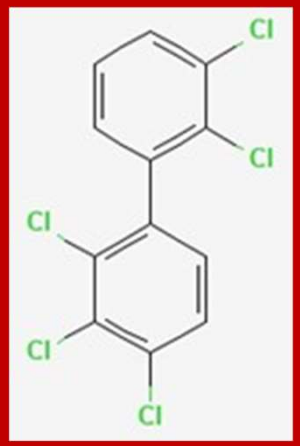
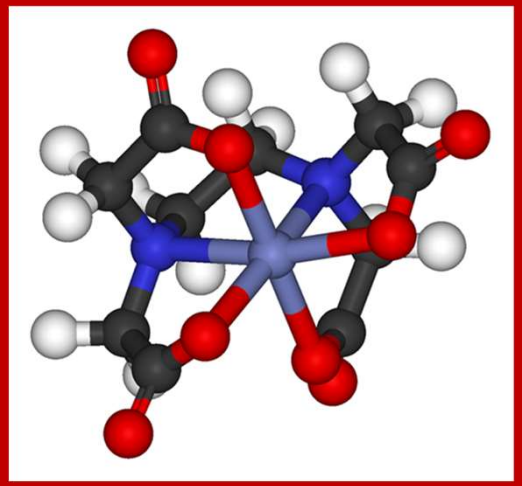
Waste Acceptance Criteria for Low-Level Radioactive and Hazardous Wastes





Scope of This Lecture

1. What type of wastes are acceptable at two major commercial disposal facilities in the U.S.?

2. How are these wastes characterized in terms of physical and chemical properties—that are relevant to disposal?

3. How are the wastes processed on arrival, treated, packaged, and disposed?

The Two Major Commercial Facilities

Waste*Solutions* Clive Disposal Facility near Clive, Utah.

Waste Control Specialists Facilities in Andrews County, Texas.

TYPES OF WASTE DISPOSED AT CLIVE

Non-Technical List of Wastes Permitted

"Soil and debris from site cleanups.

Low-level waste created at nuclear power plants.

Byproducts and equipment used in the nuclear power generation.

Byproducts used in nuclear power plants.

Radioactive material from Department of Energy cleanup sites.

Radioactively contaminated medical waste"

Wastes accepted at Clive

Class A Low-Level Radioactive Waste

Mixed Wastes (Class A Radioactive Waste mixed with hazardous wastes)

Cannot accept Class B, Class C or Class GTCC Wastes.

Cannot accept High-Level Radioactive Waste.

Cannot accept Transuranic Waste

Cannot accept spent nuclear fuel.

Wastes accepted at Clive

U. S. EPA Low-Activity Radioactive Waste (LARW)

- Naturally Occurring Radioactive Material (NORM).
- Naturally Occurring and Accelerator-Produced Material (NARM).

These are not classified as Low-Level Radioactive Waste by the NRC.

Wastes accepted at Clive

11e. (2) Byproduct Material. Defined by the NRC as "tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content."

Clive restrictions:

less than 4,000 pCi/g (total)

Not subject to Low-Level Waste Classification. No sum of fractions.

Wastes accepted at Clive

Special Nuclear Material (NRC term). Defined as:

1. Fissile materials (capable of sustaining a nuclear fission chain reaction).
2. Potential use in the production of nuclear weapons.
3. U-235, U-233, and Pu-239 (depends on amounts).

Wastes accepted at Clive

Depleted Uranium.

Restriction: Wastes less than 10,000 pCi/g.

Radium-226.

Restriction: Wastes must contain less than 10,000 pCi/g Ra-226.

"Waste Containing Hot Particles"

Discrete fragments, ≤ 1 mm diameter, yielding greater than 1 rem/hour beta radiation.

Land Disposal Restrictions

The Land Disposal Restrictions (LDR) Program was created by the Resource Conservation and Recovery Act (1984). It is enforced by the U.S. Environmental Protection Agency (EPA).

The goal of the LDR is to prevent groundwater contamination by the leaching of hazardous wastes during land disposal.

Land Disposal Restrictions

Solid wastes that are disposed in near-surface facilities may be leached by infiltration or shallow groundwater. Hazardous constituents such as arsenic, lead, or tetrachloroethylene may dissolve in shallow groundwater, and migrate off-site into drinking-water sources.

Land Disposal Restrictions

The focus of LDR is to treat wastes *before* land disposal to minimize leaching.

Two approaches:

- **Incineration.** **Heat treatment will breakdown organic chemical wastes into less leachable forms.**
- **Stabilization and Immobilization.** **A variety of chemical and physical treatments to reduce leaching.**

Wastes accepted at Clive

"Polychlorinated Biphenyl (PCBs) Radioactive Waste"

This means Mixed Wastes. Hazardous wastes (PCB) + Class A radioactive waste.

Asbestos.

Beryllium.

What are PCBs?

What are PCBs?

Chlorinated hydrocarbons. Manufactured in the U.S. from 1929 to 1979 when they were banned.

Yellow liquids to black, waxy solids.

Non-flammable. Chemically stable. Relatively hot boiling point.

Significant electrical insulating properties.

What are PCBs?

