CLEANING UP WASTES
RECYCLING AND ENERGY RECOVERY

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AGENDA – Main Topics

- Introduction
- Waste Issues
- Water Quality
- Wastewater
- Municipal Solid Waste – Recycling
- Municipal Solid Waste – Landfills
- Greenhouse Gases
- Municipal Solid Waste – Incineration
- Waste-to-Energy
- Disposal of Other Wastes
- Air Emissions
- Air Emissions Control

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Deuteronomy 23: 12, 13, 14

- You shall have a place *outside the camp*, where you may go out;
- And you shall have an implement among your equipment, and when you sit down outside, you shall dig with it and turn and cover your refuse.
- For the Lord your God walks in the midst of your camp, to deliver you and give your enemies over to you; therefore *your camp shall be holy*, that He may see no unclean thing among you, and turn away from you.

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Some Basic Criteria For Waste Disposal

- Safety of groundwater
- Protection of surface waters
  - Rivers
  - Lakes
  - Oceans
- Elimination of disease threats
- Reduction of disease vectors (vermin)
- Reduction of greenhouse gas generation
- Resource recovery
- Protect the future
- Aesthetic issues
  - Sight
  - Sound
  - Smell

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Pollution of Groundwater

- The drinking water for about half of the U.S. population (and 95% of those living in rural areas) comes from groundwater.
- Groundwater can become dangerously contaminated with a variety of pollutants because it cannot effectively cleanse itself and dilute and disperse pollutants.
- For these reasons groundwater contamination becomes perhaps the most important driving force in effective waste clean-up and disposal.

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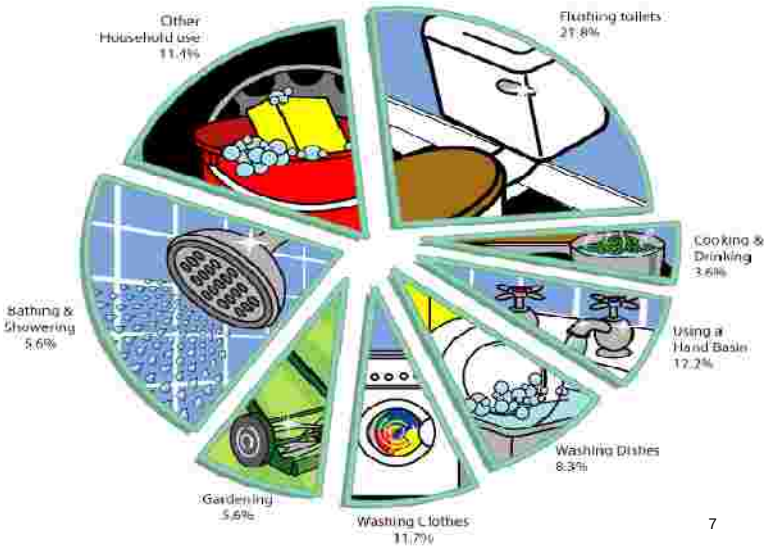

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Major Water Pollutants and Their Effects

Type/Effects	Examples	Major Sources
Pathogens Cause diseases	Bacteria, viruses, protozoa	Human and animal wastes
Oxygen-demanding wastes Deplete dissolved oxygen needed by aquatic species	Biodegradable animal wastes and plant debris	Sewage, animal feedlots, food processing wastes, animals
Plant nutrients Cause excessive growth of algae and other species	Nitrates (NO_3^-) and phosphates (PO_4^{3-})	Sewage, animal wastes, inorganic fertilizer
Organic chemicals Add toxins to aquatic systems	Oil, gasoline, plastics, pesticides, cleaning solvents	Industry, home, farms, streets
Inorganic chemicals Add toxins to aquatic systems	Acids, salts, metal compounds	Industry, households, surface runoff
Sediments Disrupt photosynthesis, food webs, other processes	Soil, silt	Land erosion
Thermal Make some aquatic species vulnerable to disease	Heat	Electric power and industrial plants

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Common Diseases Transmitted Through Contaminated Drinking Water

Type of Organism	Disease	Effects
Bacteria	Typhoid fever	Diarrhea, severe vomiting, enlarged spleen, inflamed intestine, ulcers (rare if untreated)
	Cholera	Diarrhea, severe vomiting, dehydration, circulatory collapse
	Bacterial dysentery	Diarrhea, rarely fatal except in young without proper treatment
	Enteritis	Severe stomach pain, nausea, vomiting, rarely fatal
Viruses	Infectious hepatitis (Type B)	Fever, anorexia, headache, nausea, loss of appetite, abdominal pain, jaundice, enlarged liver, rarely fatal, but may cause permanent liver damage
Parasitic protozoa	Amoebic dysentery	Severe diarrhea, headache, abdominal pain, chills, fever. If not treated can cause liver abscess, bowel perforation, and death
	Giardiasis	Diarrhea, abdominal cramps, flatulence, belching, fatigue
	Cryptosporidium	Severe diarrhea and possible death for people with weakened immune systems
Parasitic worms	Schistosomiasis	Abdominal pain, skin rash, anemia, chronic fatigue, and chronic general ill health

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Potable Water

- Potable (drinking or fresh) water (pot-able, not pat-able)
- If the water supply crisis was so much of a crisis, a way would be found to use non-potable water for toilets and other non-ingestion uses . . . and tap water would not be so inexpensive

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EPA Requirements

- Dozens of constituents and possible constituents must be investigated
- Testing for these pollutants are required on a regular basis . . daily, weekly, monthly, quarterly or yearly

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Key Differences Between EPA Tap Water and FDA Bottled Water Rules

Water Type	Disinfection Required?	Confirmed E. Coli & Fecal Coliform Banned?	Testing Frequency for Bacteria?	Must Filter to Remove Pathogens, or Have Strictly Protected Source?	Must Test for Cryptosporidium, Giardia, Viruses?	Testing Frequency for Most Synthetic Organic Chemicals?	Operator Must be Trained & Certified?	Must Test for and Meet Standards for Asbestos & Fluoride?	Must Use Certified Labs to Do Testing?	Must Report Violations to State, Fast?	Consumer Right to Know About Contamination?
Bottled Water	No	No	1/week	No	No	1/year	No	No	No	No	No
Carbonated or Seltzer Water	No	No	None	No	No	None	No	No	No	No	No
Big City Tap Water (using surface water)	Yes	Yes	Hundreds/month	Yes	Yes	1/quarter	Yes	Yes	Yes	Yes	Yes
Small Town Tap Water (using a well)	No	Yes	1/Month	No	No	1/quarter	Yes	Yes	Yes	Yes	Yes

Note: FDA requires state or local approval of bottled water sources, but there is no federal definition or control of what may be a bottled water source, so the FDA "approved source" requirement has been called a "regulatory mirage."

