NACT 285
Landfill Gas Control

1

Introductions

- Your Name ?
- Where You Work?
- How Long?
- What do you Do All Day?
- How much experience do you have with landfills?

2

2

Course Objectives

- Landfill Basics 101
- Air Pollutants
- Rules and Regulations
- Landfill Gas Collection
- Surface Monitoring
- Landfill Gas Controls
- Monitoring Equipment
- Inspection and Safety Tips

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Not So Long Ago

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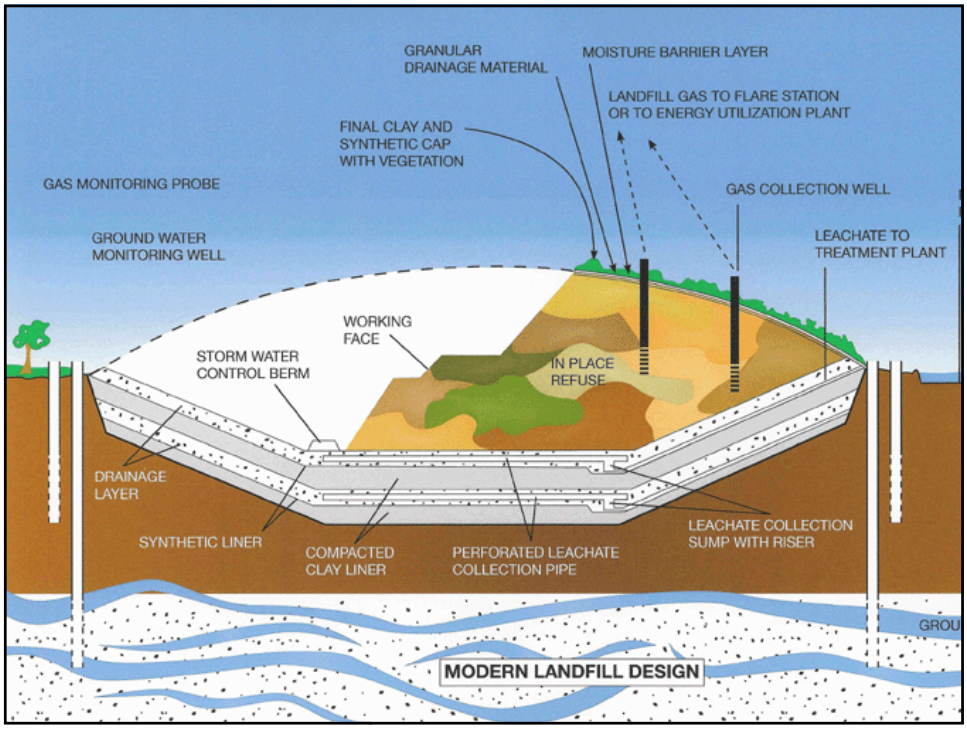
GRANULAR DRAINAGE MATERIAL
MOISTURE BARRIER LAYER
LANDFILL GAS TO FLARE STATION OR TO ENERGY UTILIZATION PLANT
FINAL CLAY AND SYNTHETIC CAP WITH VEGETATION
GAS MONITORING PROBE
GAS COLLECTION WELL
GROUND WATER MONITORING WELL
LEACHATE TO TREATMENT PLANT
WORKING FACE
STORM WATER CONTROL BERM
IN PLACE REFUSE
DRAINAGE LAYER
SYNTHETIC LINER
COMPACTED CLAY LINER
PERFORATED LEACHATE COLLECTION PIPE
LEACHATE COLLECTION SUMP WITH RISER
GROU
MODERN LANDFILL DESIGN

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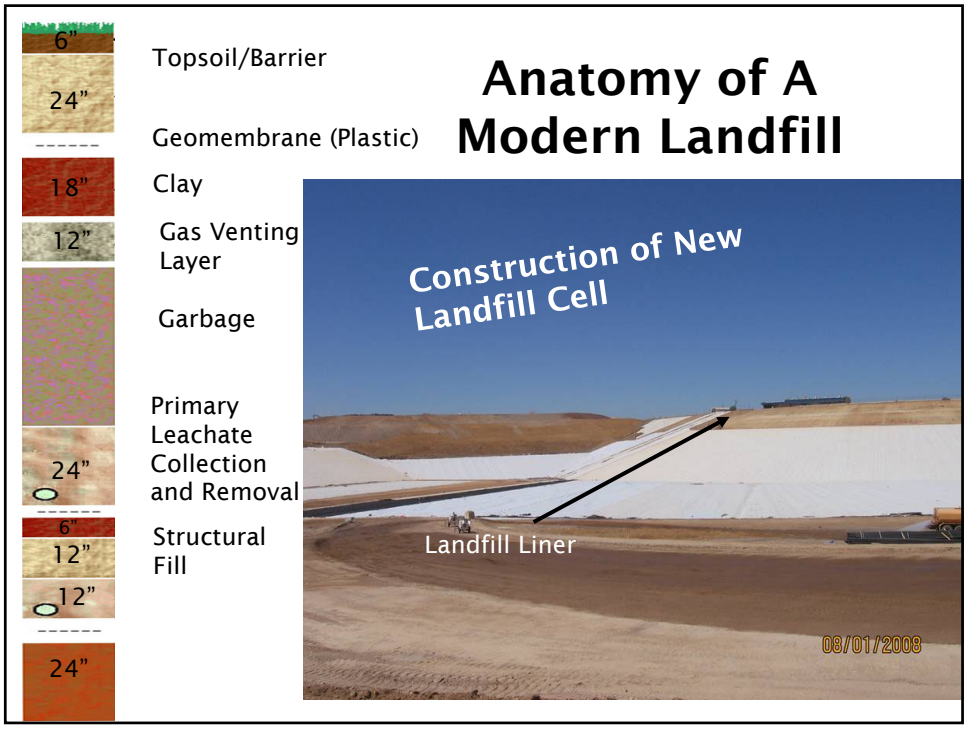
6"
24"
18"
12"
24"
6"
12"
12"
24"
Topsoil/Barrier
Geomembrane (Plastic)
Clay
Gas Venting Layer
Garbage
Primary Leachate Collection and Removal
Structural Fill
Anatomy of A Modern Landfill
Construction of New Landfill Cell
Landfill Liner
08/01/2008

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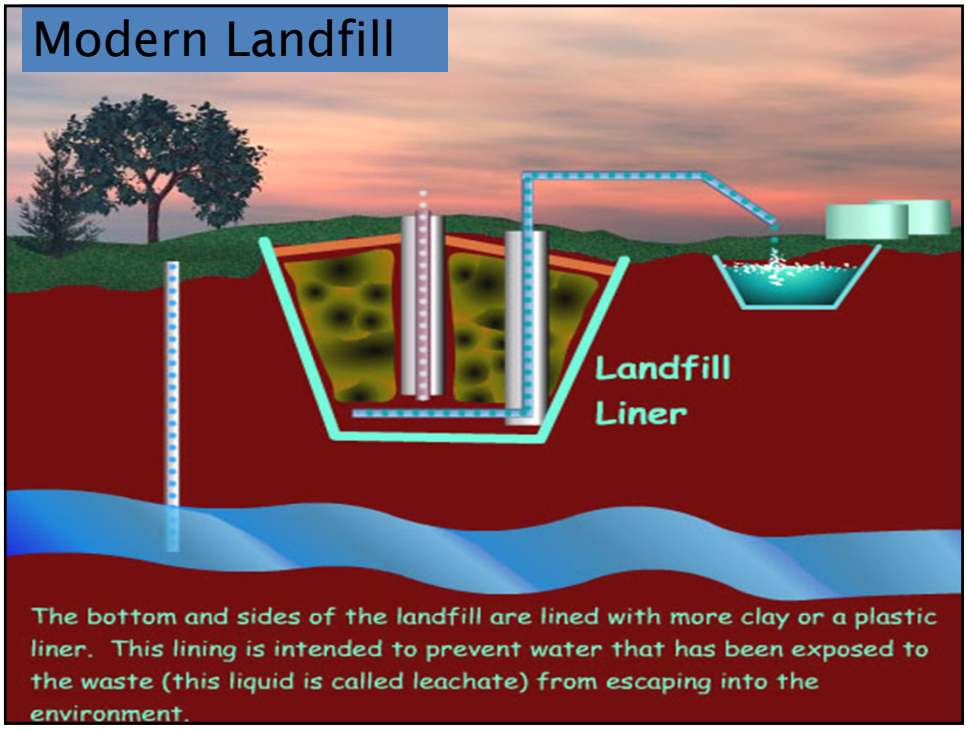

