# Landfill Logic

**Activity Summary:**
**Youth will learn about different waste disposal methods, and understand why our city uses sanitary landfills. Youth will then identify the layers of a landfill by drawing or constructing a model of a landfill to gain a better understanding of its function.**

*This lesson plan was modified by the Keep Austin Beautiful Education team for at-home learning.*

UNIT: Generation Zero

GRADES: 6th – 12th

MATERIALS:
- Landfill Clue Card sheet in Instructor Resources
- Paper and colored pencils or a technological device with a drawing app
- For landfill building activity – see suggested materials in Extension Activity section

TIME REQUIRED: 45 minutes

OBJECTIVES:
Students will be able to:
- Learn what a sanitary landfill is and understand its benefits over a dump
- Identify the layers of a landfill and accurately draw or construct a landfill model.

TEKS CORE CONCEPTS:
6th grade:
- Science: 2A, 3C-D, 7B
- ELA: 12A-B, 26A-C
- Social Studies: 1B, 3A, 7A-C, 20A-C

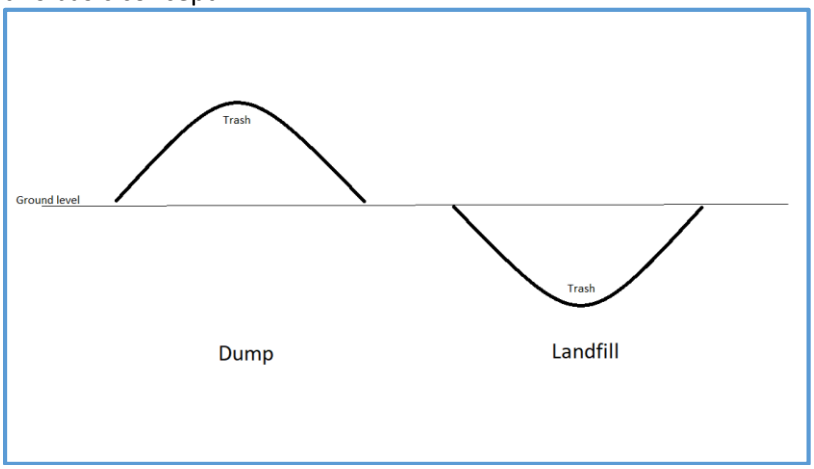
7th Grade:
- Science: 2A,2E, 3C-D, 5B, 8C, 10A
- ELA: 12A, 25A, 25C
- Social Studies: 10A, 23B

8th Grade:
- Science: 2A, 2E, 3C-D, 11B
- ELA: 12A, 25A, 25C, 26A-C

High School:
- Environmental Systems: 1B, 2I, 3D-F, 5A, 5C-F, 9A,9I
- U.S. History: 2C, 10C, 10F, 14A-B, 27A, 32B
- World Geography: 2A-B, 8A, 8C, 12A-B, 19A, 19C

## Introduction: What is a Landfill? (15 min)

1. Ask youth about waste. *Can anyone give me a definition of **trash**?* Stuff we don't use or need anymore, gross stuff, old things, etc.
2. *Where does trash go when we throw it away?* **Dump**, **landfill**. *In the City of Austin, we only use landfills to get rid of our trash.*
3. *What is the difference between a dump and a landfill? A dump is exactly what it sounds like – a place where we dump a bunch of trash.* A dump is a big pile of trash (it goes up). *A landfill is also exactly what it sounds like, it's a hole in the ground, in the land, that we fill up with trash.* A landfill is a hole in the ground they fill with trash (it goes down). Show youth the below diagram to illustrate this basic concept.




4. *Which one is better for the environment?* Landfill. A landfill is actually called a **Sanitary Landfill.** *What does sanitary mean?* Clean. *A sanitary landfill has special lining to prevent things from leaking out into the outside environment. Dumps have no protective layers to prevent pollution.*
5. Examples: *What happens when the wind blows?* Trash blows everywhere at a dump, but a landfill keeps it contained. *What about the rain?* Trash can wash away easier at a dump. *Do you think they both smell? What is going to be attracted to that smell?* All kinds of animals.
6. *Have you ever left your trash bag sitting for too long? What gathers at the bottom?* Liquid. *I call this liquid "trash juice," but it has a real name: **leachate**. (Repeat after me: leachate). Why might this be a problem in a dump or a landfill?*

7. *Does anyone know what lies/flows underneath the ground?* Edwards Aquifer. *The water from the aquifer is used as drinking water by some people, and it bubbles up in springs in places where people swim (ex: Barton Springs). If we let that leachate flow down into the aquifer, would that be good?* No. Explain that a landfill has many layers to contain the leachate and prevent the surrounding soil and water from being contaminated. Now we are going to explore how a landfill works.