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Dissolved Oxygen (DO) in Water

- Water courses (lakes, rivers, oceans, etc.) must contain oxygen or, at the very least, fish would be unable to breathe
- Where does the oxygen come from?
  - Diffusion from the atmosphere
  - Aeration as water flows over rocks and debris
  - Aeration from wind and waves
  - Photosynthes of aquatic plants (plants breathe carbon dioxide and exhale oxygen)
- How much oxygen are we talking about?

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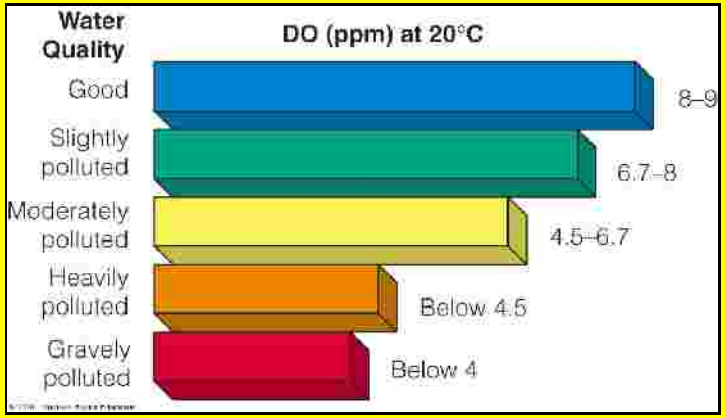
Water Quality/Dissolved Oxygen (DO) Content in Parts/Million (ppm) at 68°F (20°C)



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BOD (Biological Oxygen Demand)

- When organic matter such as dead plants, leaves, sewage, etc. is present in a water supply, micro-organisms will begin the process of breaking down this waste and DO will decrease.
- When this happens, much of the available dissolved oxygen is consumed by micro-organisms, robbing other aquatic organisms (fish) of the oxygen they need to live.
- BOD is a measure of the oxygen used by micro-organisms to decompose this waste.
- If there is a large quantity of organic waste in the water supply, there will also be a lot of micro-organisms present working to decompose this waste and the demand for oxygen will be high and the BOD level will be high.
- As waste is consumed or dispersed through the water, BOD levels will begin to decline.

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Micro-organisms (Microbes)

- A micro-organism (or microbe) is an organism that is microscopic (too small to be visible to the human eye).
- Micro-organisms can be bacteria, fungi, or protists (but NOT viruses and prions because these are generally classified as non-living).

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Typical BOD Values

- Most pristine rivers will have a BOD below 1 mg/L (ppm).
- Moderately polluted rivers may have a BOD value in the range of 2 to 8 mg/L.
- Municipal sewage that is efficiently treated would have a value of less than 20 mg/L.
- Untreated sewage varies, but its BOD averages around 600 mg/L in Europe and from 200 to 300 mg/L in the U.S.

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Classification of Water Quality of Aquatic Systems According to BOD

Water quality class	BOD (mg/l)
Not stressed	1
Slightly stressed	1 –2
Moderately stressed	2 - 6
Critically stressed	5 -10
Strongly polluted	7 -13
Very strongly polluted	10 - 20
Overly stressed	> 15

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Water Treatment

- Let us briefly look at what is necessary to insure that good quality water comes out of our faucets in Eastern Loudoun County
- In parts of Loudoun County water from the Potomac River goes through the Corbalis Water Treatment Plant on Wiehle Avenue (yes, that is in Fairfax County), and is distributed to our homes

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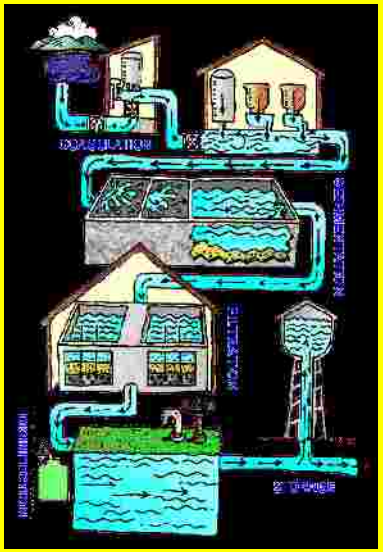

COAGULATION – removes dirt and other particles suspended in the raw water. Alum (aluminum sulfate) and other chemicals are added to form tiny sticky particles called "floc" which attract the dirt particles. The dirt and the spent alum (floc) become heavy enough to sink to the bottom during sedimentation.

SEDIMENTATION – floc settles to the bottom of the tank and the water moves to filtration.

FILTRATION – water passes through filters, some made of layers of sand and charcoal, that remove all remaining particles.

DISINFECTION – chlorine or other disinfectant (ozone, UV light, etc.) is added to kill off any residual bacteria and other micro-organisms

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Disinfection

- Addition of chlorine
- 24-hour contact time is needed for chlorine to kill bacteria in water before its release into the environment
- Sulfur dioxide is added to the treated water to remove excess chlorine because chlorine may have an adverse effect on downstream equipment
- In the future, uv-treatment to kill microbes will replace chlorine
  - Ultraviolet radiation of water reduces contact time
  - No need to add sulfur dioxide
  - Less costly procedure over-all

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Small Wastewater Treatment Systems

- Septic tank and leaching field
- Waste is held in a septic tank for a period of time (days) sufficient for sewage to be digested and made inert
- (Mostly) inert liquid is distributed (leached) to the surrounding soil where it percolates harmlessly through the earth
- Eventually the septic tank can clog with accumulated material and has to be cleaned out
- Similarly, the leaching field can become saturated and will have to be abandoned and a new field will have to be developed

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Digestion of Wastes

- Digestion is that process where organic material (food or in this case waste) is broken down to elementary compounds that are non-toxic, non-odorous and stable (non-reactive).
- Aerobic: with air; Anaerobic: without air
- In either system a source of oxygen is required for micro-organisms to survive.
- Aerobic systems applied to waste include composting, where air is introduced into the waste resulting in the generation of heat, carbon dioxide and water vapor, plus an inert "compost" that is no longer biologically active (mainly fungi).
- An anaerobic process occurs without an external source of air with required oxygen coming from the waste itself.

