: listed wastes, characteristic wastes, universal wastes and mixed wastes. For the purpose of this project, characteristic wastes will be used to identify the hazardous waste through various test methods. There are four characteristic wastes, which include: ignitability, corrosivity, reactivity, toxicity and are described in section 40 CFR 261.21, 261.22, 261.23 and 261.24, respectively. If the hazardous waste is tested and does not exhibit a least one of the four characteristics, the waste is not hazardous. Each characteristic is determined through a specific test method as outlined in the American Society for Testing Material (ASTM) Standard. The ASTM procedural methods can only be attained through contacting Global Engineering Documents, http://global.ihs.com. Please refer to the website if any of the following test methods mentioned need to be conducted. Table 4.3 below, outlines each characteristic with a brief definition and its possible test methods.

Table 4.3: Testing for the four characteristic wastes

Characteristic	Definition	Possible Sources	Potential Test Methods
Ignitability	○ Creates fire under certain conditions ○ Spontaneously combustible	○ Paints ○ Cleaners ○ Industrial sources	○ Pensky-Martens Closed-Cup Method for Determining Ignitability ○ Setaflash Closed-Cup Method for Determining Ignitability
Corrosivity	○ Acids or bases ○ Capable of corroding metal containers	○ Sulfuric acid from automotive batteries	○ PH Test (PH<2 or PH>12.5, then it is defined as corrosive)
Reactivity	○ Unstable under "normal" conditions	○ Munitions ○ Explosives	N/A
Toxicity	○ Harmful or fatal when ingested or absorbed	N/A	○ Toxicity Characteristic Leaving Procedure

Once a waste matches a listing description, such as one of the four characteristics, it is forever listed as a hazardous waste. However, if a waste no longer exhibits a characteristic of ignitability, corrosivity, reactivity or toxicity it is no longer regulated as a hazardous waste. Proper storage of hazardous waste is vital due to the fact that hazardous waste is a long term item. (ADEQ).

Step 3: Storing

Hazardous waste must be properly stored once it is identified. The storage of hazardous waste must meet 40 CFR 261. Once the waste has been classified and identified, it must be stored in a 55-gallon drum and stored to all regulatory requirements in 40 CFR 265. The wastes must be segregated by characteristic and properly marked with the identified characteristics as well as "Hazardous Waste." The drums can be kept on-site for 90 day without a RCRA permit. The 90 day limit begins the instant when the container is full, and this date and time must be marked on the container. The drums must be removed off-site to a Treatment, Storage or Disposal (TSD) Facilities once the 90 days are completed. The drums may be stored for an unlimited amount of time at the SAP.

TSD Facilities are operated under RCRA regulations and either treat, store and dispose of hazardous waste. Once the hazardous waste has been on-site for more than 90 days at Cinder

Lake Landfill, the waste shall be transported to the TSD Facility in Coolidge, Arizona. The facility name is Heritage Environmental Services LLC (Heritage) and it is an existing hazardous waste storage facility. This facility receives hazardous and non-hazardous waste. At the facility, the waste is either segregated, consolidated for recycling, treated and/or disposed. In order to transport the hazardous waste from Flagstaff, AZ to Coolidge, AZ the waste must be transported via truck and meet all Department of Transportation (DOT) standards. (ADEQ).

4.3.2 Toxic Wastes

Asbestos

Asbestos is a mineral compounds that was used in manufacturing and construction industries from the early 1900s to the 1970s. The mineral compounds consist of silicon, oxygen, hydrogen and other various metals and are fibers that can cause serious health problems. (ADEQ, Air Quality). Asbestos may be encountered by the workers who are excavating the South Thumb and Cell C. There is a possibility that some of the construction debris could be classified as asbestos-containing materials (ACM). ACM can cause harm to human health due to the microscopic fibers that could potentially be inhaled. Under the National Emission Standards for Hazardous Air Pollutants (NESHAP), asbestos is a hazardous air pollutant. (IEPA).

The state of Arizona, ADEQ, follows the federal regulations set by the Asbestos NESHAP program. The state has not implemented any additional requirements. A notification form is required by the county in which asbestos has been identified. Asbestos must be reported if it is removed from a site. Although this form is just for renovation or demolition, it is important to comply with the regulations and notify the state if asbestos are encountered. (ADEQ, Air Quality).

4.3.3 Soil Contamination

Soil can be tested for contamination using the Toxicity Characteristics Leaching Procedure. The Toxicity Characteristic Leaching Procedure (TCLP) is a modified test to the EP Toxicity Test. For this test, liquid, solid and multiphasic wastes are tested to determine the mobility of both organic and inorganic analytes. If the waste exceeds a higher concentration as its regulatory level, it is classified as hazardous. (Buckingham). 5/40 compounds and their regulatory levels are listed in Table 4.4.

Table 4.4: TCLP Regulatory Levels

Compound	ID no.	Regulatory level in TCLP extract (mg/L)
Arsenic	(D004)	5.0
Barium	(D005)	100.0
Benzene	(D018)	0.5
Cadmium	(D006)	1.0
Carbon Tetrachloride	(D019)	0.5
Chlordane	(D020)	0.03

Source: Buckingham

5.0 Cost of Implementation

This section provides the cost of implementing the proposed Landfill Mining and Excavation Plan, including the cost of implementing the environmental controls discussed in this report. It should be noted that a cost analysis addressing the economic benefit or loss of carrying out this project is not in the scope of work provided by Aspen Engineering and Environmental Services. The cost of implementing this project will remain within the scope of what has been discussed in this report, thus, only the cost of equipment, cycle hauling, and implementing environmental controls were addressed.

The total cost of implementation is estimated to be around $16.5 million. Table 5.1 is a summary of the costs of implementing the recommended plan for the Landfill Mining and Excavation for the re-sequencing of Cell D.

Table 5.1: Summary of the Cost of Implementation

Summary of Costs	
Excavation	$6,966,246
Cycle Hauling	$5,580,000
Waste Processing	$3,153,054
Stormwater Management	$472,693
Air Quality & Dust Control	$352,723
Hazardous Waste	$14,194
Total	**$16,538,910**

The breakdown of each summary category can be found in Table 5.2 below.