## Main Activity: Draw a Landfill (20 min)

1. *Landfills are the most common form of waste management today, and Austin uses landfills exclusively to store its waste. Do you think they just dig a hole in the ground and start throwing trash in?* No. *Building a landfill is a long and complicated process, and you are going to get a chance to do learn more about that through this activity.*
2. Pass out the **Parts of a Landfill Sheet** (see Instructor Resources) and explain the activity. Youth may work in groups or individually.
    a. *On the cards are clues of how a landfill is built. Read the clues and number the cards in order from the first layer they add in a new landfill to the top layer.* Assist/guide youth as necessary to come up with the correct order (see bullet point #3)
    b. *I will come around and check on your progress. Once I say you have the correct order, you can draw your own landfill model, using the cards as a guide.*
3. After youth have their cards in the correct order, go over each part of the landfill, giving the full description and explanation of each layer.
    a. **Landfill hole** – A hole dug in the ground and the working face of a landfill. According to Texas TCEQ 2015 report, the statewide average landfill size was 241 acres. (That's about 200 football fields pieced together!) In addition, the 2015 average depth for MSW landfills was 35 feet and the average height was 84 feet, although some landfills have been permitted heights of 200-300ft. Two landfills within the state are even permitted to be higher than 300ft. (TCEQ 2015)
    b. **Clay Layer –** Clay is used to line the hole dug for the landfill. Clay is used because it is flexible and waterproof.
    c. **Geomembrane Layer –** Like a trash bag, this thick plastic layer seals in all the waste and leachate. The actual Geomembrane is typically constructed of a special type of plastic called high-density polyethylene or HDPE. HDPE is tough, impermeable and extremely resistant to attack by the compounds that might be in the leachate.
    d. **Gravel layer –** Holds pipes in place and provides another material to filter the leachate.
    e. **Leachate Pipes -** Transports leachate from inside the landfill to a collection system outside the landfill. Here the excess moisture is evaporated off while the trash sludge remains behind. Once dry, the sludge is scraped from the system and returned to the landfill as waste. Other pipes also carry away the methane gas that is created from decomposing trash.

        *Discussion points*: What happens inside a landfill article, link here: https://www.livescience.com/32786-what-happens-inside-a-landfill.html Can talk about methane capture and energy generation for sale and use on site, in addition to its impact as a greenhouse gas. Can also discuss how little is able to decompose within a landfill – why it is better to compost food/organic materials.

f. **Geotextile –** This thick felt liner serves as a filter for the leachate before it reaches the pipes. This prevents clogging in the pipe system.
g. **Geonet –** Acting as a filter for larger particle of waste, this screen traps waste and keeps it from clogging the pipe system. Now this screen is placed between two layers of Geotextile to stabilize the Geotextile and make application easier.
h. **Waste Layer –** This waste represents all the Municipal Solid Waste (landfill trash) created and sent to landfills. Close examination reveals the many categories of waste including: food, glass, plastic, rubber, textiles, paper, yard waste, wood, metals, and electronics.
i. **Daily Cover -** At the end of each working period, the waste is covered with 6-12 inches of soil. Trucks drive over the layer to compact it and use space more efficiently Daily cover reduces odors, keeps litter from scattering and helps deter scavengers.
j. **Protective Cover -** A compacted layer of clay and a thick plastic layer form a 'cap' that prevents excess precipitation from entering the landfill and prevents the escape of gas. In an actual landfill, this cap would have the leachate and methane gas pipes coming out of it.