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The Main Objectives in Water Supply and Treatment

- Discharge treated water with less than 20 ppm BOD to a water stream (less than 20 ppm BOD to the Potomac)
- Compliance with all EPA standards (removal of toxins)
- Removal of most nitrogen and phosphorous to reduce micro-biological growth (algae blooms, etc.)
- Low turbidity

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Basic Features of a Typical Municipal Wastewater Treatment Plant

- Sewage is mostly water with floating solids, suspended solids, dissolved solids and a high BOD content
- Sewage treatment converts BOD to solids and then remove these and other solids from the flow.
  - First, remove floating solids
  - Second, hold sewage in tanks for a relatively long period of time (many hours), allowing suspended solids to settle out into a primary sludge
  - Third, inject air into the sewage, promoting the growth and activity of micro-organisms, and provide additional tanks for settlement of secondary (waste activated) sludge
  - Fourth, disinfect the resulting water flow and discharge it to a public waterway
  - Fifth, neutralize the sludge through digestion or incinerate it

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EUPHANISMS

- Sewage Treatment Plant
- Water Recycling Facility
- Wastewater Treatment Plant
- Water Reclamation Facility

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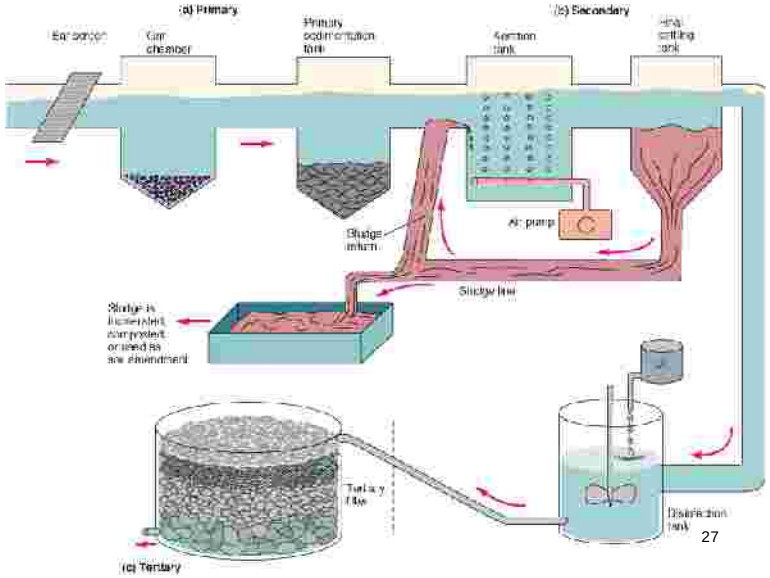

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Sewage Treatment

- Raw sewage reaching a municipal sewage treatment plant typically undergoes:
  - Primary sewage treatment: a physical process that uses screens and a grit tank to remove large floating objects and allows settling.
  - Secondary sewage treatment: a biological process in which aerobic bacteria remove as much as 90% of dissolved and biodegradable oxygen demanding organic wastes.

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Sewage Treatment - continued

- Advanced or tertiary sewage treatment:
  - Uses a series of chemical and physical processes to remove specific pollutants (especially nitrates and phosphates).
- Water is chlorinated to remove coloration and to kill disease-carrying bacteria and viruses (disinfection).

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Disinfection

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- 24-hour contact time is needed for chlorine to kill bacteria in water before its release into the environment
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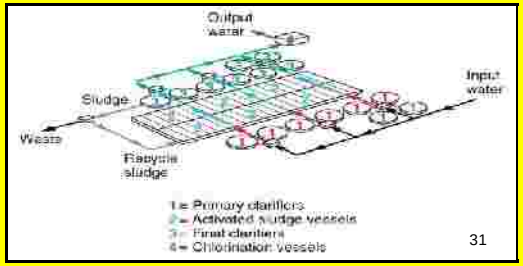
Typical Municipal Wastewater Treatment Plant

Wet Stream



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Reclaimed Water Utilization

- Irrigation type utilization:
  - Residential lawns, golf courses, parks, cemeteries, schools
  - Commercial or industrial grounds,
  - Landscape areas, highway medians, roadways
- Industrial and non-irrigation type utilization:
  - Industrial process or cooling water
  - Decorative ponds or fountains
  - Fire fighting or suppression
  - Dust control, street sweeping soil compaction
  - Individual vehicle washing for personal purposes
- Generally, not be used for:
  - Irrigation of direct food chain crops
  - Swimming pools, hot tubs, spas, or similar
  - Direct reuse as a raw potable water supply (except in Loudoun County)

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Digestion of Wastes

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- An anaerobic process occurs in air-tight tanks with required oxygen coming from the waste itself producing methane, carbon dioxide and a residual inert material, a more concentrated sludge.