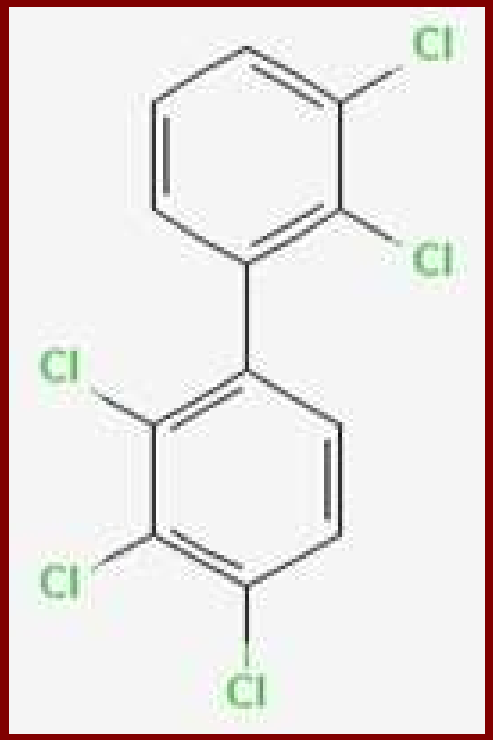
Formerly used in electrical capacitors and transformers.

Electrical equipment such as voltage regulators.

Motors. Hydraulic systems.

Plastics. Paints.

What are PCBs?



A major PCB is Aroclor 1254

1,2,3-trichloro-4-(2,3-dichlorophenyl)benzene

$C_{12}H_5Cl_5$

Light yellow, viscous liquid

Relatively insoluble in water: solubility in water: 12 µg/L at 25° C.

What are PCBs?

Found to be persistent in the environment. Do not readily biodegrade.

Can become bioconcentrated in plants and animals.

Human Carcinogen.

Banned in 1979, but still present in older wastes such as those created by site cleanup or decommissioning.

What is Asbestos?

A class of naturally occurring fibrous silicate minerals. The most common form is chrysotile or white asbestos

$Mg_3(Si_2O_5)(OH)_4$

Asbestos is not chemically toxic.

Galbestos (galvanized steel sheets + asbestos).

What is Asbestos?

Inhalation hazard.
Can result in lung diseases or lung cancer.
Friable asbestos. Can be crumbled by hand into fibers and dust. Non-friable asbestos is normally more resistant to pressure.
ACM (Asbestos-Containing Material).
Can occur as insulation in attics and walls.
Formerly used in roofing and pipe coatings.

What is Asbestos?

Waste Restrictions at Clive

No free liquids in containers.

Liquids could create leachate.

Limitations on the amounts of chelation agents in wastes:

- Less than 22% by weight in mixed wastes.
- Less than 0.1% by weight in low-level radioactive wastes.

Why? What are chelation agents?

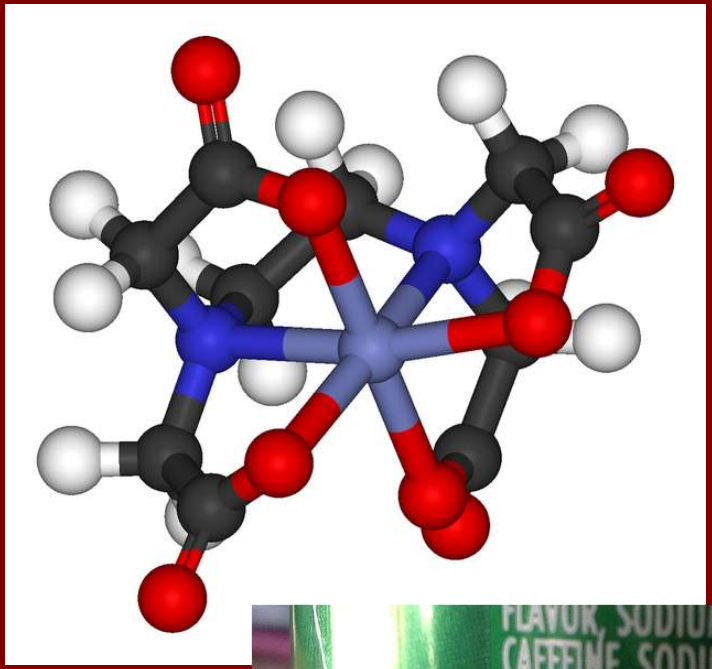
What are Chelation Agents?

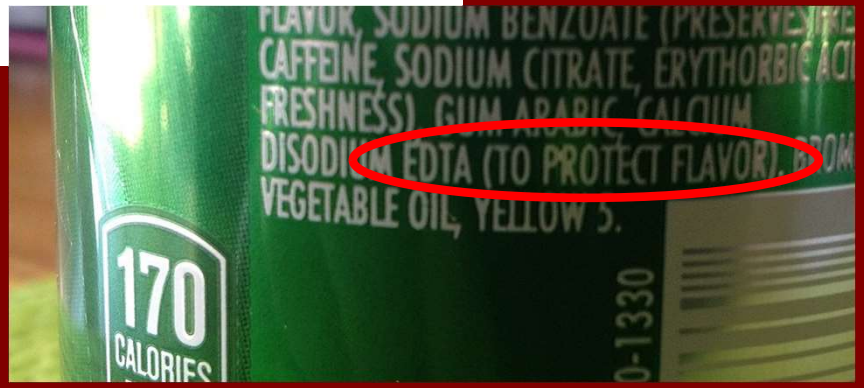
Chelation agents form chemical bonds between metal ions and relatively large organic molecules. The metal ion is then "enveloped" will help mobilize the metal into solution from a solid waste, and prevent it from precipitating out of solution.