Table 5.2: Cost of Implementation Breakdown

Summary Category	Cost Components	Quantity	Cost ($)
Excavation	Excavators	2	4,056,192
	Loader	1	1,164,108
	Dozer	1	1,745,946
Cycle Hauling	Dump Trucks	3	5,580,000
Waste Processing	Trommel Screen	1	178,000
	Vibratory Screener	1	65,000
	Dozer	1	1,745,946
	Backhoe	1	1,164,108
Stormwater Management	Asphalt Tipping Floor	-	83,732
	Erosion & Drainage Control	-	388,961
Air Quality & Dust Control	GEM2000	2	153,000
	MiniRAE3000	3	137,700
	DOCSII	1	5,495
	DOCSII System	1	2,500
	Water	3	54,028
Hazardous Waste Transport	Hazardous Waste	-	14,194
		Total	**$16,538,910**

The cost of excavation and processing equipment, except for the trommel screen and vibratory screener, and cycle hauling were determined using RSMeans. Stormwater management costs were also determined using RSMeans. RSMeans is software that estimates construction and earthwork costs by considering cost of equipment and labor. Further cost breakdown can be found in Appendix 9.4.

6.0 Summary of Project Costs

This section provides the comparison between the proposed and the actual services provided by AEES. The total cost for the engineering services increased from $29,396 to $31,029. The actual cost is 5.4% greater than the proposed cost.

Table 6.1: Cost of Proposed Engineering Services

1.0 Personal	Person	Hours	Rate, $/hr.	Cost. $
	Senior Engineer	70	104	7,280
	Engineer	200	69	13,800
	Engineering in Training	150	48	7,200
	AA	30	34	1,020
	Total Personnel	450		29,300
2.0 Travel	Local Meetings			
	12 mtgs*20mi/mtg	$0.40/mi		96
3.0 Total				29,396

The cost of proposed engineering services was predicted by AEES prior to beginning the project.

Table 6.2: Cost of Actual Engineering Services

1.0 Personal	Person	Hours	Rate, $/hr.	Cost. $
	Senior Engineer	80	104	8,320
	Engineer	203	69	14,007
	Engineering in Training	160	48	7,680
	AA	27	34	918
	Total Personnel	470		30,925
2.0 Travel	Local Meetings			
	13 mtgs*20mi/mtg	$0.40/mi		104
3.0 Total				31,029

Table 6.2 is based on the actual hours for the engineering services after completing the project. The actual hours were logged by AEES.

The team's project schedule was altered in concurrence with the altering of the team's scope of work. Figure 6.1 is the team's first schedule.

