CINDER LAKE LANDFILL
RE-SEQUENCING CELL D
50% DESIGN REPORT

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We thank all of these individuals for their dedication and hard work towards this project.

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 the future Cell D.

The City of Flagstaff Cinder Lake Landfill is proposing a re-sequencing of Cell D. According to Matt Morales, the Project Manager at Cinder Lake Landfill, "The re-sequencing of Cell D will expand the available airspace for future waste in Cell D," potentially saving the City of Flagstaff millions of dollars. Cinder Lake Landfill is a 343-acre municipal solid waste landfill located in East Flagstaff, Arizona. Figure 1 is a map of the landfill relative to Flagstaff. The cells that are targeted for the re-sequencing of Cell D include the current Cell D, a portion of Cell C and the South Thumb. The South Thumb and Cell C contain approximately 20-30 year old municipal solid waste. Cell D is currently being used as a borrow pit, and has been excavated to a depth of approximately 20-ft. Figure 2 shows the targeted cells for this project.

Figure 1: Location of Cinder Lake Landfill relative to Flagstaff, AZ. (Google maps)

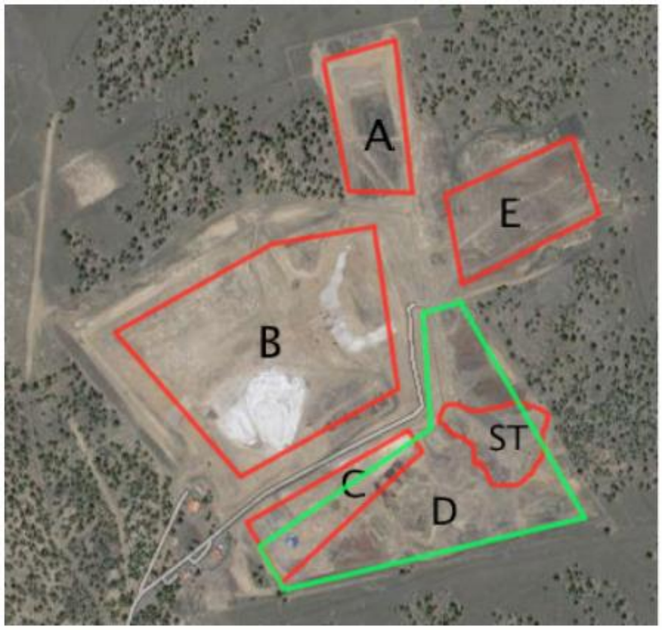

Figure 2: The green outline denotes the future Cell D design. The South Thumb (ST), Cell C (C) and Cell D are the targeted cells for the design.

The landfill operations are currently restricted to remaining below the tree line to sustain a certain aesthetic appeal within the community. The restriction on waste elevation makes the possibility of expanding the volume, by increasing the depth, a highly valued project. The expansion of Cell D, by area, will also create more usable space for future waste by changing the current non-uniform shape. The future design of Cell D is shown in Figure 3. The project also has the potential to save money spent in future landfill cover because the mined materials may be processed as a cover material which could reduce the need to purchase materials. It is estimated that Cinder Lake Landfill will run out of soil cover material 19 years prior to its expected closure in 2050. It is anticipated that a portion of the municipal solid waste in Cell C has the potential to be reused as cover material. In addition to more space and cover material, the excavation of Cell D will provide valuable rock that can be sold for construction and other purposes. In all, the re-sequencing of Cell D has the potential to save millions of dollars for the City of Flagstaff.