    *Discussion points*: These methane flares are vital to releasing the methane trapped in the landfill, preventing a giant landfill "fart" (explosion) that would blow trash everywhere. In the 1970's an apartment complex in Austin that had been built over an old landfill was evacuated after methane leaks threatened this exact situation. Gus Garcia Middle School is built on an old landfill and some parts of the building are now collapsing.
k. **Vegetation Cover -** As portions of the landfill are completed, native grasses and shrubs are planted and the areas are maintained as open spaces. The vegetation is visually pleasing and prevents erosion of the underlying soils. Once a landfill is closed, it will be monitored for leachate leakage, methane levels, and settling. Often closed landfills are turned into parks and recreation areas. You can't build buildings on top of the landfill. Can mention the Texas Disposal Systems (https://www.texasdisposal.com/exotic-wildlife-ranch/) landfill in South-East Austin and how it is also used as an exotic game ranch.

4. Youth can then begin to use paper and colored pencils to draw their own landfill model. Have youth label the different parts of the landfill. Encourage creativity. See **Figure 1: Landfill Diagram in Instructor Resources** for a basic landfill diagram.

## Conclusion and Solutions (10 min)

Landfill Issues. Lead an open-ended discussion about the issues with landfills. Get the youth talking about and answering these questions.

1. *Every person in Austin makes 5.78lbs of trash every day! (Compared to 6.67lbs/per person/day in all of Texas – TCEQ 2015)*
2. Let the students know that in the Austin area, we only have approximately 20 years left until our landfills are full. *How old will you be by then? What will we do with our waste when we run out of space?* Encourage creativity here (see extension activities).
3. Discuss problems with building new landfills. *Where do we put it? How close will you live to it? Where is there enough space in this area to actually build a new landfill?*
4. *What if we built it farther away? Transportation of trash? Cost? Who pays for that?*

5. In Texas, we only have 56 years left until we reach capacity. *Are landfills a sustainable option? Where else can we put our trash?*
6. Discuss Austin's Zero-Waste Initiative as a solution to this issue. Go through the Waste by the Numbers pie-chart (**see Figure 2: Waste by the Numbers Chart in Instructor Resources**) and observe how little actually belongs in the landfill.

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## Extension Activities

### History of Trash Disposal

**See Instructor Resources, Figures 3-8 for photo references**

1. *To better understand how we currently dispose of our waste, we need to look at where we used to put it. Everyone close their eyes. Imagine it was two hundred years ago. What did Austin look like? Who roamed the streets? Was it clean or dirty? Were there a lot of animals around?* Open your eyes and discuss with the students what they imagined.
2. *Waste management has changed over the years, and we are going to learn a little bit about that together today. Take a look at the historical photos (see Instructor resources). Your goal is to figure out what is happening in each picture and put them in order of when it happened. Start with the process that happened the longest time ago.* Have youth write down the order of the photos they think took place in the history of waste disposal.
3. Together, reveal the correct order (see below) and discuss the events. Make sure to highlight that these events are not exactly linear. Many systems were often used simultaneously.
    a. Figure 3: Drawing of horse drawn cart – Trash was generally thrown out wherever they pleased. That trash was eaten by animals that roamed the streets. Then in the 1800's people discovered the correlation between disease and waste and the first "dump truck" appeared. Horse drawn carriages like these began popping up to collect that trash.
    b. Figure 4: Barge dumping trash in the ocean – Many cities dumped their trash in nearby waterways. After realizing the terrible pollution that occurred when they dumped in rivers and streams, many began dumping in the ocean instead in the 1880's. Much of the trash eventually washed ashore, however, so by the 1910's this was also phased out.
    c. Figure 5: Piggery picture – Tapping into the original waste disposers, many communities began establishing "piggeries" in the early 1900's to get rid of large portions of their waste. By feeding food waste to pigs, they could get rid of as much as 2000 pounds in one day with just 75 pigs! However, as the waste stream began to change (plastic and similar non-edible waste products became more common) and terrible diseases became more and more common among the pigs from the uncooked food, piggeries were phased out by the 1960's.
    d. Figure 6: Cart carrying mattresses – In the 1910's the first commercialized recycling began as well. This picture shows a mattress recycling program implemented in NYC.
    e. Figure 7: Landfill site – In the 1960's and 70's, the EPA began initiating standards for **sanitary landfills**. The regulations were tightened tremendously, giving birth to the

modern day, heavily regulated landfill. Leakage of toxic liquids and methane gases still pose a problem, however.