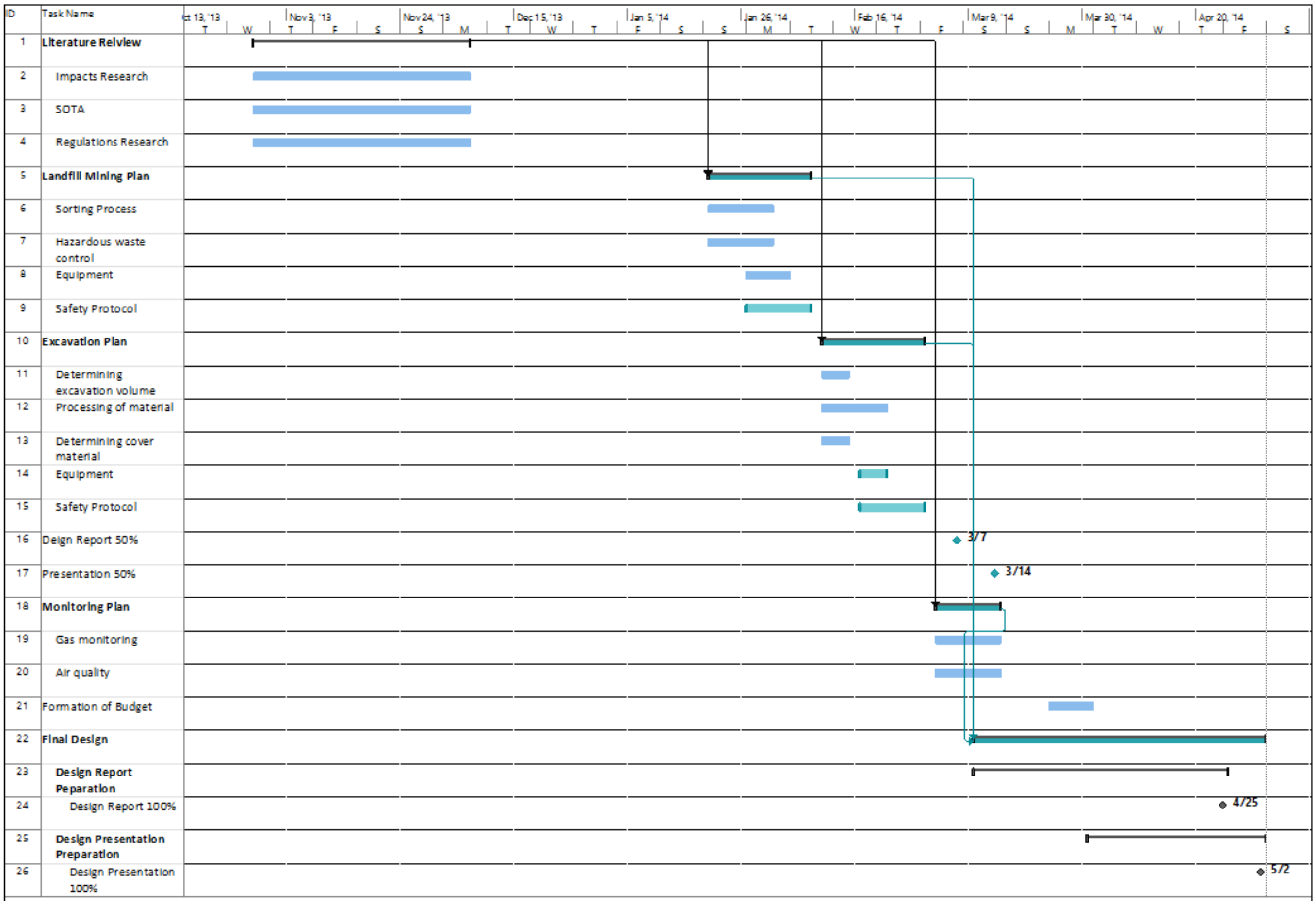
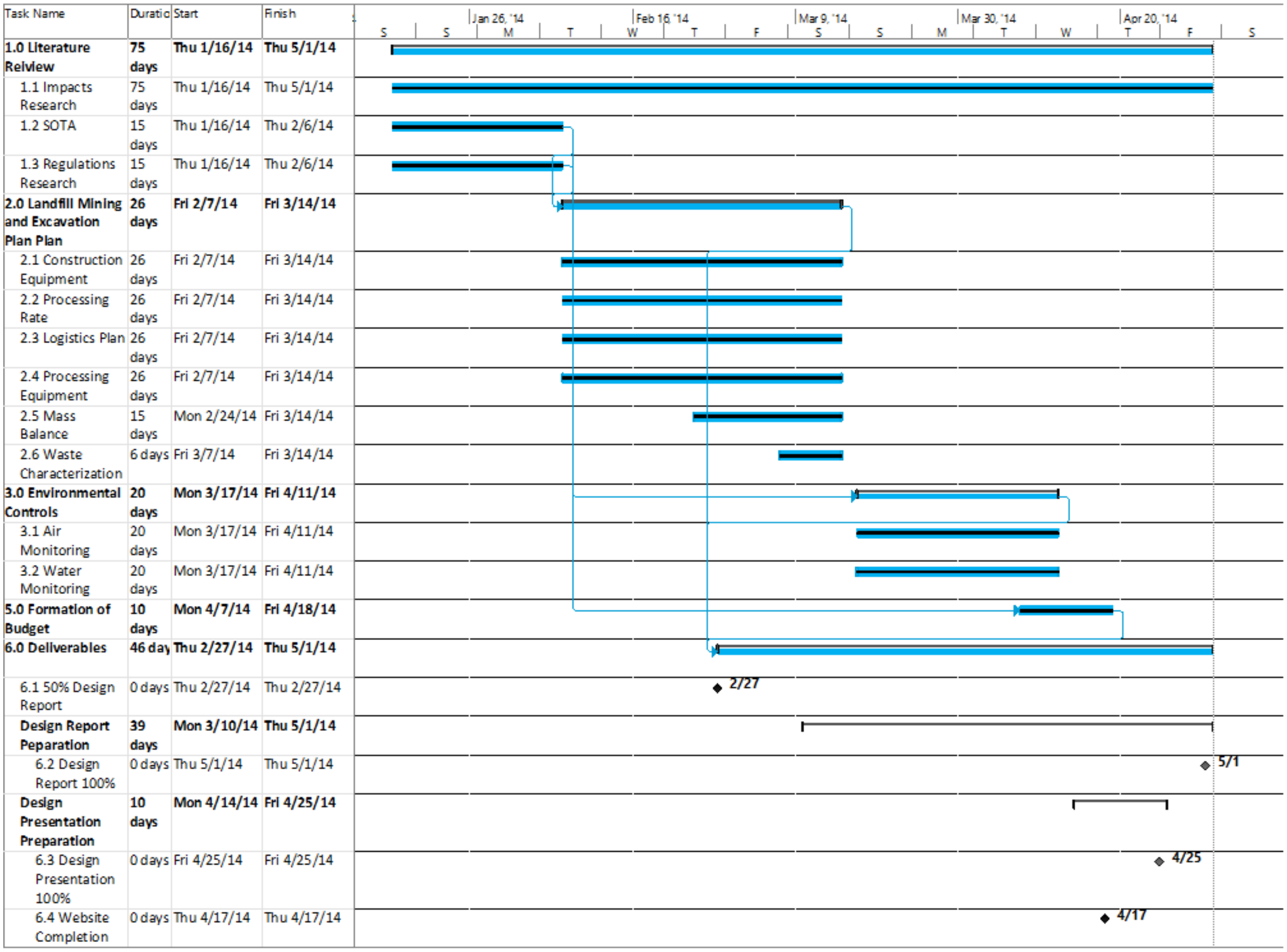


Figure 6.1: Original Project Schedule.

The team initially intended to begin the Literature Review in October and finish by December. After a break, the team would continue the project in January and finish in May. The Landfill Mining Plan and the Excavation Plan were separate tasks. Safety protocols were imbedded in the respective plans.

Figure 6.2 is the most recent project schedule.



Task Name	Duratic	Start	Finish
1.0 Literature Relview	**75 days**	**Thu 1/16/14**	**Thu 5/1/14**
1.1 Impacts Research	75 days	Thu 1/16/14	Thu 5/1/14
1.2 SOTA	15 days	Thu 1/16/14	Thu 2/6/14
1.3 Regulations Research	15 days	Thu 1/16/14	Thu 2/6/14
2.0 Landfill Mining and Excavation Plan Plan	**26 days**	**Fri 2/7/14**	**Fri 3/14/14**
2.1 Construction Equipment	26 days	Fri 2/7/14	Fri 3/14/14
2.2 Processing Rate	26 days	Fri 2/7/14	Fri 3/14/14
2.3 Logistics Plan	26 days	Fri 2/7/14	Fri 3/14/14
2.4 Processing Equipment	26 days	Fri 2/7/14	Fri 3/14/14
2.5 Mass Balance	15 days	Mon 2/24/14	Fri 3/14/14
2.6 Waste Characterization	6 days	Fri 3/7/14	Fri 3/14/14
3.0 Environmental Controls	**20 days**	**Mon 3/17/14**	**Fri 4/11/14**
3.1 Air Monitoring	20 days	Mon 3/17/14	Fri 4/11/14
3.2 Water Monitoring	20 days	Mon 3/17/14	Fri 4/11/14
5.0 Formation of Budget	**10 days**	**Mon 4/7/14**	**Fri 4/18/14**
6.0 Deliverables	**46 day**	**Thu 2/27/14**	**Thu 5/1/14**
6.1 50% Design Report	0 days	Thu 2/27/14	Thu 2/27/14
Design Report Peparation	**39 days**	**Mon 3/10/14**	**Thu 5/1/14**
6.2 Design Report 100%	0 days	Thu 5/1/14	Thu 5/1/14
Design Presentation Preparation	**10 days**	**Mon 4/14/14**	**Fri 4/25/14**
6.3 Design Presentation 100%	0 days	Fri 4/25/14	Fri 4/25/14
6.4 Website Completion	0 days	Thu 4/17/14	Thu 4/17/14

Figure 6.2: Most Recent Project Schedule.