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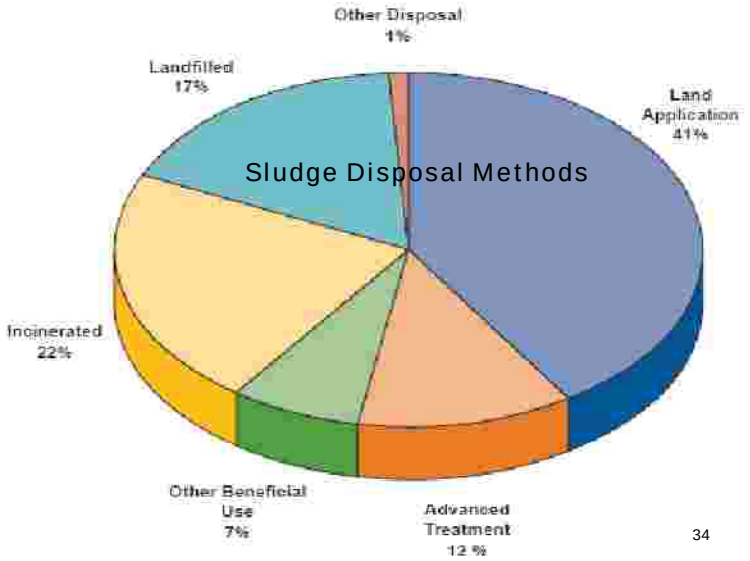

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Broad Run Water Reclamation Facility

- The BRWRF is an 11 million gallon per day (mgd) water reclamation facility in Ashburn, a separate (not combined) sewer system.
- The facility is subject to the Dulles Watershed Regulations, that requires stringent standards because it discharges treated wastewater upstream of a drinking water supply in the Potomac River.
- The facility is also subject to other specific state regulations as well as Chesapeake Bay regulations.

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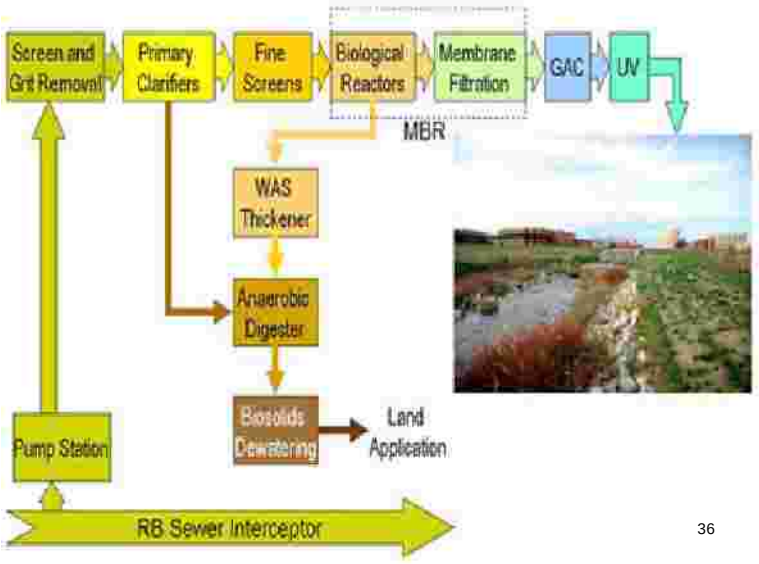

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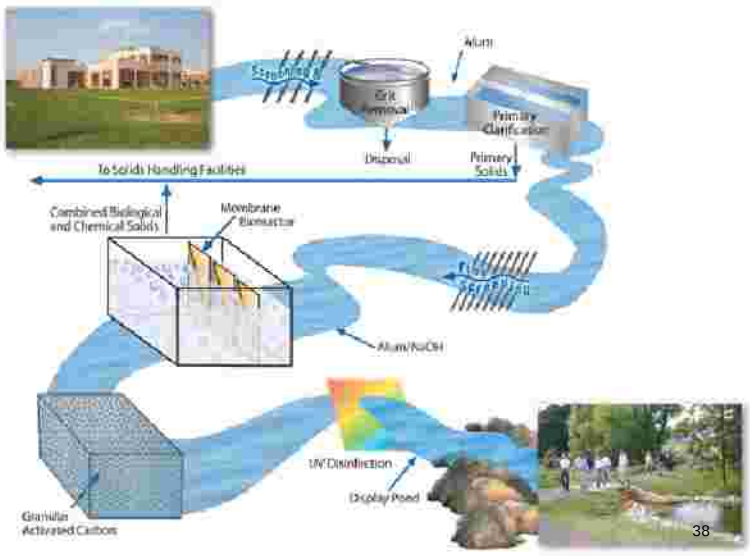

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Class (Type) No.	Description	Approximate Composition (%)	Moisture Content (%)	Combustible Matter in Dry Matter (%)	Heating Value (Btu/lb)	Heating Value (kJ/kg)	Principal Components
0	Trash	Trash, 100	10	9	8,500	19,771	Highly combustible waste. Paper, wood, cardboard cartons and up to 10% treated paper, plastic or rubber scraps; commercial and industrial sources.
1	Rubbish	Rubbish, 80 Garbage, 20	25	10	6,500	15,119	Combustible waste, paper, cartons, rags, wood scraps, floor sweepings; domestic, commercial and industrial sources.
2	Refuse	Rubbish, 50 Garbage, 50	50	7	4,300	10,002	Rubbish and garbage; residential sources.
3	Garbage	Garbage, 80 Rubbish, 20	70	6	2,500	5,815	Animal and vegetable wastes, restaurants, hotels, markets, institutional, commercial and street sources.
4	Animal, solids and organic wastes	Animal and human tissue, 100	85	5	1,000	2,326	Carcasses, organs, solid organic wastes; hospital, laboratories, abattoirs, animal pounds and similar sources.

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East Asian MSW Generation Rates

(India Infrastructure Report, Chapter 8, 2006)

lb/capita/day

Low income	*1.41*
Nepal	1.10
Bangladesh	1.08
Myanmar	0.99
Vietnam	1.21
Mongolia	1.32
India	1.01
Lao PDR	1.52
China	1.74
Sri Lanka	1.96

Middle income	*1.61*
Indonesia	1.68
Philippines	1.15
Thailand	2.43
Malaysia	1.79

High income	*3.62*
South Korea	3.51
Hong Kong	11.18
Singapore	2.43
Japan	3.24

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Western Countries MSW Generation Rates

(India Infrastructure Report, Chapter 8, 2006)

lb/capita/day

USA	4.41	The Netherlands	3.02
Japan	2.47	Belgium	2.43
Germany	2.18	Hungary	2.36
Mexico	1.87	Austria	2.60
France	2.84	Greece	1.87
Turkey	2.40	Portugal	1.98
Italy	2.12	Sweden	2.23
Canada	3.97	Finland	3.75
Spain	1.98	Switzerland	2.43
Poland	2.05	Denmark	2.78
Australia	4.17	Norway	3.09