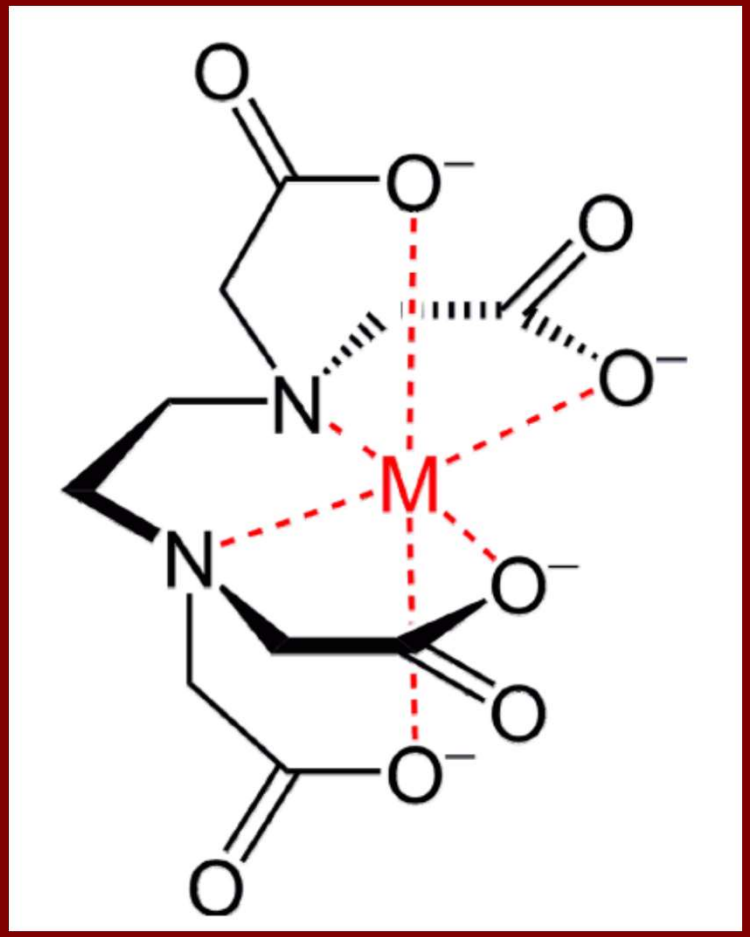
EDTA

Ethylenediaminetetraacetic acid (EDTA)

$C_{10}H_{16}N_2O_8$







Waste Profiling (Characterization)

Collecting solid samples for analytical results.

Why?

Provide information for waste . . .

1. Acceptance and compliance with licenses and permits.

2. Treatment if needed.

3. On-site storage and disposal planning.

Waste Profiling (Characterization)

Waste generators must engage certified laboratories for analytical results.

Clive requires information about physical properties (size, texture, density, water content). Free liquids must be less than 1% by waste volume.

Radiological information.

Chemical composition.

Hazardous characterization.

Waste Profiling (Characterization)

Radiological concentrations.

Gamma spectroscopy, liquid scintillation.

Process knowledge, dose-to-curie, and scaling factors—if validated by direct methods.

Note that the Utah Division of Waste Management and Radiation Control (DWMRC) limits Ra-226 to less than 10,000 pCi/g (Hence, a Utah-based definition of Class A waste).

Waste Profiling (Characterization)

pH (liquids)

For non-hazardous wastes, TCLP results are required.

Toxicity Characteristic Leaching Procedure.

A laboratory-based liquid extraction of a solid-waste sample. The extract is chemically characterized for hazardous waste classification.

TCLP Rotating Tumbler

40 CFR 261.24 Table 1

TABLE 1—MAXIMUM CONCENTRATION OF CONTAMINANTS FOR THE TOXICITY CHARACTERISTIC

EPA HW No.[1]	Contaminant	CAS No.[2]	Regulatory Level (mg/L)
D004	Arsenic	7440-38-2	5.0
D005	Barium	7440-39-3	100.0
D018	Benzene	71-43-2	0.5
D006	Cadmium	7440-43-9	1.0
D019	Carbon tetrachloride	56-23-5	0.5
D020	Chlordane	57-74-9	0.03
D021	Chlorobenzene	108-90-7	100.0
D022	Chloroform	67-66-3	6.0
D007	Chromium	7440-47-3	5.0
D023	o-Cresol	95-48-7	[4] 200.0
D024	m-Cresol	108-39-4	[4] 200.0
D025	p-Cresol	106-44-5	[4] 200.0
D026	Cresol		[4] 200.0
D016	2,4-D	94-75-7	10.0
D027	1,4-Dichlorobenzene	106-46-7	7.5
D028	1,2-Dichloroethane	107-06-2	0.5
D029	1,1-Dichloroethylene	75-35-4	0.7
D030	2,4-Dinitrotoluene	121-14-2	[3] 0.13
D012	Endrin	72-20-8	0.02
D031	Heptachlor (and its epoxide)	76-44-8	0.008
D032	Hexachlorobenzene	118-74-1	[3] 0.13
D033	Hexachlorobutadiene	87-68-3	0.5
D034	Hexachloroethane	67-72-1	3.0
D008	Lead	7439-92-1	5.0
D013	Lindane	58-89-9	0.4
D009	Mercury	7439-97-6	0.2
D014	Methoxychlor	72-43-5	10.0
D035	Methyl ethyl ketone	78-93-3	200.0
D036	Nitrobenzene	98-95-3	2.0
D037	Pentrachlorophenol	87-86-5	100.0
D038	Pyridine	110-86-1	[3] 5.0
D010	Selenium	7782-49-2	1.0
D011	Silver	7440-22-4	5.0
D039	Tetrachloroethylene	127-18-4	0.7
D015	Toxaphene	8001-35-2	0.5
D040	Trichloroethylene	79-01-6	0.5
D041	2,4,5-Trichlorophenol	95-95-4	400.0
D042	2,4,6-Trichlorophenol	88-06-2	2.0
D017	2,4,5-TP (Silvex)	93-72-1	1.0
D043	Vinyl chloride	75-01-4	0.2

Less than 5.0 mg/L = Not hazardous waste

Greater than 5.0 mg/L = Hazardous waste

Waste Treatment

Goal: Minimize the potential for leaching, i.e., EPA Land Disposal Restrictions.