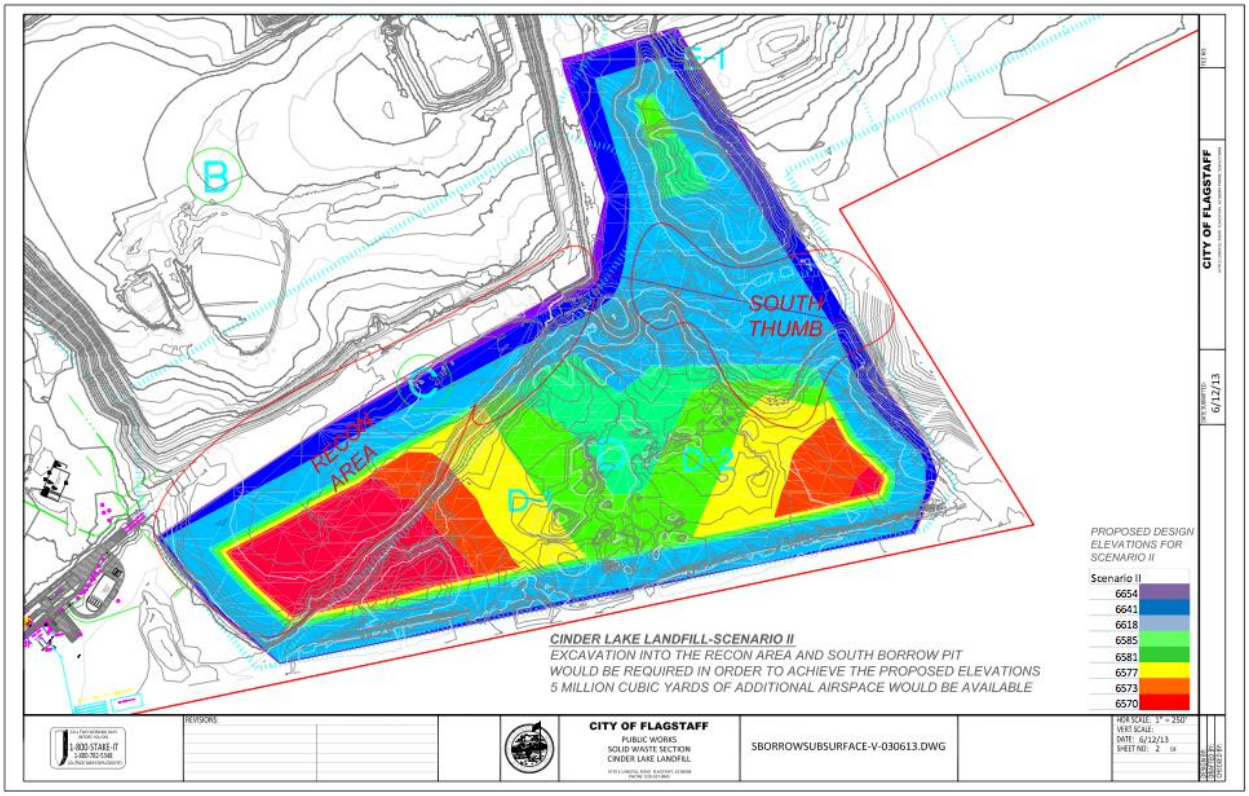

Figure 3: Design of future Cell D, including a portion of Cell C and the South Thumb.

2.0 Background

A literature review was conducted on landfill mining and regulations. A thorough understanding of landfill mining is necessary for the success of this project. Although there are currently no landfill mining regulations that exist, the project of re-sequencing Cell D must abide to all other city, state and federal regulations.

2.1 Landfill mining

Landfill mining is a young concept due to the recent introduction of engineered landfills in the 1970's. Approximately 50 landfill mining projects have occurred since 1953, the first project being in Israel (Eklund, Mats). Various articles and case studies were gathered as sources to conduct the literature review. The three case studies analyzed were projects conducted at Naples Landfill in Florida, Edinburg Landfill in New York and Perdido Landfill in Florida. Two of the three landfill mining projects were completed in the early 1990's and the third was completed in the late 2000's.

The purpose and benefits of landfill mining varies depending on the current condition of the landfill. Reasons for landfill mining include recovering materials, recovering landfill airspace, reducing the size of the landfill or transferring material from an unlined to a lined landfill (US EPA, 1993). According to the EPA, the benefits of landfill mining include: reduction of closure costs, reclamation of land for other uses, avoided liability through site remediation and costs offset by sale or use of recovered materials (US EPA, 1997). Landfill mining projects have been conducted in the United States as well as internationally.