### Imagining a Zero-Waste Future:

1. Introduce Austin's Zero-Waste Goal: The city of Austin has a goal to be waste free by the year 2040. This means we need to divert at least 90% of our waste away from the landfill.
2. Have students research and make a list of short and long term issues surrounding landfills.
3. *What do you imagine a zero-waste future could look like?* Have students respond in whatever format works for them, and encourage creative expression: list, poem, drawing, etc.

### City of Austin's Watershed Protection Department Watershed Detectives Activity:

Students learn about the local impact of an old landfill on part of our Colorado River Watershed here in Austin, TX. Link to lesson plans: https://www.austintexas.gov/department/watershed-detectives

### Build a Landfill – 3D model alternative to the drawing a landfill activity

**Suggested materials (see below for associated layer for each):** plastic container, playdoh, plastic film/saran wrap, some small gravel, straws or pipe cleaner, felt or construction paper (green and brown), netting, shredded paper

1. *Landfills are the most common form of waste management today, and Austin uses landfills exclusively to store its waste. Do you think they just dig a hole in the ground and start throwing trash in?* No. *Building a landfill is a long and complicated process, and we are going to have the opportunity to build our own!*
2. Pass out the **Parts of a Landfill Sheet** (see Instructor Resources) and explain the activity. Youth may work in groups or individually.
    a. *On the cards are clues of how a landfill is built. Read the clues and number the cards in order from the first layer they add in a new landfill to the top layer.* Assist/guide youth as necessary to come up with the correct order (see bullet point #3)
    b. *I will come around and check on your progress. Once I say you have the correct order, you can build your own landfill model, using your materials and the cards as a guide.*
3. Go over each layer of the landfill and their purpose, then have youth build a 3D model of the landfill using the designated materials for each layer.
    a. **Hole/plastic container** – Represents a hole dug in the ground and the working face of a landfill. According to Texas TCEQ 2015 report, the statewide average landfill size was 241 acres. (That's about 200 football fields pieced together!) In addition, the 2015 average depth for MSW landfills was 35 feet and the average height was 84 feet, although some landfills have been permitted heights of 200-300ft. Two landfills within the state are even permitted to be higher than 300ft. (TCEQ 2015)
    b. **Clay Layer/Playdoh –** Clay is used to line the hole dug for the landfill. Clay is used because it is flexible and waterproof.
    c. **Geomembrane Layer/plastic film –** Like a trash bag, this thick plastic layer seals in all the waste and leachate. The actual Geomembrane is typically constructed of a special type of plastic called high-density polyethylene or HDPE. HDPE is tough, impermeable and extremely resistant to attack by the compounds that might be in the leachate.

d. **Gravel layer/gravel –** Holds pipes in place and provides another material to filter the leachate.
e. **Leachate Pipes/straws or pipe cleaner -** Transports leachate from inside the landfill to a collection system outside the landfill. Here the excess moisture is evaporated off while the trash sludge remains behind. Once dry, the sludge is scraped from the system and returned to the landfill as waste. Other pipes also carry away the methane gas that is created from decomposing trash.
f. **Geotextile / Felt or construction paper–** This thick felt liner serves as a filter for the leachate before it reaches the pipes. This prevents clogging in the pipe system.
g. **Geonet / Screen –** Acting as a filter for larger particle of waste, this screen traps waste and keeps it from clogging the pipe system. Now this screen is placed between two layers of Geotextile to stabilize the Geotextile and make application easier.
h. **Waste Layer –** This waste represents all the Municipal Solid Waste created and sent to landfills. Close examination reveals the many categories of waste including: food, glass, plastic, rubber, textiles, paper, yard waste, wood, metals, and electronics.
i. **Daily Cover/brown felt or construction paper -** At the end of each working period, the waste is covered with 6-12 inches of soil. Trucks drive over the layer to compact it and use space more efficiently Daily cover reduces odors, keeps litter from scattering and helps deter scavengers.
j. **Protective Cover/container lid -** A compacted layer of clay and a thick plastic layer form a 'cap' that prevents excess precipitation from entering the landfill and prevents the escape of gas. In an actual landfill, this cap would have the leachate and methane gas pipes coming out of it.
k. **Vegetation Cover/felt or construction paper -** As portions of the landfill are completed, native grasses and shrubs are planted and the areas are maintained as open spaces. The vegetation is visually pleasing and prevents erosion of the underlying soils. Once a landfill is closed, it will be monitored for leachate leakage, methane levels, and settling. Often closed landfills are turned into parks and recreation areas. You can't build buildings on top of the landfill.