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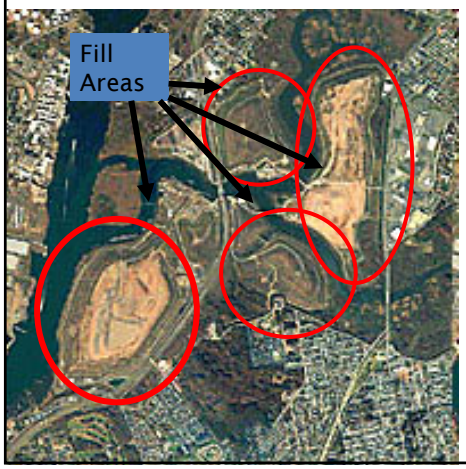
- New York City's garbage for over 50 years
- **Fresh Kills Landfill is the largest landfill in the world.**
- 2,200 acres, (over 50 football stadiums) received 14,000 tons per day.
- Shut down in 2001.



- It became the disposal site for the remains of the World Trade Center after the terrorist attack of September 11, 2001.

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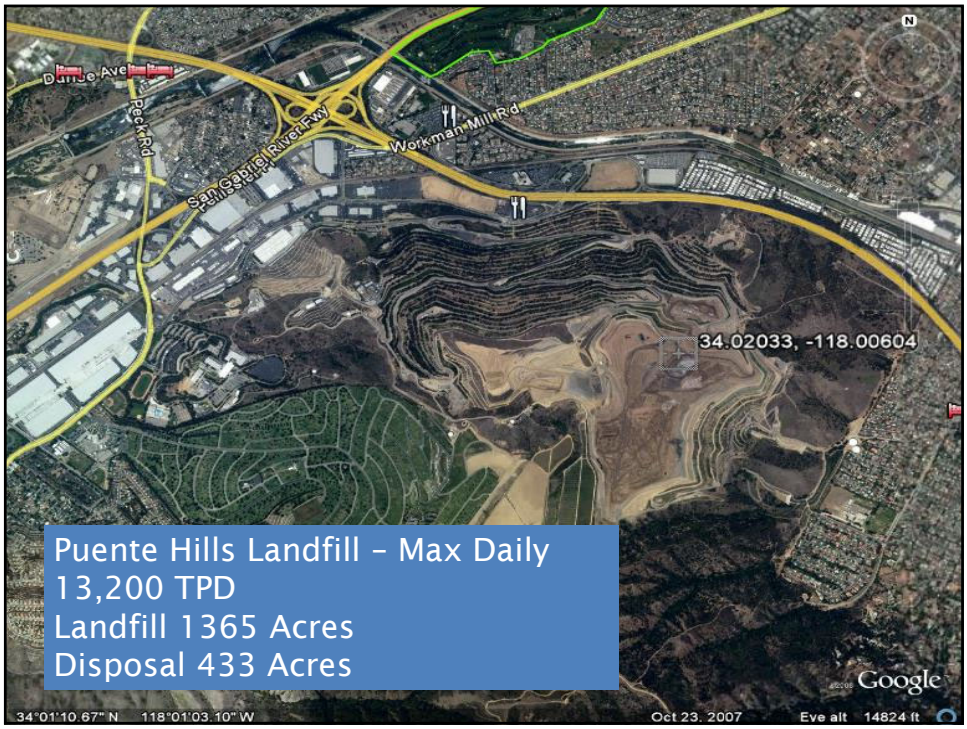
Puente Hills Landfill – Max Daily
13,200 TPD
Landfill 1365 Acres
Disposal 433 Acres
34.02033, -118.00604
Google
34°01'10.67" N 118°01'03.10" W
Oct 23, 2007
Eve alt 14824 ft

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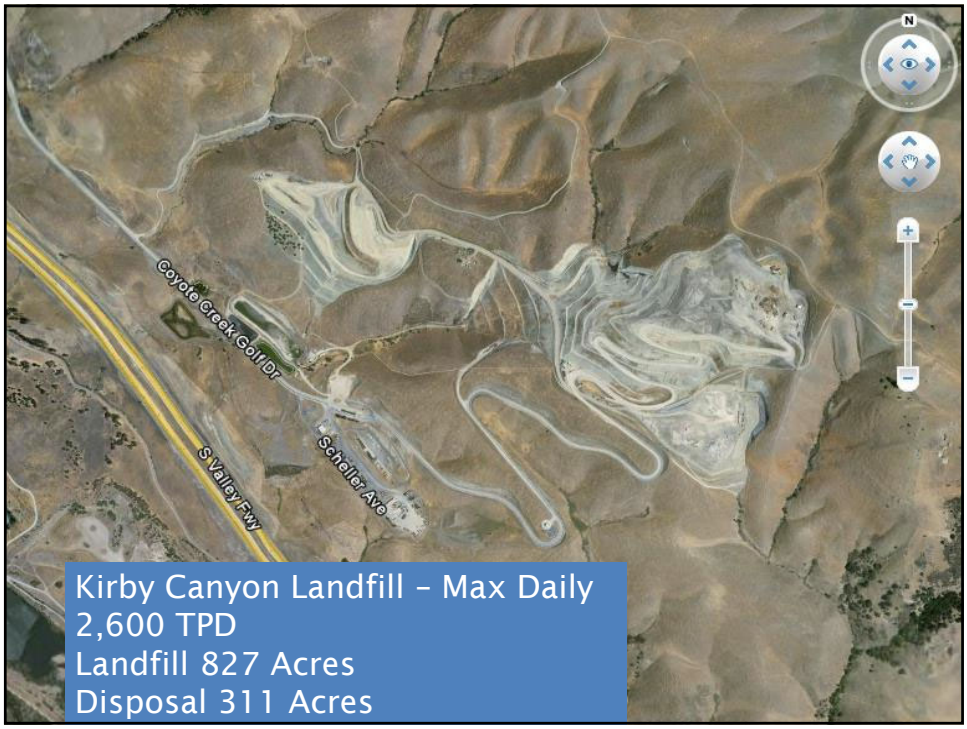
Coyote Creek Golf Dr
S Valley Fwy
Scheller Ave
Kirby Canyon Landfill – Max Daily
2,600 TPD
Landfill 827 Acres
Disposal 311 Acres

11


37.87417, -121.18828
S Austin Rd
Forward Landfill – Max Daily
8,668 TPD
Landfill 567 Acres
Disposal 354 Acres
Google
37°52'25.86" N 121°11'16.73" W
May 2002
Eye alt 3386 ft

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Daily and Alternative Daily Cover

- Dirt
- Tarps
- Construction and Demolition (C&D)
- Greenwaste
- Sludge
- Tire Shreds
- Foam/Cellophane

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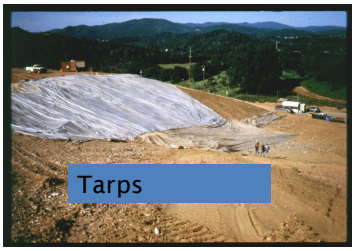
Most Landfills Operate 7 Days a Week, 365 Days a Year!