High-pressure washing of non-porous metal surfaces with water.

Chemical stabilization.

Reduce the chemical reactivity of the waste if needed for disposal.

Example: pH neutralization with bases or acids.

Waste Treatment

Macroencapulation

Hazardous debris and radioactive lead.

1. Surfaces coated with an organic polymer.

2. Wastes mixed with concrete.

Figure 3-1. Macroencapsulation of RCRA Hazardous Debris

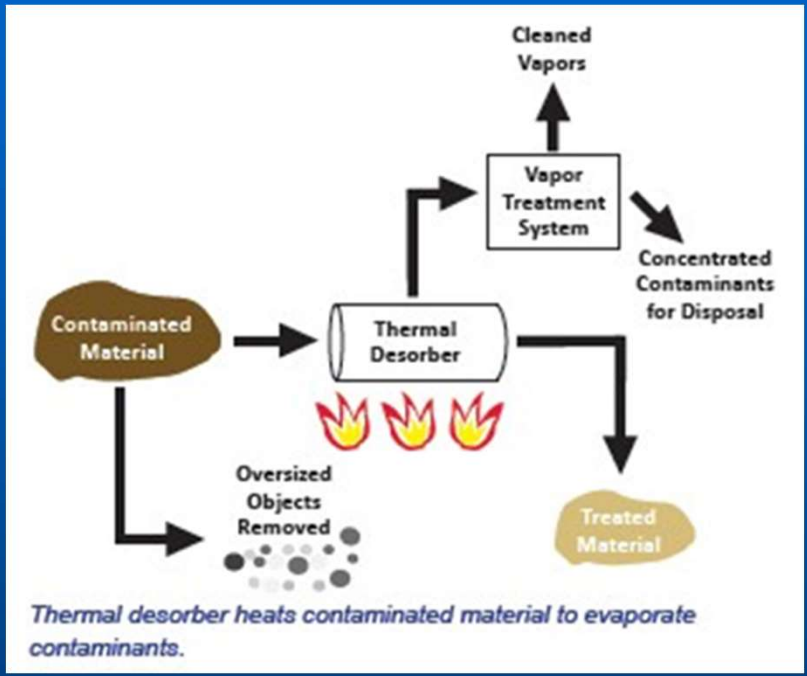
Waste Treatment

Vacuum-Assisted Thermal Desorption.

Used for treating solids and liquids that contain volatile organic chemicals and PCBs. Some Hg and As.

The wastes are heated from 200° to 1,000° F to evaporate ("desorb") contaminants and separate them from the solids (mixed wastes). The off-gases are collected and treated as needed.

Thermal Desorption



https://www.youtube.com/watch?v=3i_jxWDX2sY (2:04)

Acceptable Waste Forms

Dry: less than 1% free liquids per volume of waste.

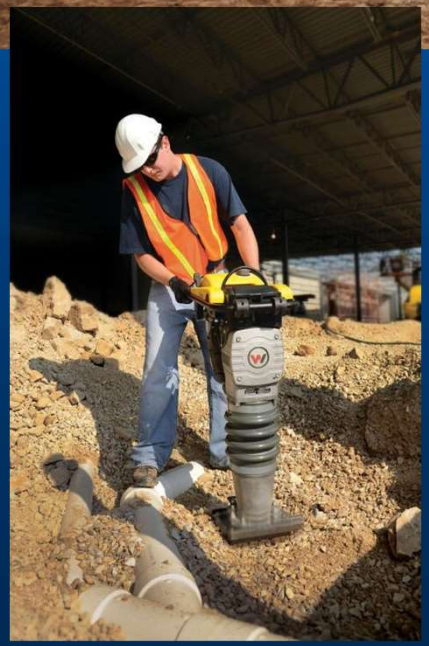
Contaminated soil and soil-like materials (sludges, broken concrete, dry-active waste, metals) must be less than 4 inches (10 cm) in size so that they can be compacted in lifts in the disposal cell.

Acceptable Waste Forms

Soil-like wastes are compacted in lifts increase density and to reduce hydraulic conductivity. Done to reduce the potential to leach contaminants into groundwater.

A lift is a layer. Each layer is compacted in the field with rollers and compactors.

Rollers and Compactors



Acceptable Waste Packaging

Bulk wastes. Relatively small masses. Relatively homogenous mixtures.

Transported using metal boxes, 55-gallon drums, supersacks.

The containers are not returned to the vendor and are buried with the waste.