AEES did not begin the Literature Review in October as intended. Instead, AEES started the project in January. This reduced that time the team had to work on the entire project. The Landfill Mining Plan and Excavation Plan were combined because they are so intertwined that it made more sense. Health and Safety was eliminated from our scope to allow for more focus on environmental controls.

7.0 Conclusion

The purpose of this report is to address the needs of Cinder Lake Landfill for a landfill mining and excavation plan to achieve the proposed design of the future Cell D. Aspen Engineering and Environmental Services has provided a comprehensive Landfill and Excavation Plan based on research of similar past projects and analysis of the current conditions of the project site. Relevant equipment and environmental control measures have also been chosen and addressed to support the efficient completion of this project. It is expected that over the course of 5 years, approximately 940,000 yd^3 of waste and 1.6 million yd^3 of rock will be excavated from the project site. The total cost of implementation is estimated to be around $14.8 million. The mining of landfill waste and excavation of rock will aid in the overall re-sequencing of Cell D. The re-sequencing of Cell D will provide more airspace for future waste and could also provide economic benefits in the form of processing reusable or sellable materials, such as, previously landfilled metals, concrete, and cover soil, and excavated rock. Reclaimed soil can be used as cover soil at the landfill, which is currently lacking. Gaining airspace will also allow for the extension of the closure date of Cinder Lake Landfill. The added longevity of the landfill will postpone the need for a new disposal site. The recovery of airspace and cover soil also minimized the impact of landfill operations on the environment. The recovery of airspace reduces the need for more land to be repurposed for waste disposal. The reuse of soil as cover material reduces the impact on land currently being used for fill material.

8.0 References

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9.0 Appendix

9.1 Summary of Excavation and Landfill Mining Volumes

Excavation of Cell D			Soil Expansion Considered	
Volume	1,600,000	cu. Yd.	2,080,000	cu. Yd.
Timeline	39	months		
working days	21.7	days/month		
Processing rate	1,891	cu. yd. /day	2,457.76	cu. yd. /day
	51,046	cu. ft. /day	66,359.45	cu. ft. /day
Pile height	20	ft		
	6.67	yd		
Expansion Rate	30	%		
Void Ratio				
Area	240,000	sq. yd.	312,000	sq. yd.
	2,160,000	sq. ft.	2,808,000	sq. ft.
Area/day	284	sq. yd. /day	369	sq. yd. /day
	2,552	sq. ft. /day	3,318	sq. ft. /day
	0.06	acre/day	0.08	acre/day
Waste Excavation				
	Recon (Cell C)		South thumb	
Volume	734,458	cu. Yd.	206,858	cu. Yd.
Timeline	16	months	5	months
Processing rate	2,115	cu. yd. /day	1907	cu. yd. /day
	57,115	cu. ft. /day	51476	cu. ft. /day
	2,855,755	lb/day	2573809	lb/day
Pile height	10	ft	5	ft
	3.33	yd	1.67	yd
Area	220,337	sq. yd.	124114.8	sq. yd.
	1,983,037	sq. ft.	1117033.2	sq. ft.
working days	21.7	days/month	21.7	days/month
area/day	635	sq. yd. /day	1144	sq. yd. /day
	5,712	sq. ft. /day	10295	sq. ft. /day
	0.13	acre/day	0.24	acre/day

9.2 South Thumb Composition

Waste density	1350	lb/cu. Yd.
Soil Unit Weight	162.24	lb/cu.ft.
	4380	lb/cu. Yd.

waste to soil density ratio
0.31

Total volume	206858	cu. Yd.	**total weight**	213470	tons
volume of waste	158126	cu. Yd. of waste	**weight of waste**	106735	tons
volume of soil	48732	cu. Yd. of soil	**weight of soil**	106735	tons

Equations used to determine soil waste ratio

$$1)\ W_{Soil} = W_{Waste}$$

$$2)\ W = \rho \times V$$

$$3)\ V_S + V_W = V_{Total}$$

$$4)\ \rho_S V_S = \rho_W V_W$$

Piles/Recovery of South Thumb Waste					
Piles	Tons	% of Initial Pile	Volume (yd^3)	Area (yd^2)	Area/day (yd^2/day)
initial	213,470	100.00	206,858	62,057	179
fines	106,735	50.00	103,429	31,029	89
Metals	2,050	0.96	1,986	596	2
landfill	104,685	49.04	101,443	30,433	88
bulky	5,112	2.39	4,953	1,486	4
Haz Waste	355	0.17	344	103	0.3

9.3 Cell C Composition

Total volume	734,458	cu. Yd.	**total weight**	713,886	tons
volume of waste	680,297	cu. Yd. of waste	**weight of waste**	595,260	tons
volume of soil	54,161	cu. Yd. of soil	**weight of soil**	118,626	tons
Area of Soil	16,248	sq. Yd. of soil	Area/day of Soil	47	sq. Yd./day
Area of waste	204,089	sq. Yd. of waste	Area/day of waste	3,827	sq. Yd./day
Density =	1750	lb/cu. yd.			