Active or Working Face

Walking Floor Trucks

15



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Treated Auto Shredder Fluff
Sludge and Construction and Demolition Waste

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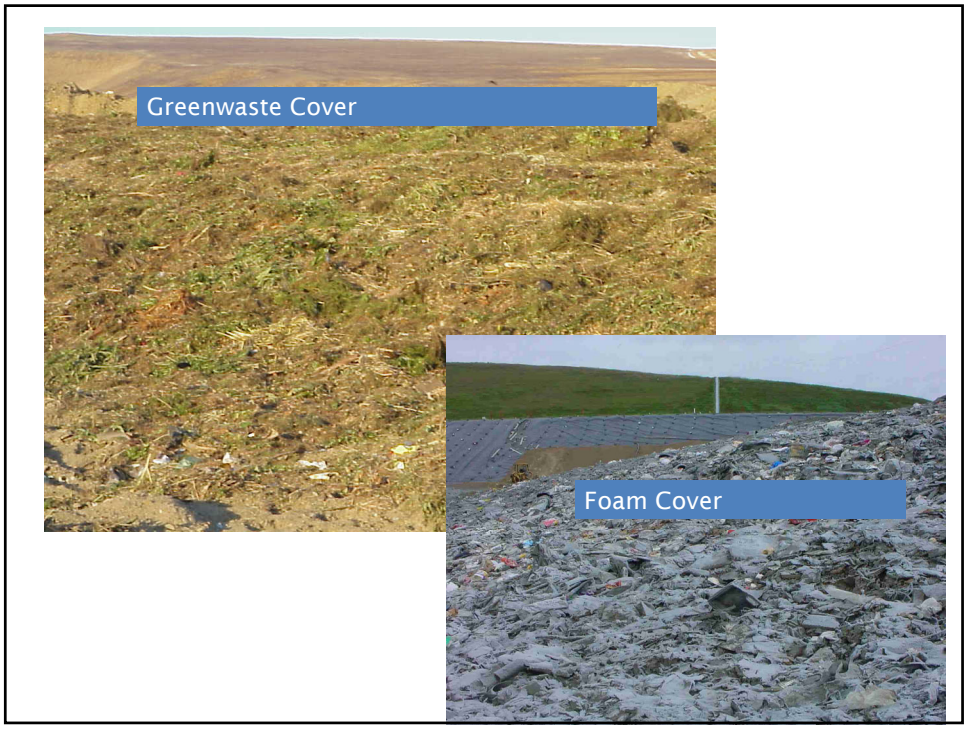
Greenwaste Cover
Foam Cover

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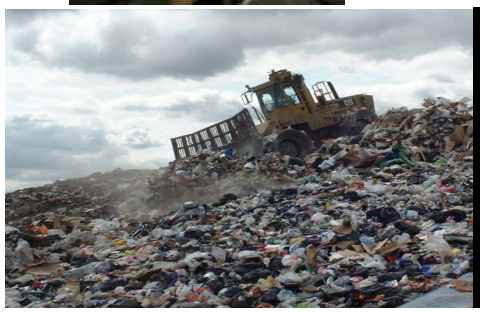
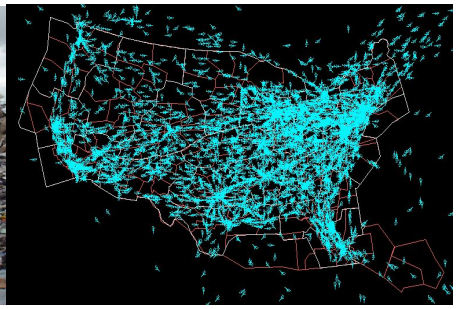
How Do Landfills Make $$

- Compaction
- Airspace





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Landfill Statistics

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Waste Generated, Diverted and Disposed

- 88.2 million tons generated
  - 42.0 tons disposed
  - 46.2 tons diverted
- 52% generated was diverted

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Path of Solid Waste

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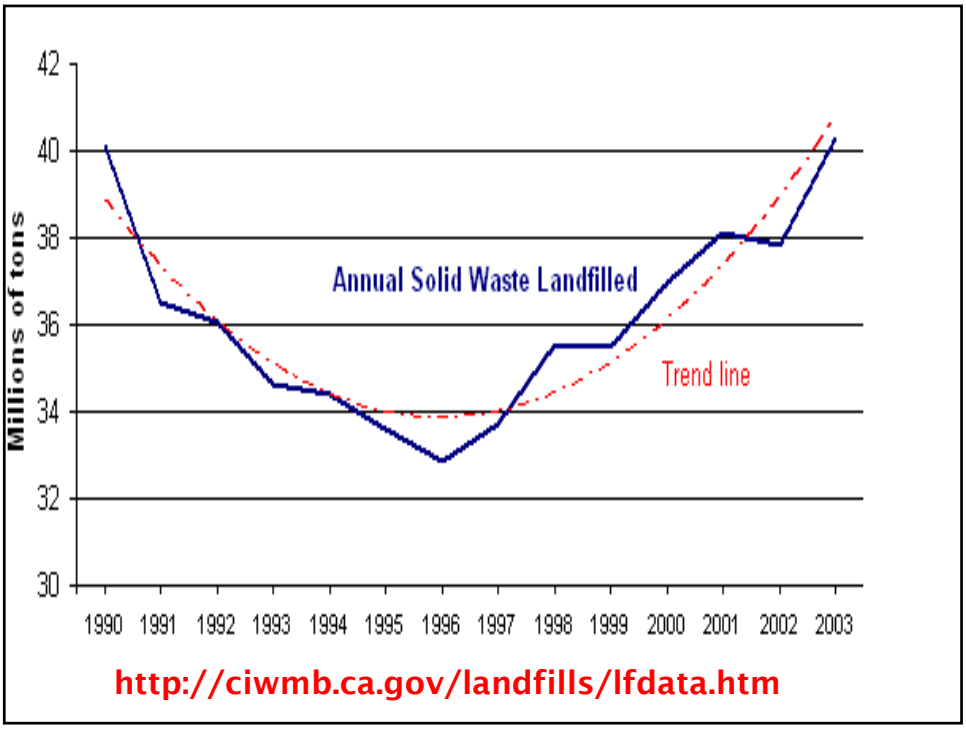

http://ciwmb.ca.gov/landfills/lfdata.htm

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Waste Disposal By Sector Household

Household

- 17,309,226 tons/yr
- 2.1lbs/person/day
- Leaves and Grass 10% of total

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Waste Disposal By Sector Business

Business

- 25,963,839 tons/yr
- 8.5 lbs/employee/day
- Paper 11% of total
- Retail Trade- Restaurants highest category

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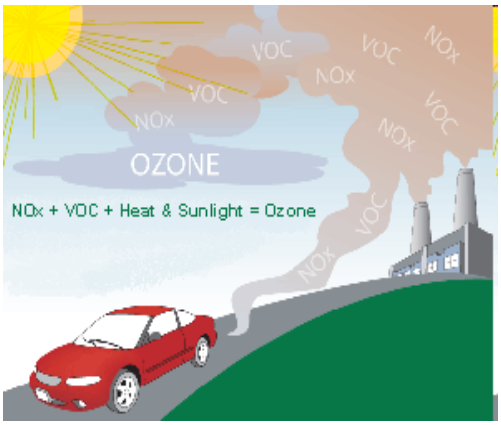
National Criteria Pollutants for Ambient Air

- Ozone
- Carbon Monoxide
- Nitrogen Dioxide
- Sulfur Dioxide
- Particulate Matter
- Lead



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Primary Air Pollutants at Landfills

- Methane (CH_4)
- Non-Methane Organic Compounds (NMOCs)
- Volatile Organics (VOCs)
- Toxics (HAPs)
- Odors
- Particulate Matter (PM)
- CO_2

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How Do We Capture Those Pollutants?