2.1.1 Naples Landfill, Collier County, Florida

A landfill mining demonstration project was performed at Edinburg Landfill that began in 1991 was completed in 1993. Naples Landfill is a 320 acre-landfill and is classified as a Class 1 landfill. A landfill mining demonstration project was conducted under the EPA Municipal Solid Waste Innovative Technology Evaluation (MITE) Program. The waste that was mined contained residential waste from the 1970's. The Florida waste composition in the 1970's consisted of (by weight) 37% paper, 10.6% glass, 1.6% plastic, 9.6% metal, 32.4% food, wood and yard wastes, and 8.8% other. However, the waste that was mined consisted of (by weight) 3% paper, 2.1% glass, 4.3% plastic, 2.4% metal, 7.2% yard, food and wood wastes, and 81.1% other. The 81% of the other material includes soil, textile, rubber and undefinable materials Approximately 292 tons of waste was excavated and processed for the study. Of the 292 tons of waste that was excavated, 171 tons was recovered as a soil fraction and used as a landfill cover. Therefore, approximately 58% of excavated material was soil fraction. 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 knite/de-stoner and magnetic separators consisted of the equipment used for processing. A flow diagram of the waste processing is shown below in Figure 4.

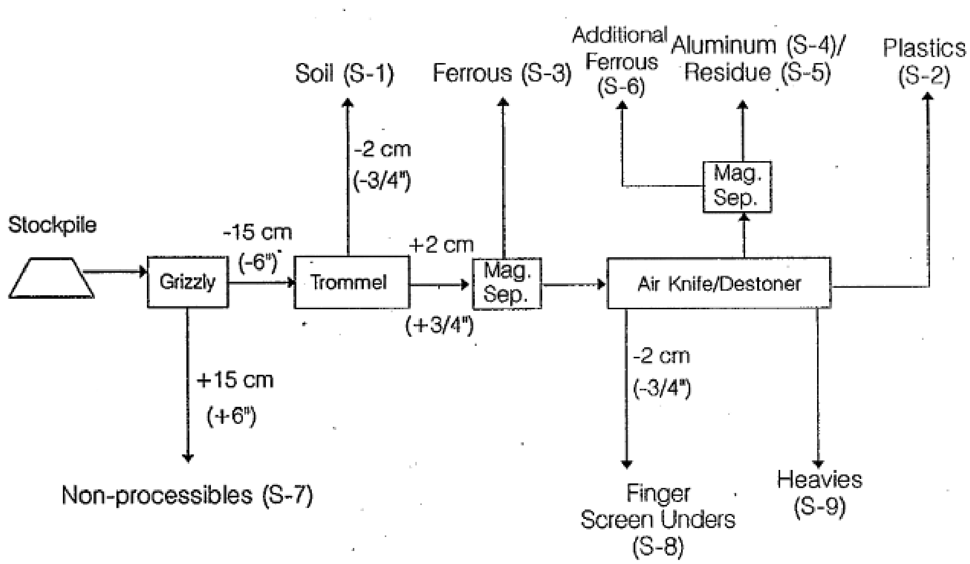

Figure 4: Processing block flow diagram from Naples Landfill mining demonstration project.

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. Overall, the demonstration project proved to be a cost saving project through avoiding future costs in soil for landfill cover and new landfill space. (EPA, 1993).

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).

2.1.2 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 recovered material was used for construction fill. The objectives of this project was 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 total project cost for the two phases was $5 per cubic yard for processing and excavation. (US EPA, 1997)

2.1.3 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 the mining of 2.5 acres of the unlined disposal site. Approximately 54,000 yd^3 were mined during the project, 70% of which was soil. Trials were completed testing the effectiveness of a trommel screen versus shredding waste and vibratory screen. Placing the waste directly into the trommel screen was more effective at separating fines from waste than first shredding the waste then placing it into the vibratory screener. Mesh type screening was ineffective because of frequent clogging. The approximate mining rate was 540 yd^3/day, though it was expected to be higher once shredding was stopped. It was also determined that scraping the waste, using a dozer, prior to digging with the excavator was not as efficient as using the excavator alone. (Perdido Landfill, 2009).