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# Landfill Logic

## Instructor Resources

Parts of a Landfill Sheet

| | |
|---|---|
| **Clay Layer**<br><br>This is the very last layer to stop leachate from polluting the soil and groundwater. This layer is the first layer placed in the freshly dug landfill pit | **Geonet**<br><br>This plastic mesh screen is the first layer after the waste. It stops solid pieces of trash from getting through but allows leachate to trickle down to the Geotextile layer and collection pipes. |
| **Geomembrane Layer**<br><br>Like a trash bag liner in your bin at home, a thick plastic liner covers the whole landfill pit after it is lined with clay. This seals in the garbage and prevents it from entering the environment below. | **Waste**<br><br>Each day waste from the town is brought to the landfill and dumped in the working face above the geonet layer. |
| **Gravel Layer**<br><br>A thick layer of gravel is laid atop the Geomembrane Layer to allow leachate to filter down from above layers. | **Daily Cover**<br><br>At the end of each day, the waste is covered with 6-12 inches of soil. The next day waste will be added to another section and covered again. |
| **Pipe System**<br><br>Pipes with holes in them are placed in gravel where they draw the leachate and methane gas into a collection system. | **Protective Cover**<br><br>Once a landfill is full a compacted layer of clay and a thick plastic layer form a 'cap' that prevents excess precipitation from entering the landfill cell and prevents the escape of landfill gas. |
| **Geotextile**<br><br>A thick felt liner is used as a strainer to separate small pieces of waste that have made it through the geonet. This is the last major filter of leachate before it reaches the gravel and collection pipes | **Vegetation Cover**<br><br>When landfills are full, they are closed and capped with native grasses and shrubs. After 30 years of monitoring for methane and leachate leakage, the landfill is used for recreation areas. |