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We Capture the Landfill Gas!!!

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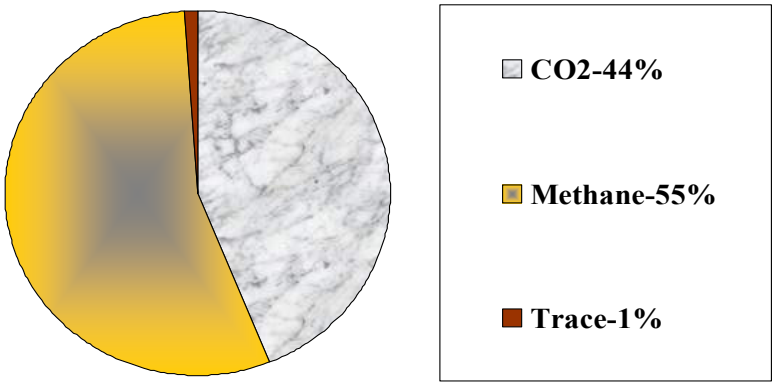
Components of Landfill Gas



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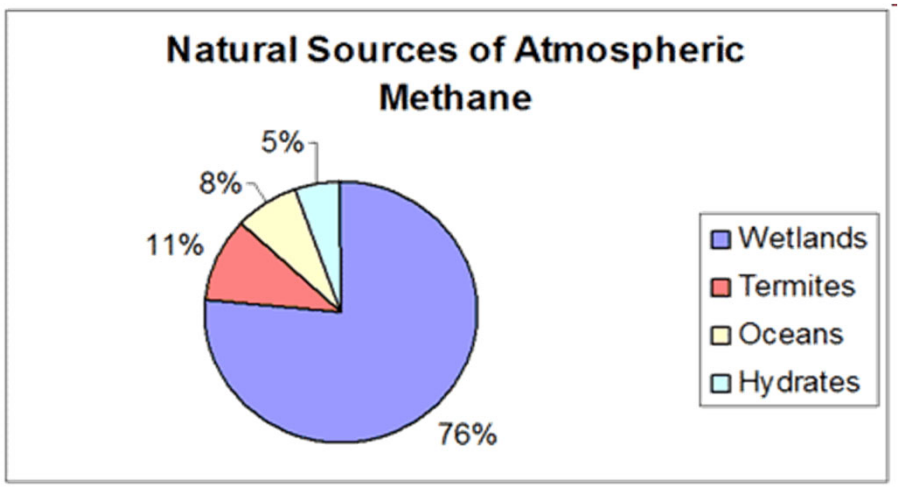

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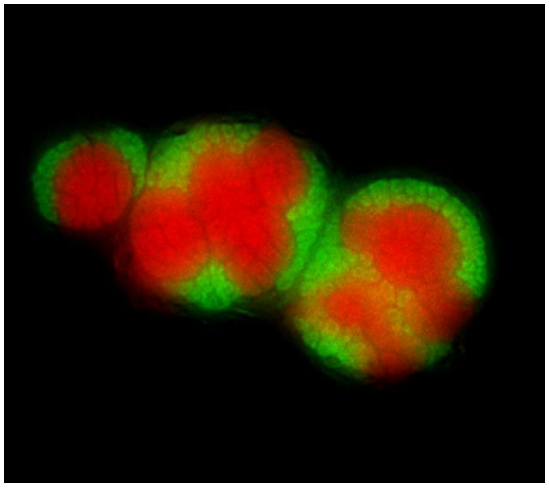
How is Methane Produced at Landfills?



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Properties of Methane

- Colorless
- Odorless and tasteless
- Lighter than air
- Relatively insoluble in water
- Highly explosive

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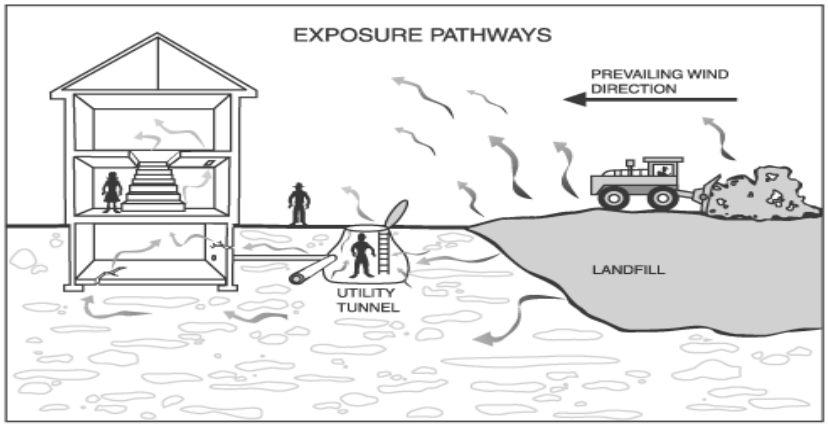
Exposure Pathways



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Methane (CH_4)

Explosive Hazard

Vegetation/Crop Damage

Economic

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Effects of Methane/ Landfill Gas

Well Drilling In Neighborhood

Dying Vegetation

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What Else is in Landfill Gas?

- Methane - 45 to 60 %
- CO2 - 40 to 60 %
- N2 - 2 to 5 %

Trace amounts:

- O2,
- ammonia,
- H2,
- sulfur compounds,
- solvents,
- alcohols
- hydrocarbons

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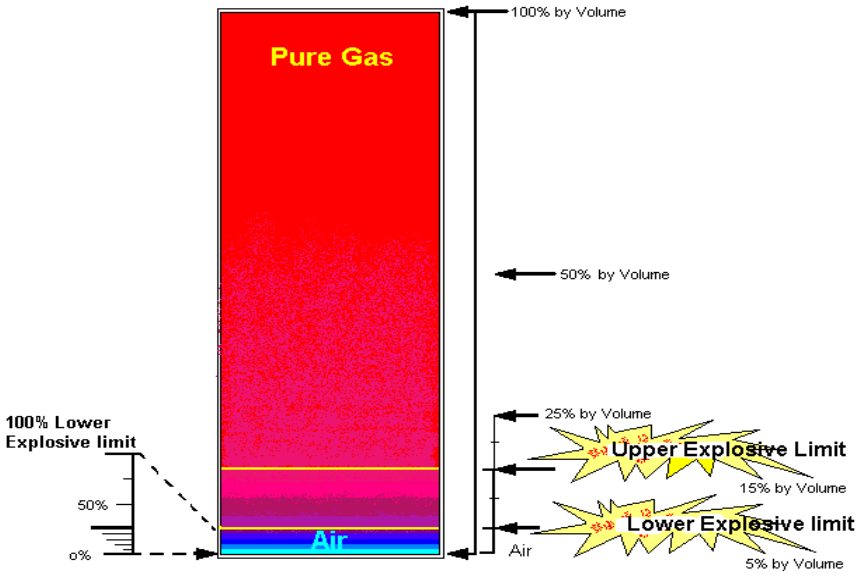
Upper and Lower Explosive Limits of Landfill Gas