2.2 Regulations

Neither Arizona local 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 things such as hazardous waste handling and testing, worker safety, and regulations that govern normal landfill operations.

2.2.1 Hazardous Waste

Hazardous waste is identified by the characteristics of ignitability, corrosively, reactivity, and toxicity. Regulations pertaining to the identification and current lists of hazardous waste are found in 40 CFR 261. Testing methods, such as the Toxicity Characteristic Leaching Procedure (TCLP), are provided by the EPA for identification of hazardous waste based on regulatory levels provided in 40 CFR 261.20-24. Arizona Department of Environmental Quality (ADEQ) provides the locations and contact information of hazardous waste disposal facilities, if needed.

2.2.2 OSHA Standards and Requirements

The Occupational Safety and Health Administration (OSHA) provides regulations concerning worker safety under 29 CFR 1926. Regulations concerning workers address personal protective equipment, safe excavation and blasting practices, and proper handling of toxic and hazardous waste. Regulation 29 CFR 1926.1101 is specifically important to the excavation of waste because it addresses proper handling procedure of asbestos, which may be present in the 20-year-old construction debris and among other waste.

A waste inspection program that inspects all workers including engineers, drivers and casual men are conducted at landfills. Landfills have personal protection devices that obey to Level C requirements. The personal protection devices are worn by various personnel such as the excavation personnel (Hunt, 2013, p. 223).The fall protection standard requires that Landfill personnel must provide fall protection when the employees are exposed to a potential of at least a 6-foot fall. Workers in various sites have to be protected using guardrail systems, personal fall arrest systems and safety net systems. It is the duty of the employer to identify the system of fall protection to ensure that a suitable criterion is met. There are requirements for training for all construction activities. OSHA also has requirements for workers that are engaged in general industrial operation. Health and occupational standards are clear that every worker in a site must be in full gear (helmet, gloves and an overalls).

2.2.3 Code of Federal Regulations (CFRs)

The CFRs expect that Landfills must be well designed to protect the environment from various elements such as contaminants that could be present in the solid waste stream. Additional safeguards are to be provided to prevent the decomposition of landfills in areas that are environmentally sensitive. Engineering systems such as the on-site environmental monitoring systems have to be used to monitor landfill gas, and signs of ground water. Location restriction on-site activities ensures that landfills are built in suitable geological area away from flood plains and restricted areas.

2.2.4 Resources Conservation and Recovery Act (RCRA)

Under RCRA, the operator of the facility must comply with the protection of groundwater by installing and maintaining a liner system. The system has to be provided during processing, screening, receiving, post-processing and storage are in contact with contaminated materials, the ground and storage areas. It is the duty of the employer to identify the system of fall protection to ensure that a suitable criterion is met. There are requirements for training for all construction activities. RCRA expects that; solid wastes must be well designed to protect the environment from various elements such as contaminants that could be present in the solid waste stream. Today, landfill mining uses screening equipment and conventional soil.

2.2.5 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 Cinder Lake Landfill project, they have been consulted for good practices.

Regulations will be cited within the document when addressed.

2.3 Project Impacts

The landfill mining project has the following benefits to the economy and environment:

- ❖ The recovered soil material can be used as landfill cover material, saving the city of Flagstaff the cost of purchasing new landfill cover material.
- ❖ Revenues may be accrued from the recyclable materials such as plastic, metals and glass. The soil that is excavated from Cell D could be used as cover material or may be sold as construction fill and landscaping material.
- ❖ Recovered materials can be used for other purposes. The waste excavated and processed from Cell C could potentially be recovered and sold as an aggregate.