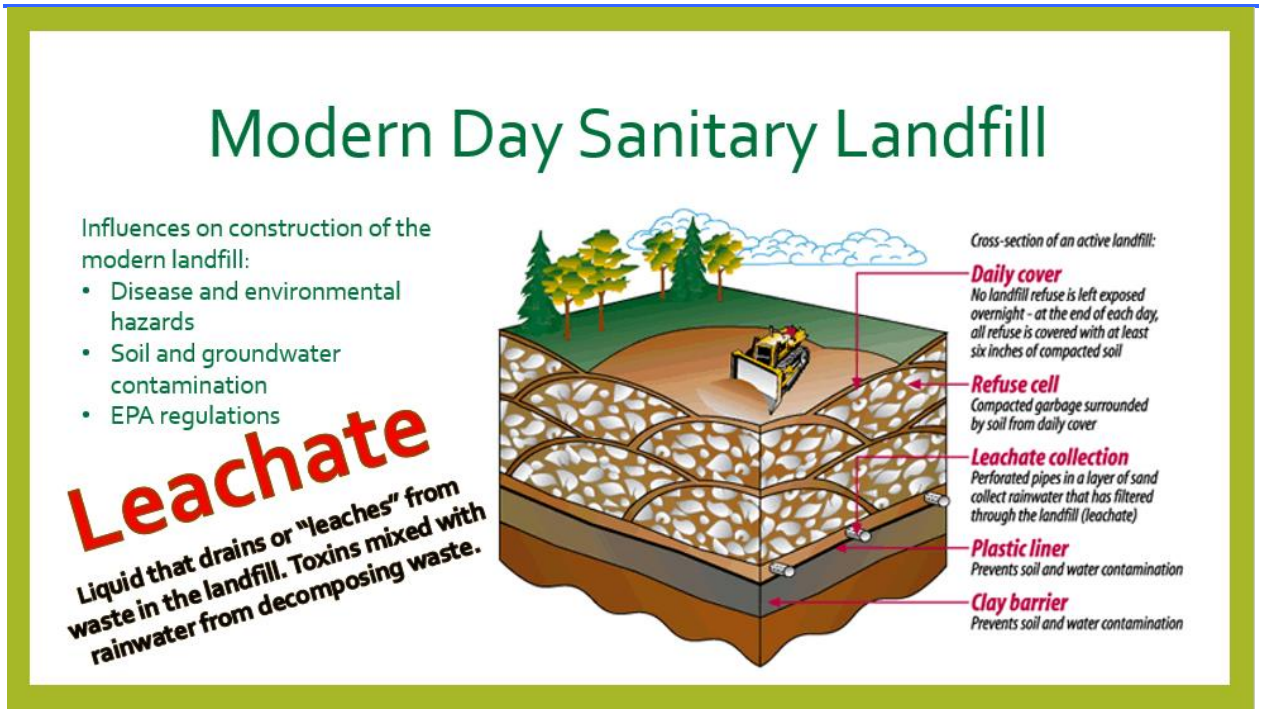



**Figure 1: Landfill Diagram**

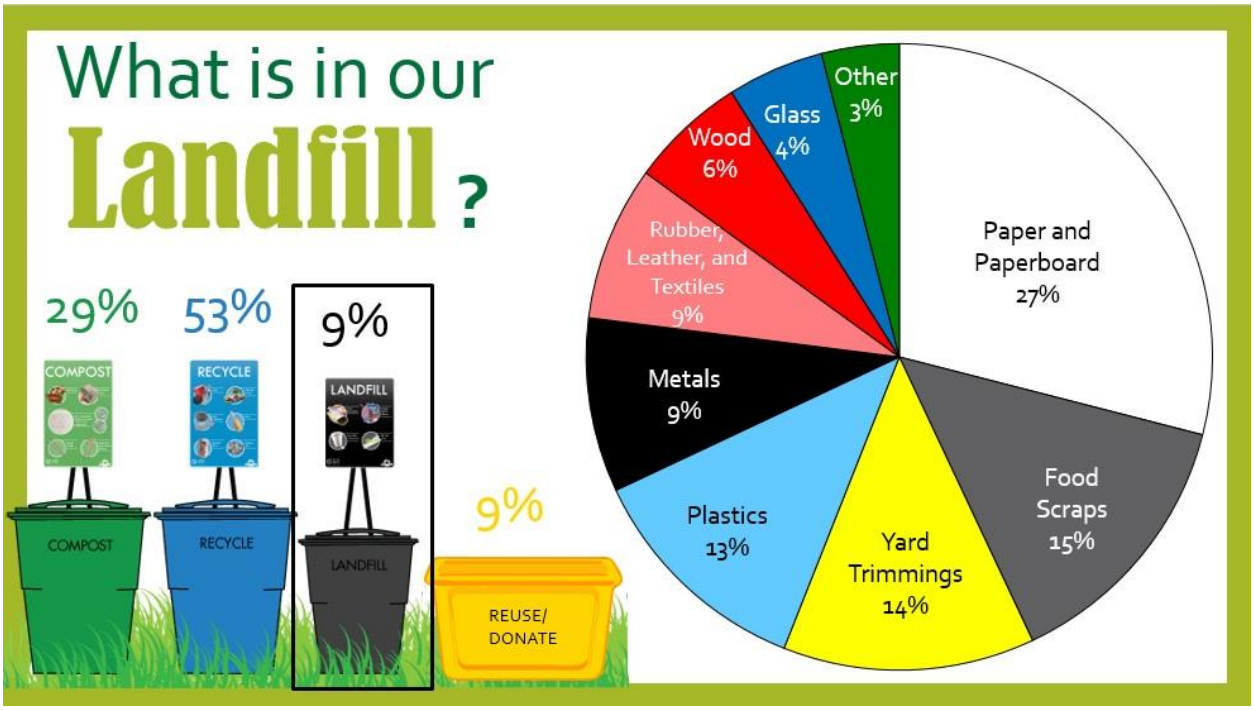



**Figure 2: Waste by the Numbers Chart**

## Photo references for History of Trash Disposal Activity

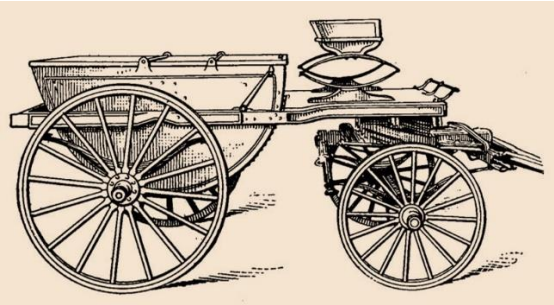


**Figure 3: Drawing of a Horse-Drawn Cart**

**Figure 4: Barge dumping trash in the ocean**

**Figure 5: Piggery**

**Figure 6: Cart carrying mattresses**

**Figure 7: Landfill site**

# Landfill Logic

## Background Information

**ADDITIONAL INFORMATION**

- EPA Site About Landfills www.epa.gov/wastes/nonhaz/municipal/landfill.htm

**Background**

Not many people think about their garbage or waste after it leaves their hands. However, there are many more reasons to be concerned. With the population growing rapidly, it becomes more and more difficult to find room to dispose of our waste, especially in urban settings. Americans discard way more items than they recycle. If this trend of waste production continues, our landfills will be completely full in 20 years. Space that is dedicated to landfills results in a loss of habitat, odor, and the potential for environmental contamination. While some resources can be harvested from landfills, many more natural resources are taken from the environment to produce new materials. In addition, landfills are very expensive to build and maintain. Americans spend $7 billion a year on trash disposal. The cost of building a landfill depends on where you are, but it can range anywhere from 1 million to 20 million dollars or more.

**Evolution of Waste Collection**

Municipalities work with private waste and recycling companies to collect and properly dispose of garbage. Waste Management is currently the largest trash hauler in the world. How did they get there? Every time we fill up our garbage can, we pay money to the city we live in or directly to a waste company to have it removed and properly disposed of. Each garbage truck is weighed and assessed a tipping fee – price per ton. Although the upfront cost of a landfill can be incredibly high, garbage is becoming more expensive to dispose of which generates revenue for the waste company. As recycling becomes more efficient and widespread and land becomes scarcer, one day the hope is that diverting waste from landfills and reprocessing it into a new product will create bigger profits than charging to dispose of it in the ground.