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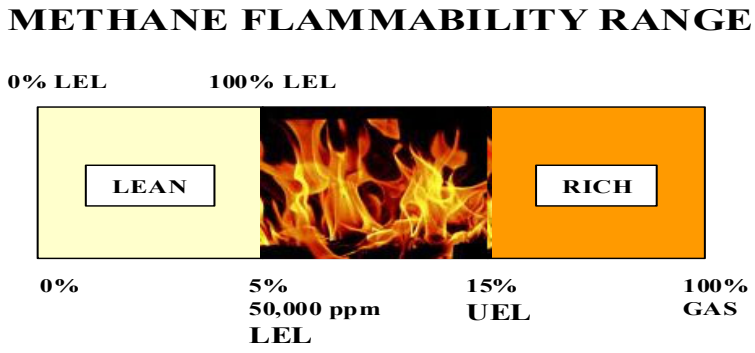
Methane Explosive Limits



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Methane General Statistics

Landfill methane:

- ✓40% of human-made emissions
- ✓21 times the global warming impact of CO_2
- ✓50 - 90% Recovery possible

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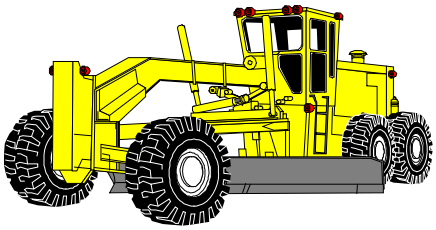
Landfill Gas Production Timeline

- ✓Aerobic -- Days or months
- ✓Anaerobic -- After all the O_2 is gone
- ✓Methanogenic -- 6 to 18 months
- ✓Steady State -- 50 Years post-closure



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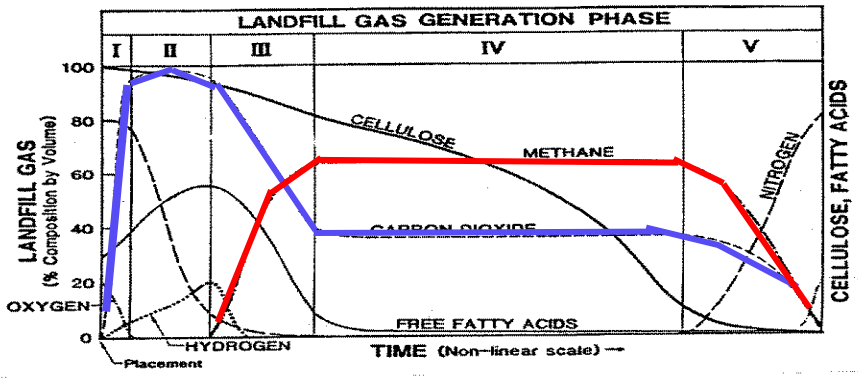
Overall Landfill Gas Timeline

TYPICAL LANDFILL GAS GENERATION PATTERN



SOURCE: Farquar and Rovers, 1973, as modified by Rees, 1980, and Augenstein & Pacey, 1991

Figure 2. Typical landfill gas generation pattern

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Volatile Organic Compounds Key Notes

- High Vapor Pressure
- Low Water Solubility
- Aids in Formation of Ozone

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Volatile Organic Compounds & Ozone

VOCs + NOx + Sunshine
=
Ozone

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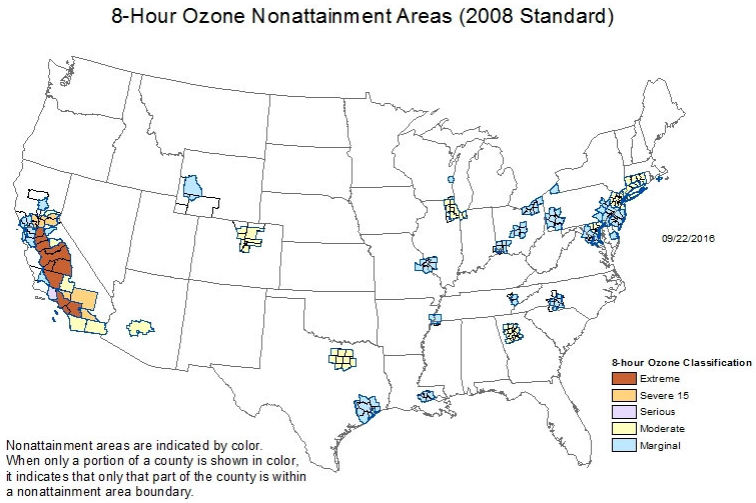
Do You Work in One of these Counties??



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VOC's in Landfill Gas

- ✓13.6 to 35.8 Tons of VOCs per million tons of refuse
- ✓Vegetation damage

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Toxic Compounds

- ✓Thousands of chemicals
- ✓Over 180 CAA Hazardous Air Pollutants (HAPs)

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LFG Concentration Statistics

Concentration - PPBV

Compound	Contamination Detected *	Median	Ave **	Max **
Perchloroethylene	241	38	1,100	45,000
Trichloroethylene	228	30	840	11,000
Methylene Chloride	197	37	4,800	160,000
1,1,1-Trichloroethane	180	2 U ***	650	96,000
Benzene	180	132 U	2,500	480,000
Vinyl Chloride	160	106 U	2,200	72,000
Ethylene Dichloride	65	5.1 U	600	98,000
Chloroform	58	0.8 U	360	11,000
Carbon Tetrachloride	31	1.2 U	11	2,100
Ethylene Dibromide	24	0.3 U	4	660

* = Landfill Gas Sampling was Conducted on 340 Landfills.

** = Medians and Maximums of the Average Sampling from Sites.

*** = U - Means Non-Detected; The number shown is detection limit.

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Odors (PUs)

- ✓Character
- ✓Intensity
- ✓Frequency
- ✓Duration
- ✓Individual Sensitivity

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Odor Issues

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Particulate Matter

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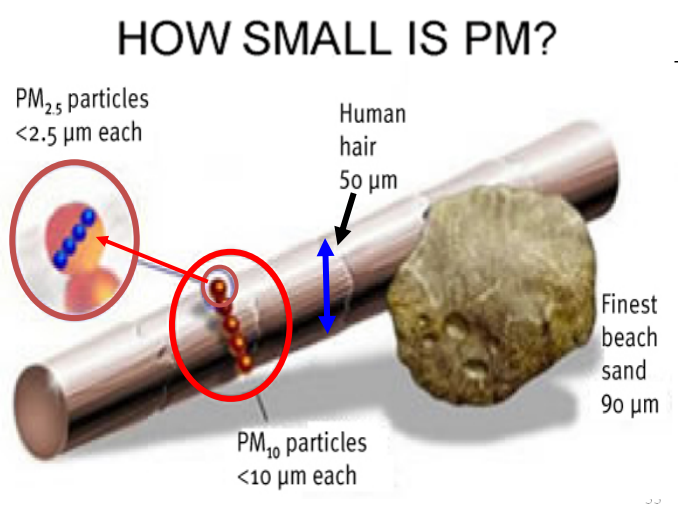
Particulate Matter (PM)

- ✓Dust
  - ✓Soil
  - ✓Waste



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Violation?