3.0 Excavation Plan (Staging)

The excavation plan is devised for the current Cell D. The goal of the excavation of Cell D is to extend the current depth of approximately 20 feet to a design depth of 50 feet. A geotechnical analysis and report was produced by Speedie and Associates on February 20, 2013. According to the report, the remaining 30 feet of soil in Cell D is classified as basalt. In order to efficiently remove the basalt, a detailed plan has been developed which includes the required equipment, the excavation rate, the duration of excavation, and the overall schematics for equipment and excavated material placement.

3.1 Required Equipment

An analysis of earthmoving equipment was performed in order to determine the necessary equipment for excavation. The chosen equipment is available from the CAT® rental store in Flagstaff, AZ. The equipment will be rented on a monthly basis. The earthmoving equipment will assist one another to transport the soil from Cell D to a temporary stockpile in Cell E. The following equipment is needed for excavation: excavator, loader, dozer and dump truck. Additionally, an analysis of the models of the equipment was accomplished through a decision matrix, see Appendix 8.1**.** The following list below contains the equipment and their respected models that will be used for the excavation of Cell D. Following, are images of the four required equipment pieces.

1. 328D LCR Hydraulic Excavator
2. 950K Wheel Loader
3. 735 Articulated Dump Truck
4. D5K2 Dozer

Figure 5: 328 LCR Excavator

Figure 6: 950K Wheel Loader

Figure 7: 735 Articulated Truck

Figure 8: D5K2 Dozer

3.1.1 Excavator

The 328D LCR Hydraulic Excavator will be used to transport the soil directly from Cell D to a pile located directly next to location of excavation. Attachments, a hammer and bucket, will be needed for the 328 LCR Hydraulic Excavator. The hammer-excavator attachment is necessary to break-up the basalt in Cell D. The hammer has the capability of performing up to 800 blows per minute. The bucket attachment will proceed the use of the hammer in order to transport the soil. The volume of the buckets range from 1 yd^3 to 2 yd^3.

3.1.2 Loader

The 950K Wheel Loader will be used to transport the soil from the pile produced by the excavator into the dump truck. With a dump height of 9’9”, the loader can effectively transport the soil into the dump truck. The capacity of the loader bucket is 12yd^3.

3.1.3 Dump Truck

The 735 Articulated Truck will be used to transfer the soil to Cell E. The articulated truck has a capacity to hold a heaping volume of 25.8yd^3.

3.1.4 Dozer

The D5K2 dozer will assist the loader, dump truck and excavator by maintaining a clean workspace and area. Misplaced soil can be moved by the dozer.

3.2 Excavation Rate & Duration

The excavation rate of the soil (basalt) in Cell D is 8,000 yd^3/day. This volume rate is based off of a soil expansion rate. The 10% of the excavated basalt is predicted to have an expansion rate of 30% (Speedie & Associates, 2013). Therefore, the excavated volume is predicted to increase from 1.6 million yd^3 to 1.97 million yd^3. With the assumption that the excavation will take 12 months with 21.7 working days per month, the excavation rate per day was calculated to be 8,000 yd^3. Table 1 outlines a spreadsheet calculation that was performed for the excavation rate.

Table 1: Calculated excavation rate for Cell D

Cell D Excavation			Soil Expansion Considered	
Volume	1,600,000	cu. Yd.	1,973,333	cu. Yd.
Timeline	12	months		
working days	21.7	days/month		
Excavation rate	6,144	cu. yd. /day	7,578	cu. yd. /day
	165,899	cu. ft. /day	204,608	cu. ft. /day
Pile height	6	ft		
	2	yd		
% soil	10	%		
Expansion Rate	30	%		
Void Ratio				
Area	800,000	sq. yd.	986,667	sq. yd.
	7,200,000	sq. ft.	8,880,000	sq. ft.
area/day	3,072	sq. yd. /day	3,789	sq. yd. /day
	27,650	sq. ft. /day	34,101	sq. ft. /day
	0.63	acre/day	0.78	acre/day

This excavation rate is equivalent to 16.6 yd^3/min. If the excavation of Cell D was performed in 9 months, the excavation rate would increase to 21 yd^3/min, which would create a further time constraint to complete the excavation. The timeline for the excavation of Cell D is 12 months. As stated previously, the duration of excavation was calculated in conjunction with the excavation rate. To achieve the excavation in 12 months, five (5) 328D LCR Hydraulic Excavators will be rented to perform an excavation rate of 3.3 yd^3/min per hydraulic excavator.