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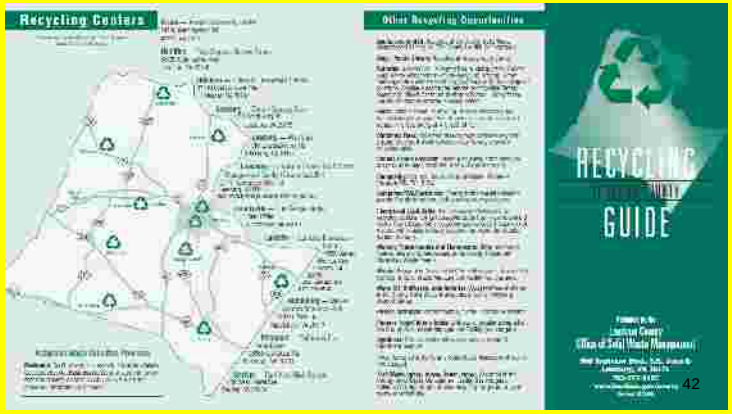
Loudoun County recycles over 50,000 tons of MSW per year. More informaiton can be found on their site:

http://www.loudoun.gov/Default.aspx?tabid=331&fmpath=/SWMP



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Material Recovery Facility (MRF)

- A solid waste management facility that separates materials for the purposes of recycling from an incoming mixed solid waste stream by using manual and/or mechanical methods
- A facility at which previously separated recyclables are collected.
- Generally two types of MRFs exist
  - Clean or source-separated MRFs and
  - Dirty or non-source-separated MRFs

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U.S. Recycling Rates

- Tires - 22%
- Plastic containers - 25%
- Overall plastics – 5%
- Glass containers - 28%
- Yard waste - 41%
- Paper and Paperboard - 42%
- Aluminum packaging - 54%
- Steel cans - 60%
- Auto batteries - 93%

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Recycling

- Recycling is important in reducing waste volume and also in conserving energy.
- It takes only 1/3 amount of energy to form a beverage can from recycled aluminum as it does from virgin aluminum.
- It takes 1/3 less energy to form steel products from scrap than from ore

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Markers Identify Plastic Type

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Plastics

- Type 1 - PETE Polyethylene Terephthalate (PET) - Soda & water containers, some waterproof packaging.
- Type 2 - HDPE High-Density Polyethylene - Milk, detergent & oil bottles, toys and plastic bags.
- Type 3 - V Vinyl/Polyvinyl Chloride (PVC) - Food wrap, vegetable oil bottles, blister packages.
- Type 4 - LDPE Low-Density Polyethylene - Many plastic bags. Shrink wrap, garment bags.
- Type 5 - PP Polypropylene - Refrigerated containers, some bags, most bottle tops, some carpets, some food wrap.
- Type 6 - PS Polystyrene - Throwaway utensils, meat packing, protective packing.
- Type 7 - OTHER - Usually layered or mixed plastic. No recycling potential - must be landfilled.
- Types 1 and 2 are commonly recycled. Type 4 is less commonly recycled. The other types are generally not recycled.

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What is composting?

- The purposeful biodegradation of organic matter, such as yard and food waste and sewage sludge.
- Decomposition is performed by micro-organisms: basically bacteria and fungi.
- Transformation of raw materials
  - biologically
  - chemically
  - physically

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Anne Arundel County Recycling

Sort recyclables into 2 types of materials:

- Put all paper, plastic, metal and glass together in the same container(s).
- Yard waste should be bundled, bagged or put in containers marked with an "X"
- If you choose to use plastic bags, use a clear bag so that the haulers can see that there are recyclables inside
- There is no limit on the amount of recyclables you can put out for collection.
- You can use a cardboard box for recyclables, but it will be taken by the collectors for recycling.
- Keep your yard and street clean by securing papers and plastic bottles in their containers so they won't blow around before the recycling truck arrives.
- If paper gets wet, it's okay - We can still recycle it.

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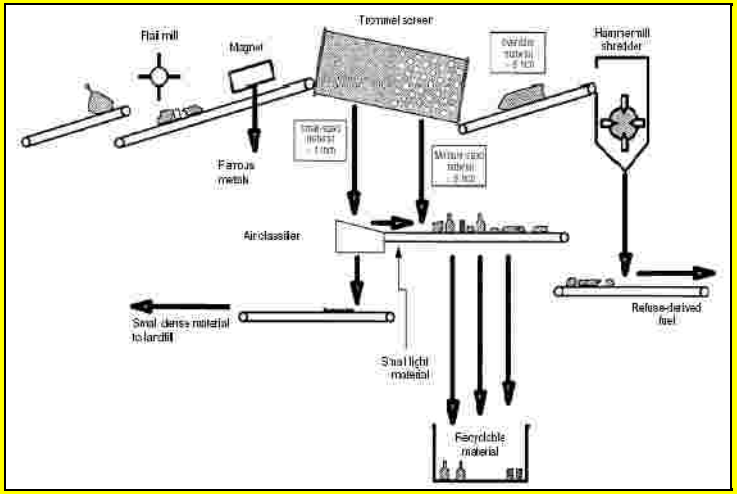

Process Design for a Typical RDF System

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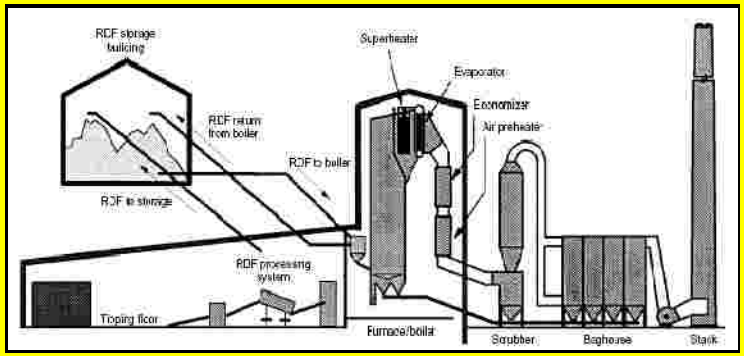
Typical Cross-Section of a Facility Burning RDF