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Sources of Particulate Matter

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Sources of Particulate Matter

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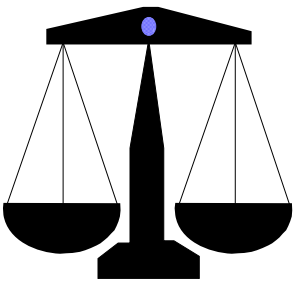
Legal Requirements

- ✓Federal
- ✓State
- ✓Local
  - ✓Agency Rules



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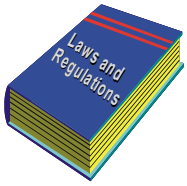
Regulation & Standards

Oversight for air quality issues is mostly at the Air Agency level, however there are Federal standards as well:

- ✓CAA Title V (40 CFR Parts 70 and 71)
- ✓NSPS (40 CFR 60 Subpart WWW and Cc)
- ✓NSPS (40 CFR 60 Subpart XXX and Cf)
- ✓NESHAPS (40 CFR 63 Subpart AAAA)



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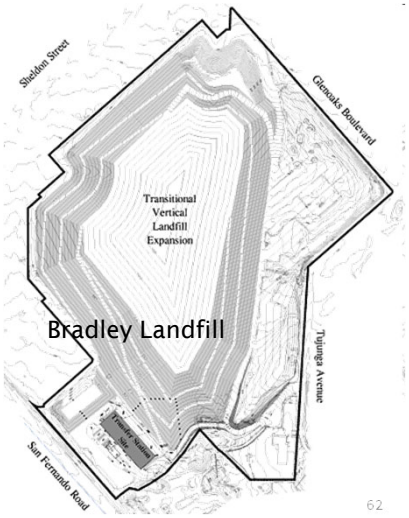
Clean Air Act - Title V

A landfill is subject to Title V if:

- **Design capacity is equal to or greater than 2.5 million Mg and 2.5 million m^3**
- **Its uncontrolled emissions are greater than the Major Source thresholds**



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40 CFR Part 60 Subpart WWW

Applies to MSW landfills constructed, modified or reconstructed after 05/30/1991

Landfills larger than 2.5 million Mg AND 2.5 million m^3 AND NMOC emissions greater than 50 Mg/yr must install landfill gas collection and control system

Regulation includes requirements for NMOC emission determination (3 tiers), collection system placement, lfg control systems, lfg treatment, wellhead operating standards, surface monitoring, removal of GCCS, corrective actions, design plans, and reporting.

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40 CFR Part 60 Subpart Cc

Requires States to enact regulations similar to WWW for MSW landfills constructed, modified or reconstructed on or before 05/30/1991 and accepted waste anytime on or after 11/08/87 or has additional capacity available for additional waste placement.

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40 CFR Part 63 Subpart AAAA

Developed as part of the federal urban air toxics strategy.

Applies to MSW landfills that accepted waste since 11/08/87 or have additional capacity and that are or at a major source of HAPS or is an area source but has a design capacity greater than 2.5 million megagrams and 2.5 m^3 and NMOC emissions equal to or greater than 50 megagrams per year.

Requires compliance with WWW or Cc plus semi annual reports and a SSM plan.

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40 CFR Part 60 Subpart XXX

Published in FR 08/29/16
Effective 10/28/16

Applies to MSW landfills constructed, modified or reconstructed <u>after</u> 7/17/14

Landfills larger than 2.5 million Mg AND 2.5 million m^3 AND NMOC emissions greater than 34 Mg/yr must install landfill gas collection and control system

Regulation includes requirements for NMOC emission determination (added Tier 4), exclusion of low lfg production areas, lfg treatment, wellhead operating standards, surface monitoring, removal of GCCS, corrective actions, design plans, SSM, and electronic reporting

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40 CFR Part 60 Subpart Cf

Published in FR 08/29/16
Effective 10/28/16

Applies to MSW landfills constructed, modified or reconstructed on or before 7/17/14 (think WWW)

States must submit plan by May 30, 2017

Landfills larger than 2.5 million Mg AND 2.5 million m^3 AND NMOC emissions greater than 34 Mg/yr AND accepted waste after 11/8/87 must install landfill gas collection and control system

Regulation requires states to include all of the requirements of XXX but adds in allowances for closed or closing landfills.

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EPA RECONSIDERATION.

EPA Administrator issued letter on 5/5/17 announcing stay of Subparts XXX and Cf for 90 days. Published in FR on 5/31/17. Stay effective 5/31/17 to 8/29/17.

Stay extended for Subpart XXX on 8/29/18.

Stay was lifted by EPA at some point

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EPA RECONSIDERATION.

On 8/26/2019, EPA finalized modifications to Subpart Cf to extend state plan submittal date to 8/29/19 and lengthen EPA review timelines.

On 3/9/20, EPA issued a notice of failure to submit state plans.

Federal plan proposed on 8/22/19

States must either submit plans or accept federal plan.

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New Source Review (NSR) Considerations

Potentially applicable to any ***new*** or ***modified*** source

- BACT - Best Available Control Technology, may be required on new or modified sources
  - Secondary Pollutants
  - Toxics (TBACT)
- LAER for nonattainment NSR

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New Source Review (NSR) Considerations Cont.

- May result in more stringent requirements than those in NSPS or Agency Rules
  - Permitting authority will study feasibility (Achieved-in-Practice, Technologically Available, Alternate Basic Equipment)
  - Cost effectiveness

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New Source Review (NSR) Considerations Cont.

- Public Notice – Projects with significant environmental impacts
  - Annual and daily emissions thresholds
  - Triggering offsets
  - Triggering Major Modification

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New Source Review (NSR) Considerations Cont.

- Offsets – Availability and cost concerns
- Monitoring, Recordkeeping, Reporting (MRR)
- Source Testing

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How are Emissions Assessed?

VOC Emissions:

✓Samples from well sites Mass-balance calculations (SOx and HCl)

✓ LandGEM - AP-42 based methodology (Section2.4.4.1)

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Emissions Assessment Cont.

PM10 Emissions:

AP-42 Drop Equation (Section 13.2.4.3) Maximum limits on earth moved for daily cover

AP-42 on road and off road vehicle emissions

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LANDGEM Tool for Calculating Annual Emissions Version 3.02

http://www.epa.gov/ttn/catc/products.html#/software

National Technical Information Services
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650