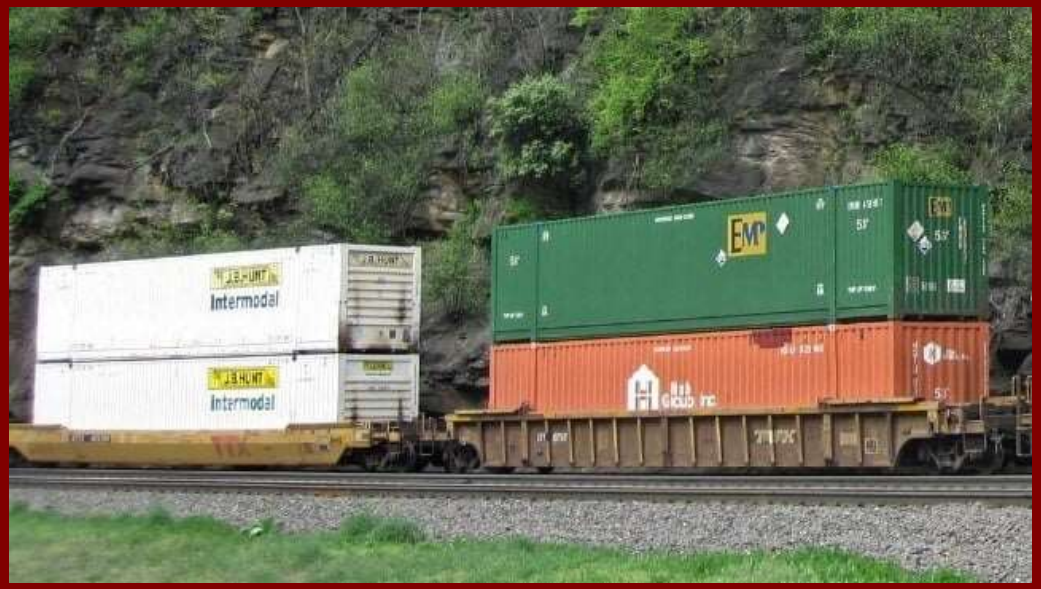
Acceptable Waste Packaging

Non-Bulk wastes. Relatively larger masses. Heterogenous mixtures.

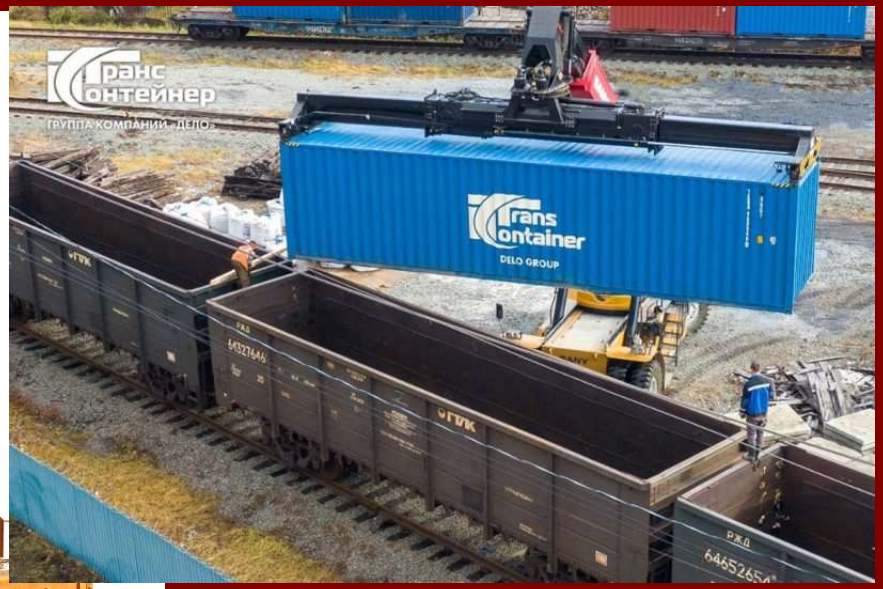
Transported using intermodals, Sealands, roll-offs—which are all metal boxes.

Gondolas. Open or covered railroad boxes on wheels.

Intermodals



Gondolas (rail cars)