	%	Volume (yd^3)	area (yd^2)	area/day (yd^2/day)	tons
Concrete	10.34	70,376	21,113	61	61,579
Ashalt Paving	0.86	5,865	1,759	5	5,132
Asphalt Roofing	6.03	41,052	12,316	35	35,921
Lumber	42.24	287,367	86,210	248	251,446
Drywall	9.48	64,511	19,353	56	56,447
Rock, soil, fines	11.21	76,240	22,872	66	66,710
Metal	8.62	58,646	17,594	51	51,315
Remainder/Conposite C&D	10.34	70,376	21,113	61	61,579
Total				583	590,128

9.4 Cost of Implementation

Equipment *RSMeans

Type	Quantity	Total Months	Total Price
Excavator	2	60	4,056,192
Dozer	2	60	3,491,892
Loader	1	60	1,164,108
Backhoe	1	60	1,164,108
Truck	3	60	5,580,000

Stormwater Management

Type	Quantity	Price per Month ($)	Total Months	Total Price
Asphalt Area	-	-	-	$83,732
Erosion & Drainage	-	-	-	$388,961
Vibratory Screener	1	8000	16	$128,000
Trommel	1	9000	5	$45,000
			Total	$645,693

Air Quality + Dust Control

Type	Quantity	Price per Month	Total Months	Total Price
GEM2000	2	1275	60	$ 153,000
MiniRAE3000	3	765	60	$ 137,700
DOCSII	1	-	-	$ 5,495
DOCSII System	1	-	-	$ 2,500
Water	3	-	60	$ 54,028
			Total	$352,723

Hazardous Waste

Cost per Load	Loads per Year	# of Years	Total Price
700	4	5	$14,194.44

9.5 Equipment Decision Matricies

Excavators

	0.4	0.3	0.3	
Equipment	**Cost (40%)**	**Efficiency (30%)**	**Durability (30%)**	**Total**
321D LCR Hydraulic	1.8	0.9	0.3	3
320E LRR Hydraulic	1.8	0.9	0.3	3
328D LCR Hydraulic	**1.4**	**1.2**	**0.6**	**3.2**
329E Hydraulic	1.2	0.9	0.9	3
336E L Hydraulic	0.8	1.2	0.9	2.9
349E Hydraulic	0.8	1.2	1.05	3.05
				5

Medium Excavators = 20-25 metric tons

Large Excavators = 36 - 90 metric tons

*http://www.catrentalstore.com/empire/equipment/earthmoving-equipment/excavators

***Each category is based on a 1-5 scale

Cost: 1 = most expensvie & 5 = least expensive

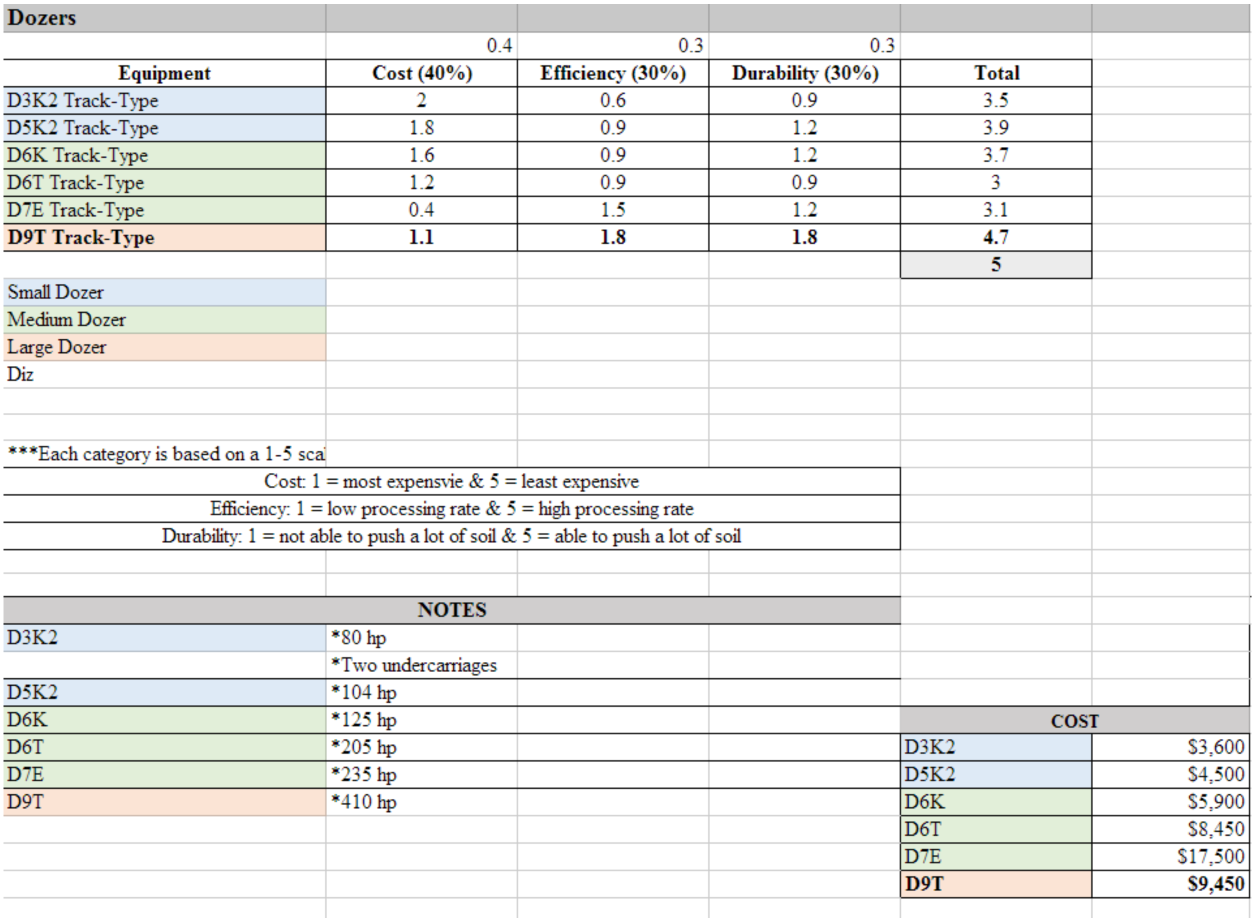
Efficiency: 1 = low processing rate & 5 = high processing rate