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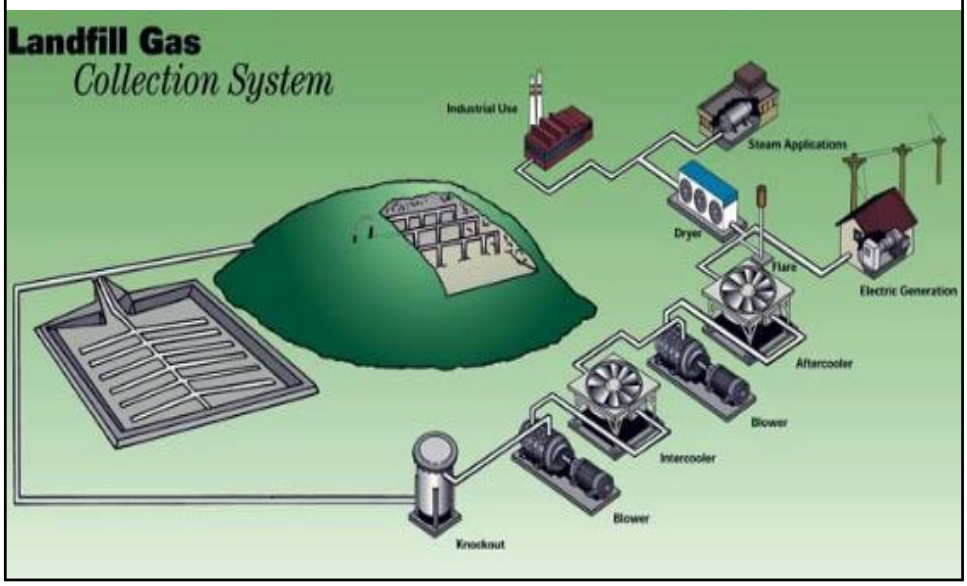
Gas Collection



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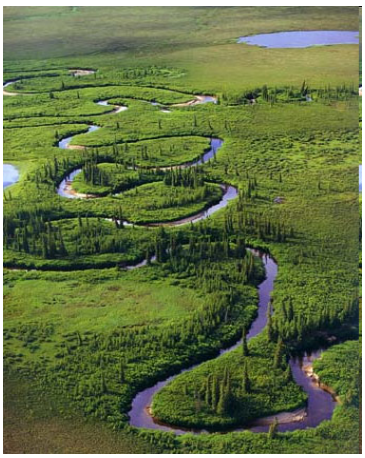
LFG - Movement



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Monitoring and Movement

- ✓Gas follows the path of least resistance
- ✓Moves over, under, and around obstacles in its path
- ✓Dilutes as it travels away from source
- ✓Pressure gradients

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LFG – Monitoring Systems

✓Subsurface perimeter

✓Surface emissions

✓Enclosed space (buildings)

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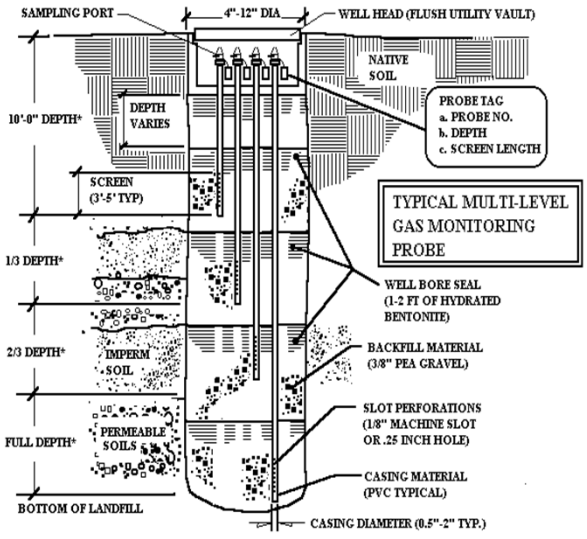
Typical Monitoring Well Diagram



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Typical Monitoring Wells

Installation of a Three Tier Probe

Monitoring Probe with Cap

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Well Installation

Drilling for a New Monitoring Well

Well Casings

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Gas Collection & Control System Design Criteria

- ✓Expected ambient and gas temperature
- ✓Above/below ground header system
- ✓Future requirements to bury system
- ✓Seasonal conditions to bury system
- ✓Existing odor problems

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Gas Collection & Control System Design Criteria

- ✓Landfill location and type
- ✓Geometry, geography, topography, hydrology, geology
- ✓Existing landfill design and history
- ✓Refuse depth to surroundings
- ✓Existing permit conditions

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Gas Collection & Control System Design Criteria

- ✓ Tonnage chronology
- ✓ Landfill surface cover material (past and present)
- ✓ Placement and compaction of refuse
- ✓ Leachate presence and control
- ✓ Groundwater monitoring network

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Gas Collection & Control System Design Criteria

- ✓ Utility access
- ✓ Sewer, electrical, water, cable, etc
- ✓ Condensate drainage
- ✓ Slopes, piping, and grade

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Gas Collection & Control System Design Criteria

Other Considerations?

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Various Collection Systems

- ✓Horizontal trench
- ✓Passive collection
- ✓Active vertical well

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Active Control System

- ✓Perimeter air injection trenches
- ✓Perimeter extraction trenches
- ✓Perimeter extraction wells
- ✓Perimeter air injection wells

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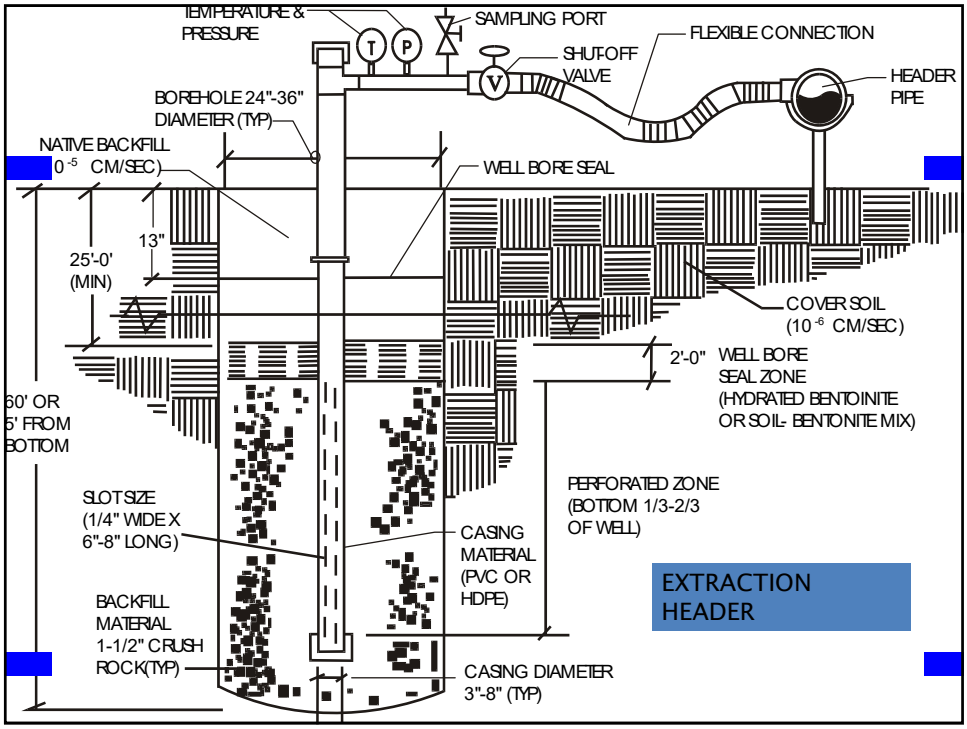

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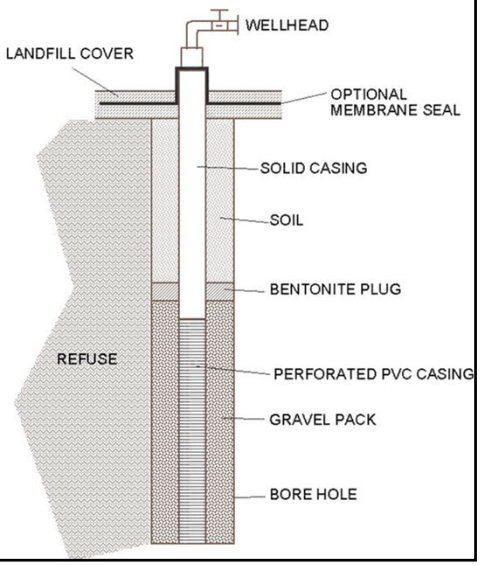
Extraction Well