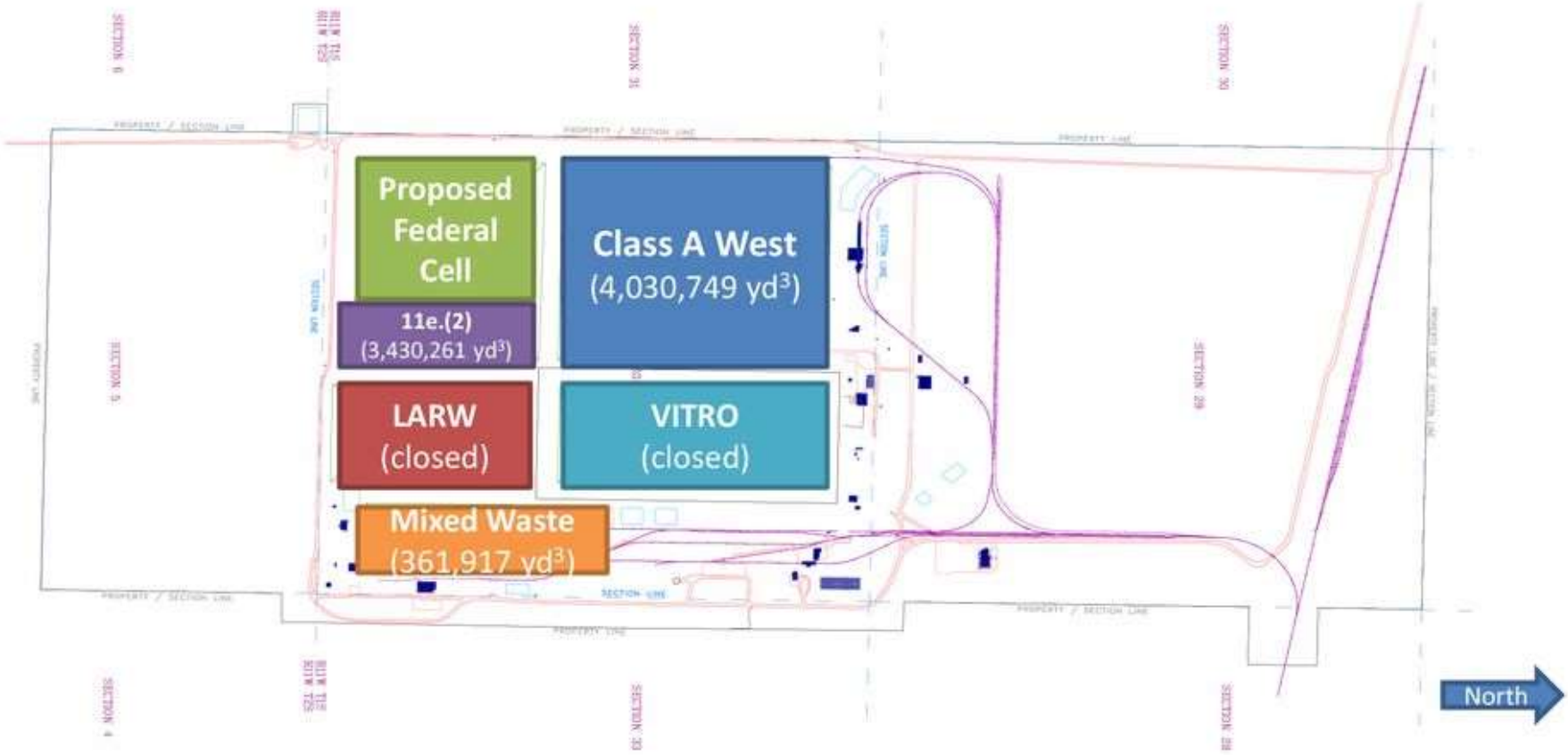
Roll-off Containers

Large Components (no packaging)

Greater than 250 tons.

Steam generators, reactor parts, turbine components.

Clive's Disposal Available Capacity



Clive Facility Overview

https://www.energysolutions.com/clive-disposal-facility/

The Andrews Texas Facility

Texas Compact Disposal Facility.
There are separate units for Compact Wastes and Federal Wastes.
Can accept Class A, Class B, and Class C Waste.
Cannot accept Greater-Than-Class C Waste, explosive wastes, gas-generating wastes, Transuranic Waste, and spent nuclear fuel, High-Level Radioactive Waste.