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FEATURES OF RDF SYSTEMS

- Shredding
- Removal/Recovery of Metals, Glass
- Expensive to Buy, to Run
- Materials Sales Justify Costs
- Slightly Increased Heating Value
- FBF Application

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Susan Strasser – *WASTE AND WANT: A Social History of Trash (1999), Chapter 6*

- An old bucket will make three bayonets
- Two pounds of kitchen fats will make enough glycerine to fire five anti-tank shells
- Similarly with used toothpaste tubes, aluminum pots and pans, old lawnmowers, old newspapers, etc.
- Many of these materials were stockpiled and were never used during the war
- Scrap drives have had more use as propaganda than as a means of collecting strategic materials . . .
- These campaigns gave the homefront the impression that they were actively participating in the war effort

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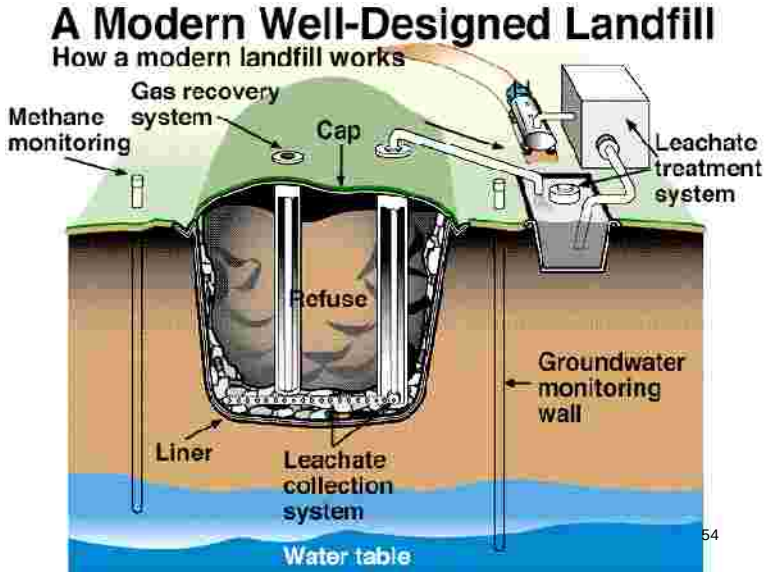

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MSW/GHG

- When MSW is landfilled it eventually decomposes to yield methane, carbon dioxide and other trace constituents
- If MSW is combusted, the only resultant GHG is carbon dioxide
- The methane (CH_4) generated by a landfill has a much greater GHG warming factor
- CH_4 has a CO_2 equivalence factor of 21
- This means that one pound (kg) of CH_4 is equivalent to 21 pounds (kg) of CO_2 in its effect on greenhouse warming

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The Six Greenhouse Gases of Concern

- Carbon dioxide (CO_2) - Cycles naturally between the atmosphere and living organisms. Plants and algae remove CO_2 from the atmosphere via photosynthesis, while animals release CO_2 via respiration. In addition it is released to the atmosphere by burning fossil fuels, driving automobiles, deforestation, etc.
- Methane (CH_4) - A natural byproduct of decomposition (landfills), and produced via agriculture and livestock.
- Nitrous oxide (N_2O) - Released naturally from soils and oceans, and is also generated from the use of nitrogen fertilizers.
- Perfluorocarbons (PFCs) - Used primarily in the production of aluminum.
- Hydrofluorocarbons (HFCs) - Most commonly used as a replacement for Chlorofluorocarbons (CFCs) which were used in cooling and refrigeration systems.
- Sulfur Hexafluoride (SF_6) - A highly potent, man-made greenhouse gas used in the electric industry for insulation.

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EU Landfill Directive

(http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31999L0031:EN:HTML)

- The Landfill Directive (1999/31/EC) is legislation issued by the European Union to be implemented by its member states.
- The Directive's overall aim is "to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, groundwater, soil and air, and on the global environment, including the greenhouse effect, as well as any resulting risk to human health, from the landfilling of waste, during the whole life-cycle of the landfill".

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Loudoun County MSW Disposal

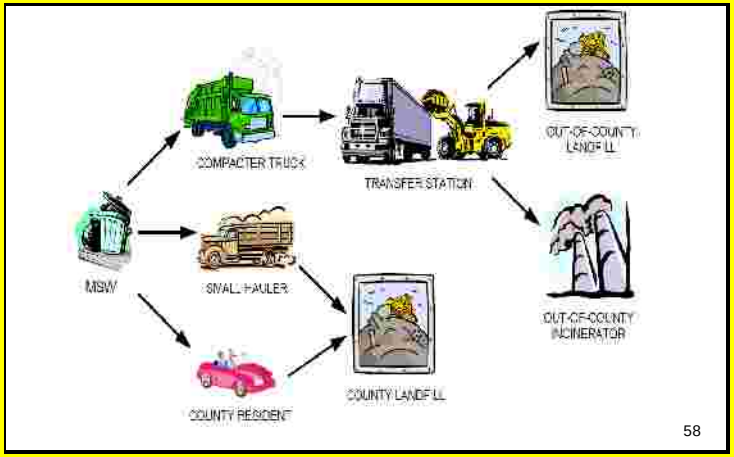

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Table 3-1: Regional Solid Waste Disposal Facilities

Facility Name and Location	Type of Facility	Type of Waste Accepted	Ownership
Atlantic Waste Disposal Sussex County Waverly, Virginia	Sanitary Landfill	MSW; C&D	Privately owned and operated
I-95 Energy/Resource Recovery Facility Fairfax County Lorton, Virginia	Incinerator	MSW	Privately owned and operated
Fauquier County Landfill Fauquier County Warrenton, Virginia	Sanitary Landfill	MSW; C&D	Owned and operated by Fauquier County
Lorton Landfill/Furnace Road Debris Landfill Fairfax County Lorton, Virginia	C&D Landfill	C&D	Privately owned and operated
King George Landfill King George County King George, Virginia	Sanitary Landfill	MSW; C&D	Owned by King George County; Privately operated
Middle Peninsula Landfill Gloucester County Gloucester, Virginia	Sanitary Landfill	MSW; C&D	Privately owned and operated
Potomac Landfill Prince William County Dumfries, Virginia	C&D Landfill	C&D	Privately owned and operated