Durability: 1 = able to excavate small loads & 5 = able to excavate large loads

NOTES	
321D LCR Hydraulic	*148 hp
	*Systen pressure ~35,000 kPa (5220 psi)
	*Drawbar pull 46,322 lbs
320E LRR Hydraulic	*153 hp
	*Drawbar pull 46,086 lbs
328D LCR Hydraulic	*204 hp
	* Drawbar pull 67,443 lb
329E Hydraulic	*229 hp
	*Drawbar pull 55,997 lbs
336E L Hydraulic	*300 hp
	*Drawdown pull 66,309 lbs
349E Hydraulic	*396 hp
	*Drawdown pull 75,3500 lbs

COST		
321D LCR Hydraulic	$7,100	*per mont
320E LRR Hydraulic	$7,000	
328D LCR Hydraulic	$8,600	
329E Hydraulic	$9,200	
336E L Hydraulic	$10,900	
349E Hydraulic	$14,700	

9.0 Appendix



Dozers				
	0.4	0.3	0.3	
Equipment	**Cost (40%)**	**Efficiency (30%)**	**Durability (30%)**	**Total**
D3K2 Track-Type	2	0.6	0.9	3.5
D5K2 Track-Type	1.8	0.9	1.2	3.9
D6K Track-Type	1.6	0.9	1.2	3.7
D6T Track-Type	1.2	0.9	0.9	3
D7E Track-Type	0.4	1.5	1.2	3.1
D9T Track-Type	**1.1**	**1.8**	**1.8**	**4.7**
				5

Small Dozer
Medium Dozer
Large Dozer
Diz

***Each category is based on a 1-5 sca

Cost: 1 = most expensvie & 5 = least expensive
Efficiency: 1 = low processing rate & 5 = high processing rate
Durability: 1 = not able to push a lot of soil & 5 = able to push a lot of soil

NOTES	
D3K2	*80 hp
	*Two undercarriages
D5K2	*104 hp
D6K	*125 hp
D6T	*205 hp
D7E	*235 hp
D9T	*410 hp

COST	
D3K2	$3,600
D5K2	$4,500
D6K	$5,900
D6T	$8,450
D7E	$17,500
D9T	**$9,450**

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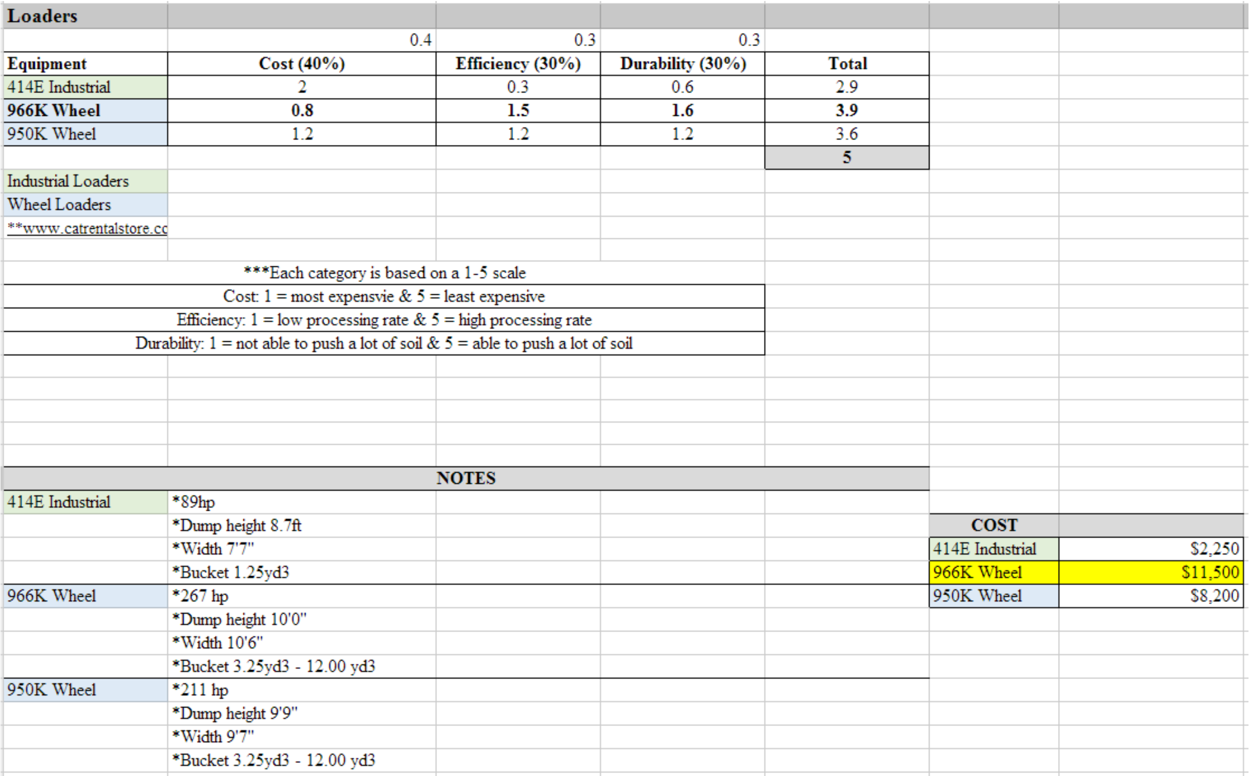


Loaders				
	0.4	0.3	0.3	
Equipment	**Cost (40%)**	**Efficiency (30%)**	**Durability (30%)**	**Total**
414E Industrial	2	0.3	0.6	2.9
966K Wheel	**0.8**	**1.5**	**1.6**	**3.9**
950K Wheel	1.2	1.2	1.2	3.6
				5