3.3 Logistics Plan

Will be completed by next week. AEES have developed the following scenarios:

1) *Excavated soil will be disposed in North Pit, followed by Cell E*
2) *Excavated soil will be disposed in Cell E via North Pit*
3) *Excavated soil will be disposed in Cell E via another road*

4.0 Landfill Mining Plan (Staging & Processing)

The landfill mining plan consists of removing municipal solid waste (MSW) from the South Thumb and a portion of Cell C. These cells are adjacent to Cell D and the MSW must be removed in order to expand Cell D to achieve the future design of Cell D. A careful analysis of landfill mining has been taken into account through the background research. The staging and processing will be addressed for the landfill mining plan.

4.1 Required Equipment

The equipment needed to perform landfill mining consists of the four earthmoving equipment pieces that will be used for the excavation of Cell D as well as screening equipment. The excavator, loader, dozer and dump truck will be used to excavate the MSW from the ground in order to process and sort the waste. Screening equipment from Screen Machine Industries was evaluated in a decision matrix, see Appendix 8.2. Trommels, scalpers and spyders were selected as the potential screening equipment and two models of each were evaluated. The scalpers and spyders are classified as vibratory screeners. The trommel would serve as an ideal technology to use for sorting the municipal solid waste in the South Thumb. The trommel is able to separate topsoil, compost and green waste product. The scalper would serve as an ideal technology to sort the construction debris that is predicted to be in Cell C. The scalper is able to screen soil, remove vegetation, rocks and scrap metal. Below, in Figure 9 and 10 is an image of the scalper and trommel.

Figure 9: Scalper 107D

Figure 10: 612W Trommel

4.2 Waste Composition

An estimated waste composition of excavated waste was determined based on analysis of cases studies and average composition of landfilled waste from the same time period as the waste to be excavated from Cinder Lake Landfill. The waste in the South Thumb and Cell C are approximately 20 years old and 10-30 years old. It should be noted that Cell C is expected to contain mostly construction debris; however, it has been assumed that, like the South Thumb, it contains MSW.

Figure 11 shows the national average percent composition of MSW entering the landfill in 1994. (US EPA, 1995).