Notes: C&D = construction and demolition; MSW = municipal solid waste

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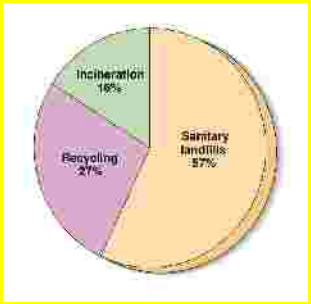
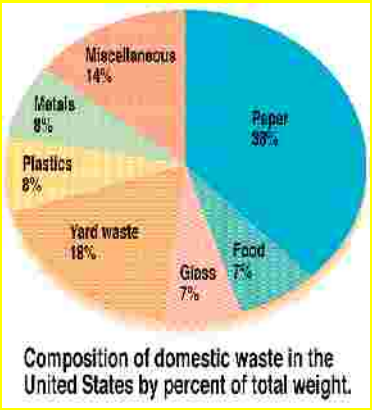
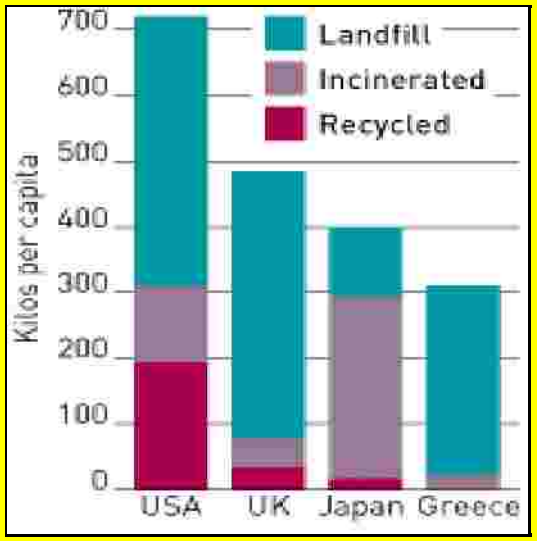
Waste Stream





Composition of domestic waste in the United States by percent of total weight.

60



Municipal Waste Stream in the USA

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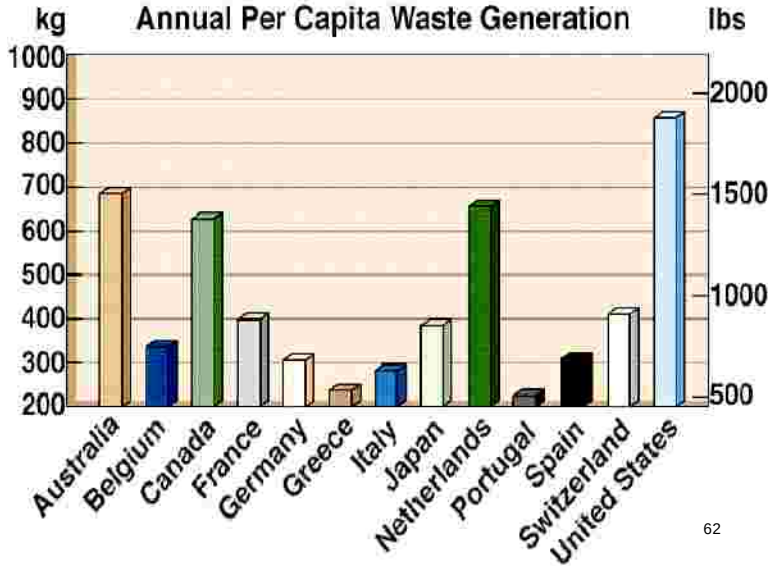

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EUPHANISMS

- Waste Reduction Plant
- Waste-to-Energy Facility
- Thermal Oxidation System
- Resource Recovery Facility
- Incinerator

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Capital Cost of a WTE Facility

- Depending on the location, size, and other factors, the capital costs range from $110,000 to $140,000 per daily ton of capacity in the USA.
- A plant that processes 1,000 tons of Municipal Solid Wastes (MSW) per day may cost between $110 and $140 million.

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Electric Power Generation

- A WTE plant processing typical MSW will generate a net of 400-500 kWh per ton for use by the local utility.
- At the price of $0.04 per kWh, the revenues per ton of MSW would be from $16 - $20.

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Operating Cost of a WTE Facility

- In addition to the capital cost, a 1000-ton per day plant would engage approximately 60 people.
- Other costs are services, materials and supplies and the cost of disposal of ash.

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WTE vs. Landfilling

- WTE plants conserve fossil fuels by generating electricity. One ton of MSW combusted reduces oil use by about 45 gallons, or coal use by about 0.28 tons.
- One ton of MSW combusted rather than landfilled reduces greenhouse gas emissions by 1.2 tons of carbon dioxide.
- WTE plants do not have the liquid discharges (leachate) that may be experienced in landfills, either now or in the distant future.
- WTE plants reduce the space required for landfills by about 90%.

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Greenhouse Gases (GHG)

- Naturally occurring gases
  - CO
  - Methane (CH_4)
- Anthropogenic gases
  - CO_2
  - nitrous oxide (N_2O_2)
  - chlorofluorocarbons (CFCs)

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Greenhouse Gas (GHG)

- When MSW is landfilled it eventually decomposes to yield methane, carbon dioxide and other trace constituents
- If MSW is combusted, the only resultant GHG is carbon dioxide
- The methane generated by a landfill has a much greater GHG warming factor
- CH_4 has a CO_2 equivalence factor of 21
- This means that one pound of CH_4 is equivalent to 21 pounds of CO_2 in its effect on greenhouse warming

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Greenhouse Gas (GHG)

- Waste-to-Energy provides a net GHG benefit
- Eliminates methane emissions from MSW
- Annually, Waste-to-Energy in the USA reduces GHG by 11 million metric tons carbon equivalent compared to landfilling
- Electricity generated from trash in the USA reduces 6 million metric tons carbon equivalent of GHG by displacing fossil fuels
- Fossil fuels contain more carbon than MSW