Industrial Loaders

Wheel Loaders

**www.catrentalstore.cc

***Each category is based on a 1-5 scale

Cost: 1 = most expensvie & 5 = least expensive

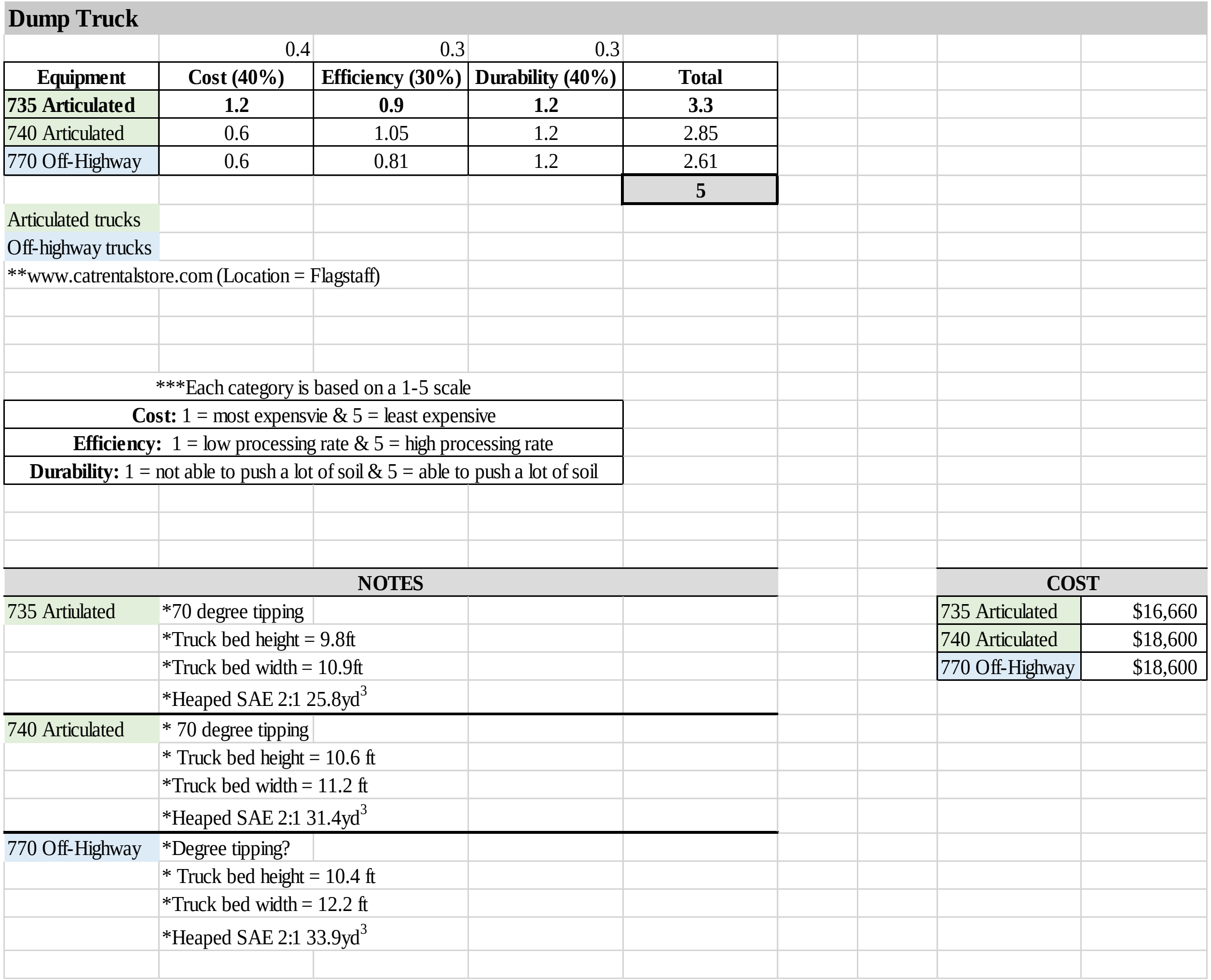
Efficiency: 1 = low processing rate & 5 = high processing rate

Durability: 1 = not able to push a lot of soil & 5 = able to push a lot of soil

NOTES	
414E Industrial	*89hp
	*Dump height 8.7ft
	*Width 7'7"
	*Bucket 1.25yd3
966K Wheel	*267 hp
	*Dump height 10'0"
	*Width 10'6"
	*Bucket 3.25yd3 - 12.00 yd3
950K Wheel	*211 hp
	*Dump height 9'9"
	*Width 9'7"
	*Bucket 3.25yd3 - 12.00 yd3

COST	
414E Industrial	$2,250
966K Wheel	$11,500
950K Wheel	$8,200

9.0 Appendix



Dump Truck

	0.4	0.3	0.3	
Equipment	**Cost (40%)**	**Efficiency (30%)**	**Durability (40%)**	**Total**
735 Articulated	**1.2**	**0.9**	**1.2**	**3.3**
740 Articulated	0.6	1.05	1.2	2.85
770 Off-Highway	0.6	0.81	1.2	2.61
				5