WASTE CONTROL SPECIALISTS

Low-Level Radioactive Waste Disposal & Regulations

WCS Current Facilities

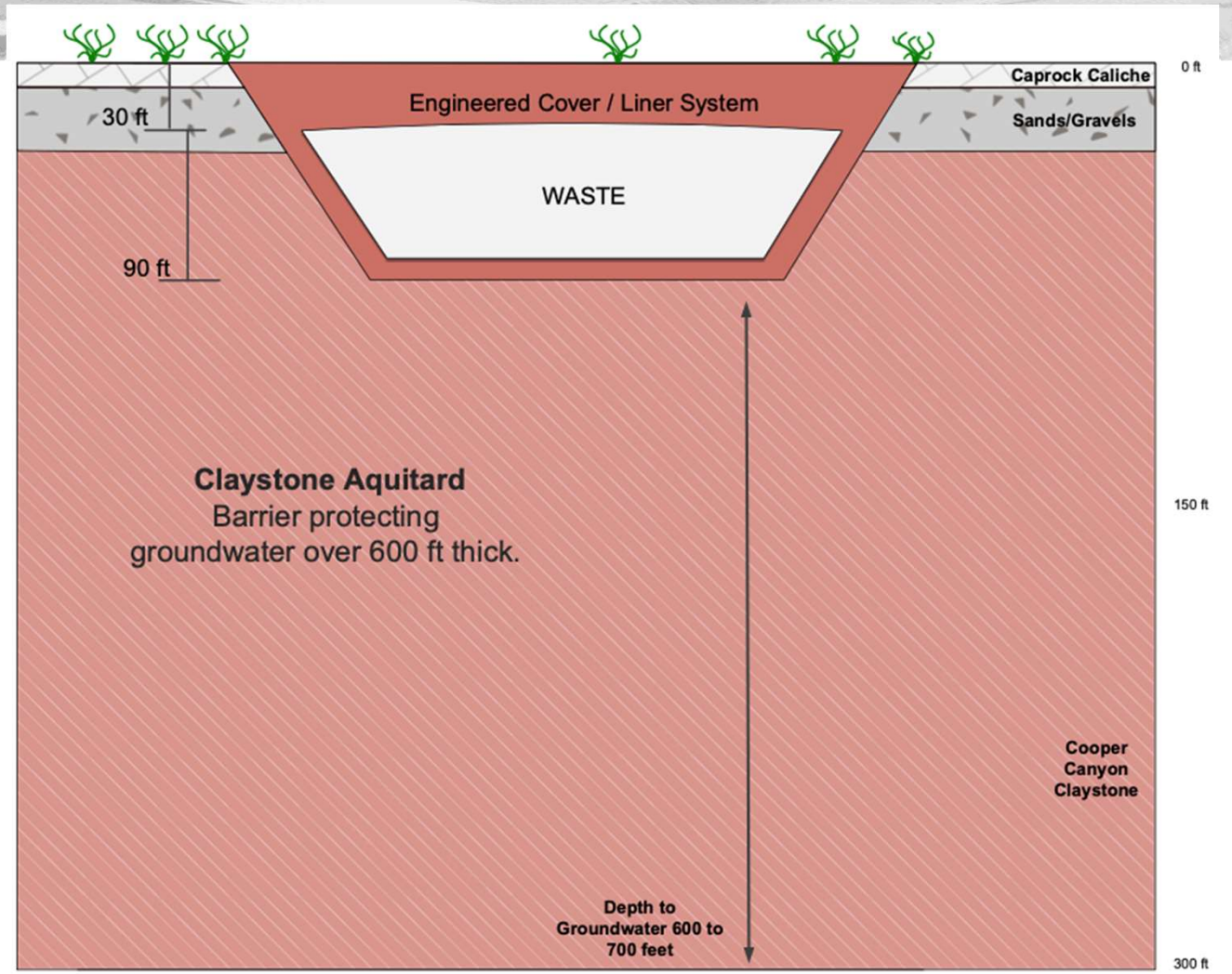
APPENDIX 2 – WASTE STREAM RESTRICTIONS

	Bulk Soil	Bulk Debris	Containerized Soil	Containerized Debris	High Dose Rate Waste	Cask Waste
Waste Form	>50% soil	>50% debris	>50% soil	>50% debris	N/A	N/A
Free Liquids	No visible free liquids	No visible free liquids	< 1%	< 1%	< 1%	< 1%
Dose Rate	< 100 mrem/hr @ 30 cm	< 100 mrem/hr @ 30 cm	At least 10% of containers are <100 mrem/hr @ 30 cm	At least 10% of containers are <100 mrem/hr @ 30 cm	90% of containers are >100 mrem/hr @ 30 cm and ≤1 Rem/hr on contact	>1 rem/hr on contact of the unshielded container
Organic Content	As disposed content cannot exceed 5%, and no shipment can exceed 10%	As disposed content cannot exceed 5%, and no shipment can exceed 10%	N/A	N/A	N/A	N/A
Void Space/ Head Space	N/A	N/A	**LLRW:** Cannot exceed 15% **LLMW**: Cannot exceed 10% **Large Components:** Minimize to the extent practical			
Chelating Agents	Maximum of 8% by weight for all waste types for each waste stream (waste profile)					

APPENDIX 7 – WASTE VERIFICATION REQUIREMENTS

	Bulk Soil	Bulk Debris	Containerized Soil	Containerized Debris	High Dose Rate	Cask Waste
Pre-shipment sample	Required	N/A	Required	N/A	N/A	N/A
Intrusive Visual Inspection	100%	100%	10% of containers from each profiled waste stream per shipment	10% of containers from each profiled waste stream per shipment	N/A	N/A
Intrusive sampling/ analysis	For each profiled waste stream: The first 10 shipments, and 10% thereafter	N/A	10% of containers from each profiled waste stream per shipment	N/A	N/A	N/A
External Radiologic Analysis	N/A	10%	N/A	10% of containers from each profiled waste stream per shipment	10% of containers from each profiled waste stream per shipment	100%

WCS Geology



- Dockum Claystone impervious and precludes the movement of liquids.
- No cross-formational flow with lower Dockum Aquifer.
- Waste is not compromised over time.

WASTE CONTROL SPECIALISTS

WCS Geology (cont.)

Characteristics	Waste Control Specialists Andrews, TX
Depth to Groundwater	600 - 700 feet (confined)
Underlying Geology	Claystone - IMPERVIOUS & precludes the movement of liquids
Thickness of Confining Layer between Waste & Groundwater	600 - 700 feet
Waste Migration Rate per 1,000 Years	Liquids Immobilized in Dry Claystone - *No Movement*
Water Movement between Shallow & Deep Aquifers	None
Primary Regional Aquifer for Surrounding Area: On Site?	Ogallala Aquifer : Not Onsite
Landfill Cover Thickness	40 feet
Landfill Design : Erosion Impacts	Below Ground : No Impacts from Erosion
Geologic Changes Expected in: *10,000 years*	None
100,000 years	None
1 million years	None

Modular Concrete Canisters

Containerized wastes placed in cylindrical or rectangular canisters (Modular Concrete Canisters).

Each canister is then filled with a flowable-concrete grout.

The void spaces between the canisters are filled with local clay.

Large components that do not fit into canisters are filled with grout before burial.

WASTE CONTROL SPECIALISTS

Compact Waste Facility

ENERPAC

ENERPAC

Acceptable Waste Packaging

Bulk soil/soil-like wastes:

Intermodals, roll-offs, B-25 boxes.

Containerized soil-like waste, debris:

Metal boxes, 55-gallon drums.

Not acceptable:

waste in cardboard, fiberboards, and wood boxes.

Cask wastes. DOT shielded casks. Will not be opened for inspection or sampling.