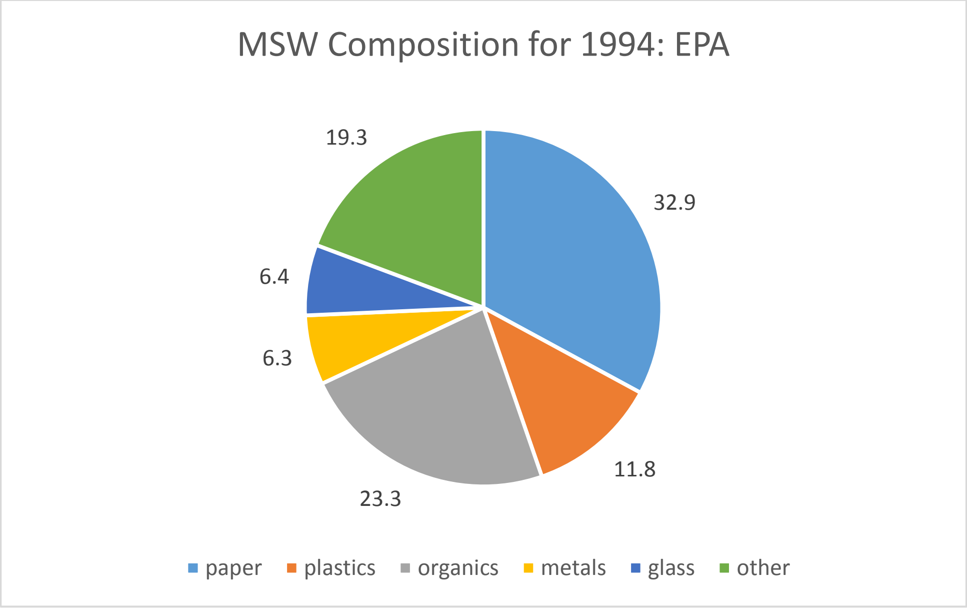

Figure 11: EPA data on national average composition of waste entering the landfill in 1994.

From the case studies previously discussed in section 2.0 Background, it was estimated that there is about a 50% ratio (by weight) between excavated soil and waste. Based on data provided by the Perdido case study, it has also been assumed that the organic material has degraded and become a part of the soil fraction. In estimating the composition of excavated materials from the South Thumb and Cell C, an analysis of the density ratio of soil and waste (4507 lb/yd^3 and 1350 lb/yd^3 respectively) and the waste composition explain above was performed. The estimated composition of excavated material for Cell C and the South Thumb can be found in Table 2.

Table 2: Waste composition (by tons) in South Thumb & Cell C

	South Thumb	**Cell C**	**Units**
Total volume	308910	316,211	cu. Yd.
volume of waste	216378	221492	cu. Yd. of waste
volume of soil	92532	94719	cu. Yd. of soil
Total weight	354569	362949	tons
weight of waste	146055	149507	tons
weight of soil	208514	213442	tons
Composition			(tons)
paper	54858	56155	
plastics	24041	24609	
organics	as soil	as soil	
metals	16008	16386	
glass	16154	16535	
other	34995	35822	

Estimating excavated composition provides insight into the amount of recoverable materials and material that are likely to be put back into the landfill.

4.3 Excavation & Processing Rate and Duration

The excavated processing and excavation rate for the South Thumb and Cell C was calculated in a similar fashion to the excavation rate of Cell D. The municipal solid waste in Cell C and the South Thumb must first be excavated and then processed in order to properly recover the materials within the cell. The excavation rate for Cell C is 5,000 yd^3/day over a duration of 3 months, and the excavation rate for the South Thumb is also 5,000 yd^3/day over a duration of 3 months. Table 3, shows the calculated waste excavation rate.

Table 3: Calculated excavation rate for South Thumb & Cell C

Waste Excavation				
Recon (Cell C)			South Thumb	
Volume	316,211	cu. Yd.	308910	cu. Yd.
Timeline	3	months	3	months
Excavation rate	4,857	cu. yd. /day	4745	cu. yd. /day
	131,147	cu. ft. /day	128119	cu. ft. /day
	6,557,371	lb/day	6405968	lb/day
Pile height	6	ft	6	ft
	2	yd	2	yd
Area	158,106	sq. yd.	154455	sq. yd.
	1,422,950	sq. ft.	1390095	sq. ft.
working days	21.7	days/month	21.7	days/month
area/day	2,429	sq. yd. /day	2373	sq. yd. /day
	21,858	sq. ft. /day	21353	sq. ft. /day
	0.50	acre/day	0.49	acre/day

The processing rate for Cell C and the South Thumb is 14,235 yd^3/day over a duration of 1 month. Overall, the combined excavation and processing for Cell C and the South Thumb will take a total of four months. Excavation and processing will occur simultaneously due to the lack of area to create a stock pile large enough to accommodate the excavated waste.

4.4 Processing Logistics Plan

The processing for the waste excavation of the South Thumb and the Recon area of Cell C includes excavation, transportation, hand sorting, screening, recovery, and discard.