Articulated trucks

Off-highway trucks

**www.catrentalstore.com (Location = Flagstaff)

***Each category is based on a 1-5 scale

Cost: 1 = most expensvie & 5 = least expensive

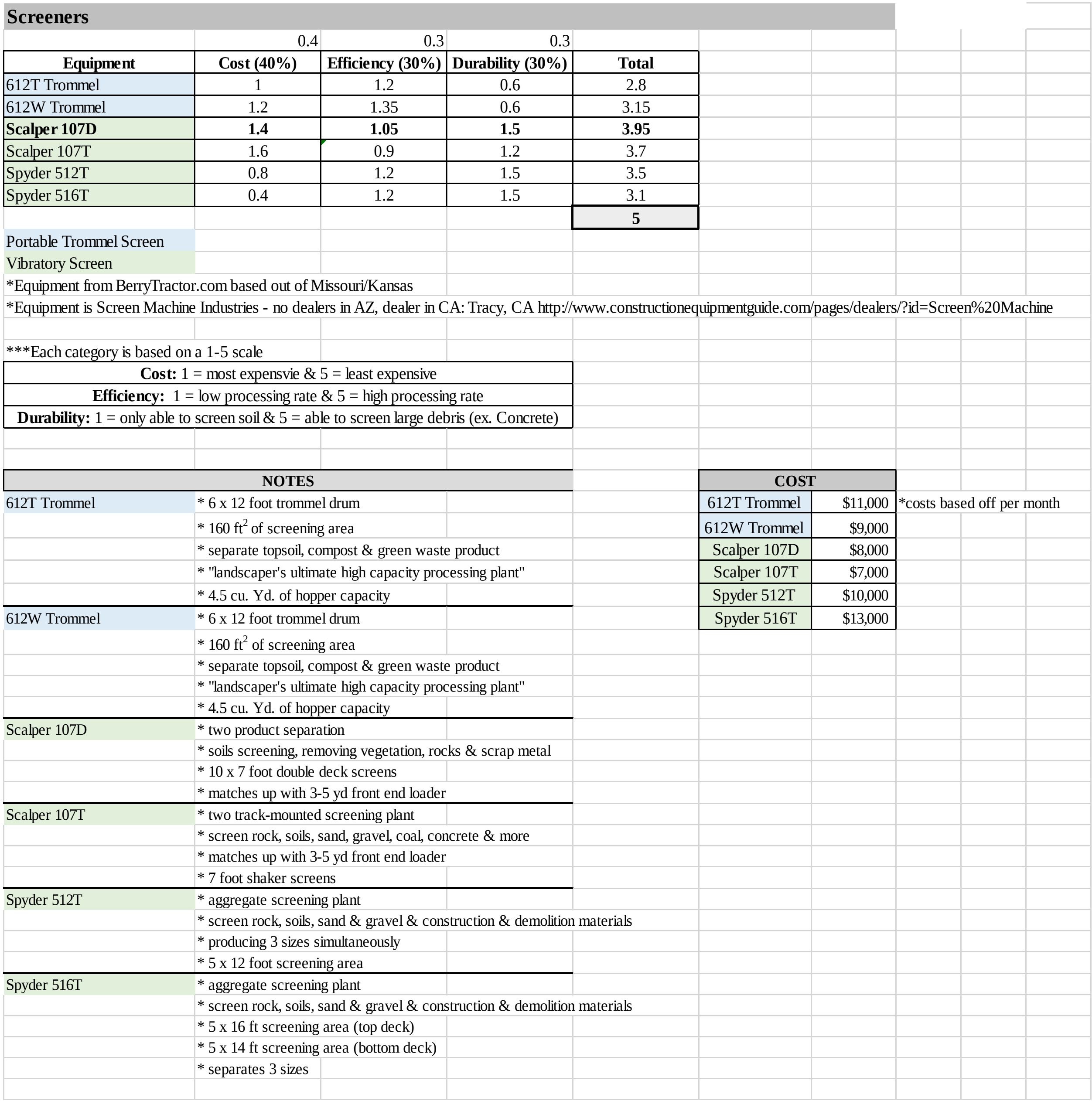
Efficiency: 1 = low processing rate & 5 = high processing rate

Durability: 1 = not able to push a lot of soil & 5 = able to push a lot of soil

NOTES	
735 Artiulated	*70 degree tipping
	*Truck bed height = 9.8ft
	*Truck bed width = 10.9ft
	*Heaped SAE 2:1 25.8yd^3
740 Articulated	* 70 degree tipping
	* Truck bed height = 10.6 ft
	*Truck bed width = 11.2 ft
	*Heaped SAE 2:1 31.4yd^3
770 Off-Highway	*Degree tipping?
	* Truck bed height = 10.4 ft
	*Truck bed width = 12.2 ft
	*Heaped SAE 2:1 33.9yd^3

COST	
735 Articulated	$16,660
740 Articulated	$18,600
770 Off-Highway	$18,600

9.0 Appendix



Screeners

	0.4	0.3	0.3	
Equipment	**Cost (40%)**	**Efficiency (30%)**	**Durability (30%)**	**Total**
612T Trommel	1	1.2	0.6	2.8
612W Trommel	1.2	1.35	0.6	3.15
Scalper 107D	**1.4**	**1.05**	**1.5**	**3.95**
Scalper 107T	1.6	0.9	1.2	3.7
Spyder 512T	0.8	1.2	1.5	3.5
Spyder 516T	0.4	1.2	1.5	3.1
				5

Portable Trommel Screen

Vibratory Screen

*Equipment from BerryTractor.com based out of Missouri/Kansas

*Equipment is Screen Machine Industries - no dealers in AZ, dealer in CA: Tracy, CA http://www.constructionequipmentguide.com/pages/dealers/?id=Screen%20Machine

***Each category is based on a 1-5 scale

Cost: 1 = most expensvie & 5 = least expensive

Efficiency: 1 = low processing rate & 5 = high processing rate

Durability: 1 = only able to screen soil & 5 = able to screen large debris (ex. Concrete)

NOTES	
612T Trommel	* 6 x 12 foot trommel drum
	* 160 ft^2 of screening area
	* separate topsoil, compost & green waste product
	* "landscaper's ultimate high capacity processing plant"
	* 4.5 cu. Yd. of hopper capacity
612W Trommel	* 6 x 12 foot trommel drum
	* 160 ft^2 of screening area
	* separate topsoil, compost & green waste product
	* "landscaper's ultimate high capacity processing plant"
	* 4.5 cu. Yd. of hopper capacity
Scalper 107D	* two product separation
	* soils screening, removing vegetation, rocks & scrap metal
	* 10 x 7 foot double deck screens
	* matches up with 3-5 yd front end loader
Scalper 107T	* two track-mounted screening plant
	* screen rock, soils, sand, gravel, coal, concrete & more
	* matches up with 3-5 yd front end loader
	* 7 foot shaker screens
Spyder 512T	* aggregate screening plant
	* screen rock, soils, sand & gravel & construction & demolition materials
	* producing 3 sizes simultaneously
	* 5 x 12 foot screening area
Spyder 516T	* aggregate screening plant
	* screen rock, soils, sand & gravel & construction & demolition materials
	* 5 x 16 ft screening area (top deck)
	* 5 x 14 ft screening area (bottom deck)
	* separates 3 sizes

COST		
612T Trommel	$11,000	*costs based off per month
612W Trommel	$9,000	
Scalper 107D	$8,000	
Scalper 107T	$7,000	
Spyder 512T	$10,000	
Spyder 516T	$13,000	