WCS
ANDREWS, TEXAS
ROBATEL
RT100
2916
RADIOACTIVE

TABLE 6.3.1
WASTE VERIFICATION ANALYSIS PARAMETERS

Parameter and Method	Type of Baseline
Free Liquids – (PFLT), SW-846 9095A	Pass/Fail – test must always pass PFLT (qualitative analysis)
Density – ASTM D 5057 or equivalent method	Numerical value obtained – results must fall within a given range as set by the profile and pre-shipment sample (quantitative analysis)
Reactivity/water compatibility – ASTM D 5058 or equivalent method	Positive/Negative – test must always be negative (qualitative analysis)
Cyanide screen – ASTM D 5059 or equivalent method	Positive or Negative – acceptable results may be positive or negative depending upon original analytical results – (qualitative analysis)
Sulfide screen – ASTM D 4978 or equivalent method	Positive or Negative – acceptable results may be positive or negative depending upon original analytical results – (qualitative analysis)
pH/corrosivity – ASTM D 4980 or equivalent method	Numerical value obtained – results must fall within a given range as set by the profile and pre-shipment sample (quantitative analysis)
Flammability Potential Screening- ASTMD 4982 or equivalent method	Positive or Negative – acceptable results may be positive or negative depending upon original analytical results – (qualitative analysis)
Gamma Spectroscopy (HASL-300) (if dose rate/activity is within acceptable range of the instrument)	Numerical value obtained – results must fall within a given range as set by the profile and pre-shipment sample (quantitative analysis)
Gross alpha-HASL-300 (if dose rate/activity is within acceptable range of the instrument)	Numerical value obtained- results must fall within a given range as set by the profile and pre-shipment sample (qualitative parameter; quantitative analysis)
Gross beta- HASL-300 (if dose rate/activity is within acceptable range of the instrument)	Numerical value obtained- results must fall within a given range as set by the profile and pre-shipment sample (qualitative parameter; quantitative analysis)

Where incoming waste shipments are verified through in-situ gamma spectroscopy, waste containers will be examined in accordance with RS-4.1.4, *Non Destructive In Situ Gamma Spectroscopy*. The gamma spectroscopy results, in combination with generator provided scaling factors, will be used to calculate the activities of significant alpha and beta-emitting components when appropriate and applicable. Results must fall within an expected range developed by review of profile documentation and any pre-shipment sample analysis (quantitative analysis). Typically, in-situ gamma spectroscopy will be performed in designated areas within the staging buildings.

Performance Assessment

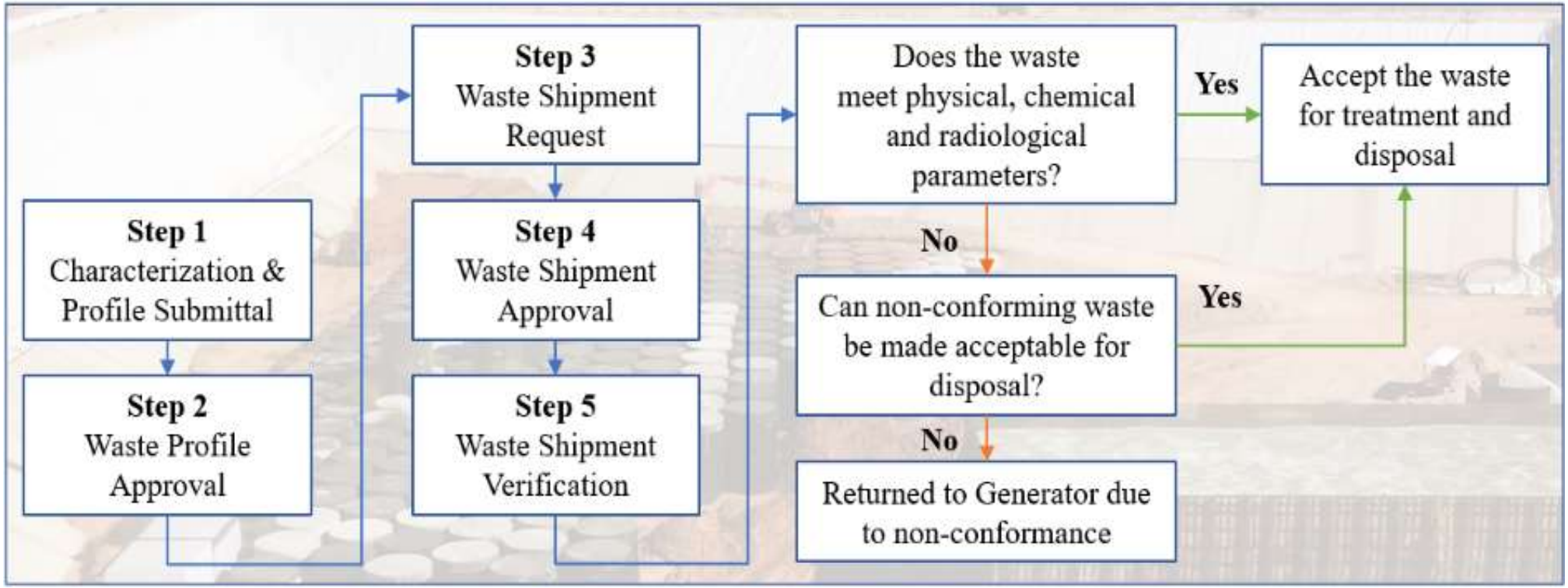
- Period of Performance under the NRC is 10,000 years. NUREG-1573 (LLW) & 10 CFR §63.114 (HLW). In Texas, the period of performance is to 1,000 years <u>or peak dose</u>. 30 TAC §336.709(1).
  - Peak Dose in the Compact Waste Facility
    - 7.6 mrem/year at 30,000 years post closure
  - Peak Dose in the Federal Waste Facility
    - 4.9 mrem/year at 20,000 years post closure
  - Peak Dose in RCRA/RSCA cell
    - 0.00033 mrem/year at 510 years post closure

Irradiated Hardware

- WCS routinely disposes of IH with dose rates >20,000 R/hr or approximately >175.4 Gy/hr on contact with a collective team dose of less than 0.02 person-rem
- State-of-the-Art transfer system with complete remote handling
- IH casks are routinely offloaded, reassembled and shipped back the same day.
- WCS is now receiving large volume shipments (400+cf) of Reactor Internals from VY D&D project.

WASTE CONTROL SPECIALISTS

General Waste Flow



The Andrews Texas Facility

https://www.youtube.com/watch?v=9IzoWY0qVqg&t=29s (0:35)

Questions?