**Choosing a Site**

Many factors must be taken into consideration before even beginning construction. Location of water sources, geologic stability, land value, and easy access are important to the decision of where to build. The Environmental Protection Agency has many regulations to ensure a site's safety and stability for many decades:

- **Location restrictions**—ensure that landfills are built in suitable geological areas away from faults, wetlands, flood plains, or other restricted areas.
- **Composite liners requirements**—a flexible geomembrane overlays two feet of compacted clay soil lining the bottom and sides of a landfill, and protecting groundwater and the underlying soil from leachate releases.
- **Leachate collection and removal systems**—sit on top of the composite liner and removes leachate from the landfill for treatment and disposal.
- **Operating practices**—include compacting and covering waste frequently with several inches of soil helping to reduce odor; control litter, insects, and rodents; and protect public health.
- **Groundwater monitoring requirements**—required testing of groundwater wells to determine whether waste materials have escaped from the landfill.
- **Closure and post closure care requirements**—covering landfills and providing long-term care of closed landfills.
- **Corrective action provisions**—control and clean up landfill releases and efforts made to achieve groundwater protection standards.
- **Financial assurance**—provides funding for environmental protection during and after landfill closure.

**The above requirements are provided directly from the EPA website.*

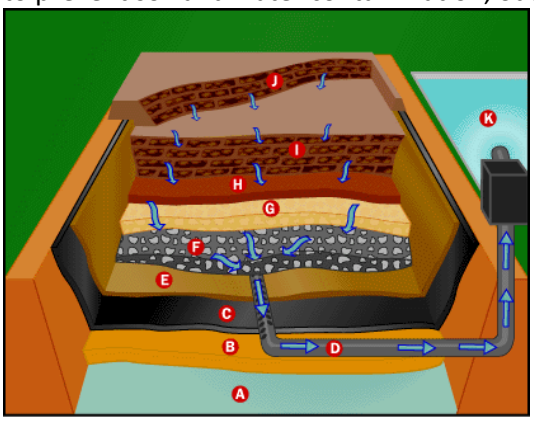
# Landfill Logic

## Background Information

Choosing the appropriate place for construction of a landfill can be very difficult. Landfill companies must consider a location in the community that is well away from complaining neighbors but close enough for trucks to access daily. New York is running out of room and now pays Pennsylvania to haul and dispose of their waste and some even ends up as far as South Carolina! Austin's landfills are located on the east and south sides of the city to avoid building over the aquifer and utilizing heavy clay soils with lower permeability.