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Waste-to-Energy

- Waste-to-Energy is sustainable
- 100% Recycling/Reuse is not practical
- Waste fuel is about 75% biomass
- Contributes to healthy fuel diversity

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Fairfax County, Virginia, I-95 Energy Resource Recovery Facility

- Occupies 23 acres
- Four 750 ton-per-day Martin waterwall furnaces with a capacity to burn 3,000 TPD of MSW at a heating value of 5,500 BTU AR
- Processes one million tons of waste annually
- Waste is reduced 90% in volume/26% by weight
- Steam generators produce over 80 MW of electricity
- Uses 11 MW for its operations, 72 MW are sold to Dominion Virginia Power (enough electricity to power 75,000 homes) displacing 2 million barrels of fuel oil.
- Ferrous and non-ferrous metals are recovered after the combustion process

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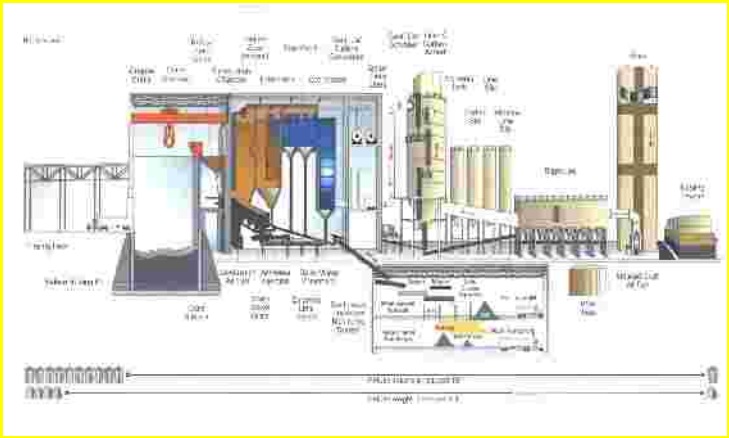

Fairfax County, Virginia
I-95 Energy Resource Recovery Facility

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Number of Combustion Units and Design tons/unit in the USA

	Mean # of Boilers	Mean tons/unit	Minimum tons/unit	Maximum tons/unit
All Facilities (89)	2.4	420	40	1,333
Mass Burn (64)	2.4	434	40	1,250
Modular (9)	2.4	103	45	150
RDF (16)	2.5	550	40	1,333

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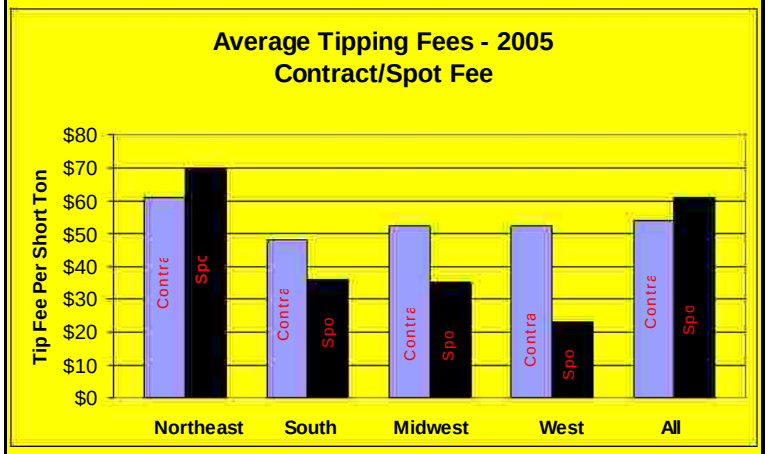

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Average Financials in the USA - 2004

Region	O&M	Debt Service	Energy Revenues	Fee per Ton
All Plants	$50.08	$34.45	$35.16	$49.37
Northeast	$52.21	$34.99	$40.00	$47.20
South	$39.85	$32.95	$20.79	$52.01
Midwest	$69.86	$47.35	$15.93	$101.28
West	$49.82	$32.84	$37.40	$45.26

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Ash Disposal

- Ash ranges from 15-25% by weight of MSW processed and from 5-15% of the volume of MSW processed.
- Ash disposal may cost $20-30 per ton.
- Ash can be treated to reduce leachability, for another 10-$15 per ton, and in a few cases has been marketed as road fill.
- Most ash is placed in a landfill or ashfill

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INCINERATION - ADVANTAGES

- Destroys organic content of waste
- Destroys microorganisms
- Reduces volume
- Reduces weight
- Immediate
- Single point source that is readily observed/monitored
- Effective control of air/odor/noise emissions
- Small footprint
- Can generate usable/exportable energy
- Residual/ash may have utility
- Can be automated

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INCINERATION - NEGATIVES

- Equipment intensive
- Skilled operators are required
- Residual (ash) may be hazardous
- Supplemental fuel is required, at least for start-up
- High capital cost

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ANY WASTE DISPOSAL FACILITY

- Complex permitting process
- Public perception
- Presence of waste haulers/trucks
- Fear of waste spillage/trucking accidents
- Fear of fires
- Fear of odors

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MSW Disposal - Composting

- Low cost plus semi-skilled labor
- Large area required
- Not applicable for all wastes (separation is required)
- Takes a long time
- Creates odors
- Markets must be found for product

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MSW Disposal - Landfill

- Low cost plus semi-skilled labor
- Large area required
- Accepts any acceptable waste without pre-treatment
- Is a permanent facility (although eventually can be closed and landscaped)
- Potential for leaking to groundwater
- Attracts birds, vermin
- Generates methane, a severe GHG
- Methane can be recovered and used for energy generation

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MSW Disposal - MRF

- Great idea!
- Medium cost of facility plus unskilled labor
- High cost for trucking pick-up
- Subject to market swings for recovered materials
- Not all MSW is recyclable (from 40 to 60% is not)
- Requires public cooperation

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MSW Disposal - Incineration

- High cost plus skilled labor
- Small area required
- Accepts any acceptable waste without pre-treatment (except white goods)
- Destruction is immediate
- Potential for materials recovery
- Potential for energy recovery, repalcing fossil fuel
- Residual (ash) may require special disposal
- Air emissions control is necessary
- Facility is stationary, readily subject to observation and regulation

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