4.4.1 Excavation

Excavators will put the excavated waste into piles. It may be necessary to remove bulky items with a loader, which will also transport bulky items to the appropriate pile in the processing area. If an area of possibly contaminated waste is encountered, the Hazardous Materials Contingency Plan will be consulted for proper handling.

4.4.2 Transportation

Front loaders will move waste from the excavated pile into the dump truck. Once full, the dump truck will transport the waste to the initial collection pile at the processing site. If bulky items are encountered and unable to be transported with the other waste, a front loader will be used for transportation to the appropriate pile at the processing site.

4.4.3 Hand Sorting

Hazardous waste and bulky materials will be “hand sorted”, sorted by hand or by loader from the initial collection pile at the processing site and placed in the appropriate pile.

<u>Hazardous Waste</u>
Hazardous waste is defined in the Health and Safety Plan. Hazardous waste will be handled and disposed of according to the Hazardous Materials Contingency Plan. If an area of the pile shows signs of contamination, the pile will be left as is and the Hazardous Materials Contingency Plan consulted for proper procedure for handling and sampling.

<u>Unknown Material</u>
If unknown materials are encountered and could be sources of contamination, they will be placed in the appropriate pile and the Hazardous Materials Contingency Plan will be consulted for sampling procedure.

<u>Bulky Materials</u>
Bulky materials will be removed from the initial collection pile and placed into the appropriate pile. Some of the bulky materials that may be encountered include white goods, tires, and large construction debris. Bulky items will be sectioned within the bulky materials pile by type to allow for easy disposal. Bulky materials will be handled and disposed of according to the current practices of Cinder Lake Landfill operations.

4.4.4 Screening

The remaining waste pile is to be screened using the trommel screen. The screen separates fines and larger material. The waste will be loaded into the trommel with a front loader. The screen will sort fines to the side of the machine and course material off the end by conveyor belt. A magnet attached to the trommel, above the conveyor belt, will collect recoverable metals. The trommel screen will be operated under the guidance of the accompanying operation manual.

<u>Metals</u>
Recovered metals will be removed from the magnet and placed in the appropriate pile. Recovered metals will be recycled or sold at the discretion of the landfill operators.

<u>Fines</u>
Fines are a composition of soil used as cover and decomposed material. Using a dozer, the resulting fines pile will be pushed away from the machine at a point prior to interfering with the operation or becoming

unsafe. Fines will be moved to the appropriate pile after screening. Recovered fines will be used at the discretion of the landfill operators, with possible uses as daily cover or fill material.

Discard Waste

Discard waste is waste that will go back into the landfill. Using a dozer, the resulting discard waste pile will be pushed away from the machine at a point prior to interfering with the operation or becoming unsafe. Discard waste will be moved to the appropriate pile after screening. Discard waste will be placed back into the landfill at the discretion of the landfill operators.

5.0 Health and Safety Plan

6.0 Cost Analysis

7.0 Conclusion

8.0 Appendix

8.1 Earthmoving Equipment Decision Matrices

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	

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
D8T Track-Type	0.4	1.5	1.2	3.1
				5

Small Dozer
Medium Dozer
Large Dozer

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

***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	
D3K2	*80 hp
	*Two undercarriages
D5K2	*104 hp
D6K	*125 hp
D6T	*205 hp
D7E	*235 hp
D8T	*317 hp

COST	
D3K2	$3,600
D5K2	$4,500
D6K	$5,900
D6T	$8,450
D7E	$17,500
D8T	$22,600

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	1.26	1.2	3.26
950K Wheel	**1.2**	**1.2**	**1.2**	**3.6**
				5

Industrial Loaders

Wheel Loaders

**www.catrentalstore.com

***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 1.25yd^3
966K Wheel	*267 hp
	*Dump height 10'0"
	*Width 10'6"
	*Bucket 3.25yd^3 - 12.00 yd^3
950K Wheel	*211 hp
	*Dump height 9'9"
	*Width 9'7"
	*Bucket 3.25yd^3 - 12.00 yd^3

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

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

8.3 Screening Equipment Decision Matrix

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	

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