**Landfill Operations and Anatomy**

Landfills are complex structures built underground. Before a landfill can begin accepting trash it must be properly sealed. Construction begins with clay and a very thick plastic liner that prevents leachate (decomposing garbage mixed with rain water) from escaping the landfill into the surrounding environment. Perforated pipes (holes) are installed in the landfill to extract toxic leachate. The pipes are embedded in gravel to prevent trash from blocking the system and a layer of thick felt called a filter geotextile is placed between the sand and waste. After the liner, filters, and pipes are constructed the landfill can begin accepting waste. Each day trash is added to a section of the landfill called a working face, mowed over by tractors for compaction, and then covered with soil each night to prevent trash blowing off. Another pipe system is put in place to collect methane, a greenhouse gas produced by anaerobic (lacking oxygen) decomposition. The methane can be burned off by flares or used as a source of energy similar to natural gas. In Austin, methane is piped into the energy grid and used by Dell. The process and the landfills themselves are strictly regulated. It is expensive to properly contain the waste to prevent soil and water contamination, odors, and methane buildup in the landfill.





**A. Surrounding environment**
**B. Clay Liner**
**C. Plastic Liner**
**D. Pipes (Methane Leachate Collection)**
**E. Sand**
**F. Gravel and pipes- Absorbs leachate**
**G. Sand**
**H. Filter geotextile- felt layer to filter**
**I. Cells – layers of trash and soil**

**Closed Landfill**

Once a landfill is full, it is capped, closed and heavily monitored for many years to detect leaks. Due to the settling of decomposing waste, development on top of landfills is usually avoided. Closed landfills are often reclaimed for parks, wildlife habitats, or recreation. In Michigan, a closed landfill is used as a ski hill and in Buda Texas Disposal Systems uses closed landfills as an exotic game ranch. However, Gus Garcia Middle School in North Austin was built on top of an old landfill and parts of the buildings are experiencing problems due to sinking from decomposing trash. In 1992 an apartment building in Northeast Austin was evacuated after high levels of methane gas had accumulated and started a fire. The apartment was built over the old Brinkley-Anderson landfill, an un-lined heap of trash that had been closed more than 35 years prior. Gas monitoring wells and leachate collection systems are active and regulated. Many landfills are using methane gas similar to natural gas which can flow as long as waste is decomposing underground.

# Landfill Logic

## Background Information

**Austin's Zero Waste Initiative**

In late 2011, Austin city council adopted the zero-waste initiative. By 2040, the City of Austin hopes to divert or "recover" 90% of all its waste. Recovering waste can occur through recycling efforts, reducing the amount of packaging a company produces, adding compost collection at the curb, and economic incentives for residents. This initiative has been adopted by one or more cities in California, New York, Colorado, Texas, Washington, North Carolina, and Hawaii. The goal of Zero Waste is to systematically eliminate waste in a landfill by changing the production, distribution, and processing of materials, providing comprehensive collection of refuse, and reclaiming waste into usable resources. The country of Sweden as of (2013) has become so efficient at recycling their waste that they have literally run out. What they don't recycle they turn into energy to power their country and now other countries in Europe are even paying Sweden to take their waste! Zero Waste implementation also eliminates environmental hazards of waste in natural environments such as groundwater, soil, and air pollution. Zero Waste initiatives began in the private sector. Honda, Hewlett Packard, Pillsbury, Toyota, and Xerox have already achieved or are in the process of reaching Zero Waste. Many other companies are following their example.

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|---|---|
| **Landfill** | A method of solid waste disposal where trash is buried between layers of soil and contained using plastic and clay liners to prevent environmental contamination. |
| **Leachate** | A mixture of rain water and decomposed waste particles which percolate down through the landfill and are piped out to prevent the toxic liquid from making contact with the liner or surrounding environment. |
| **Decomposition** | Decomposition is the natural process by which large organic materials and molecules are broken down into simpler ones. The ultimate products of decomposition are simple molecules like carbon dioxide and water. |
| **Contaminant** | A minor and unwanted pollutant in another material, metal, chemical or mixture, often at the trace level. |
| **Sanitary** | Clean. Sanitary landfills refer to the surrounding environment being unaffected from the toxins within. |