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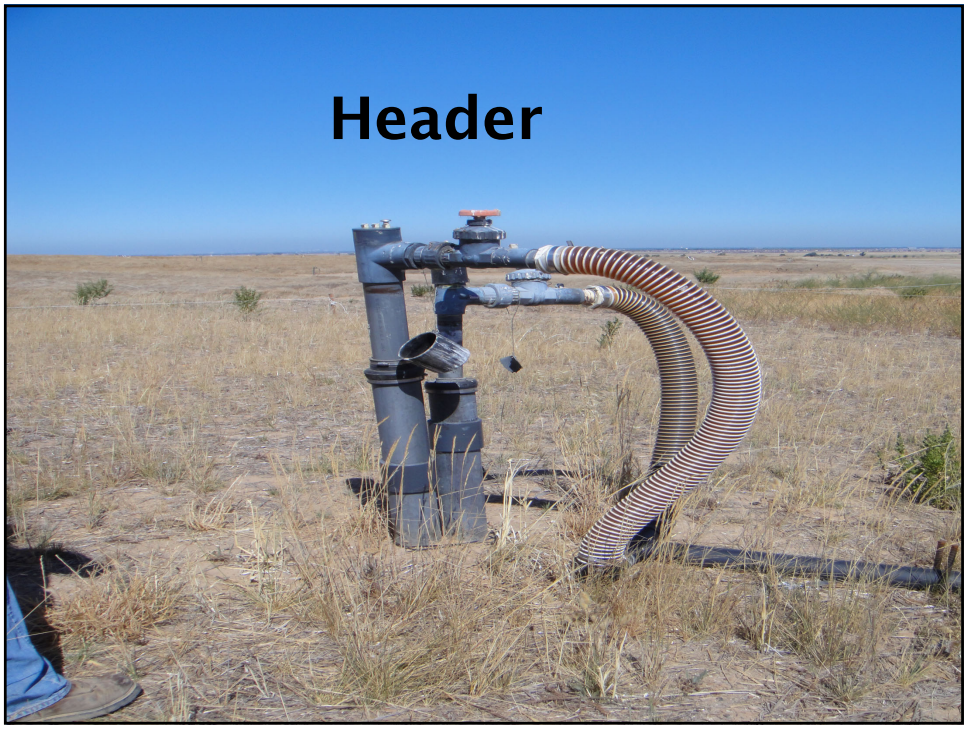
Header

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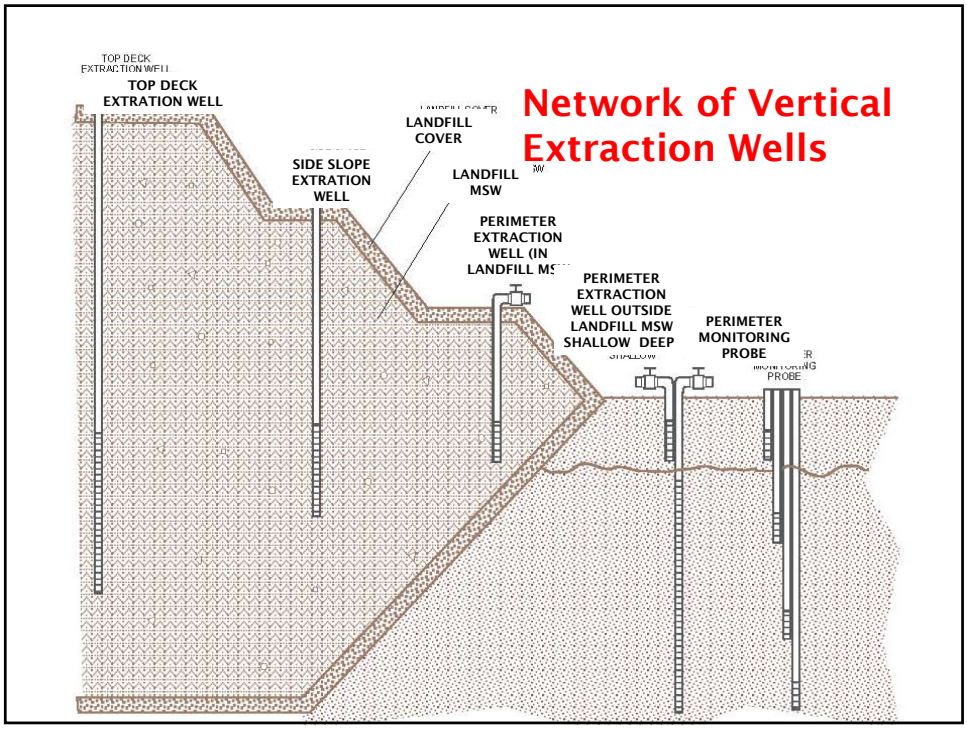
Network of Vertical Extraction Wells
TOP DECK EXTRATION WELL
SIDE SLOPE EXTRATION WELL
LANDFILL COVER
LANDFILL MSW
PERIMETER EXTRACTION WELL (IN LANDFILL MS
PERIMETER EXTRACTION WELL OUTSIDE LANDFILL MSW SHALLOW DEEP
PERIMETER MONITORING PROBE

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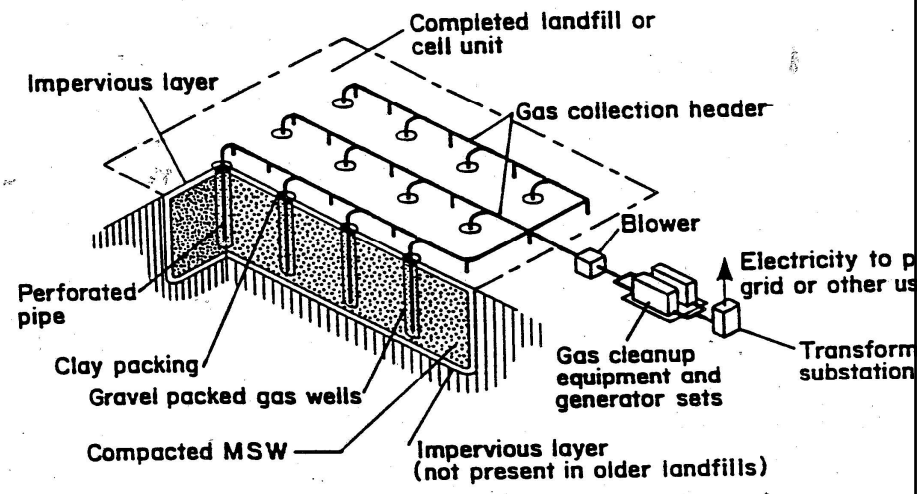
Active Vertical Well System



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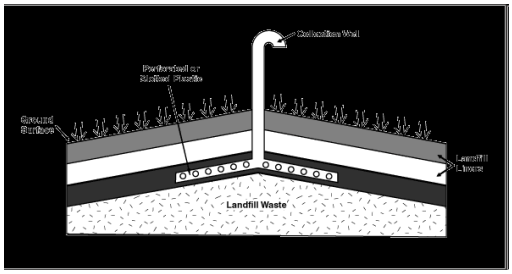
Passive Control System



✓Relief vents

✓Perimeter barrier trenches

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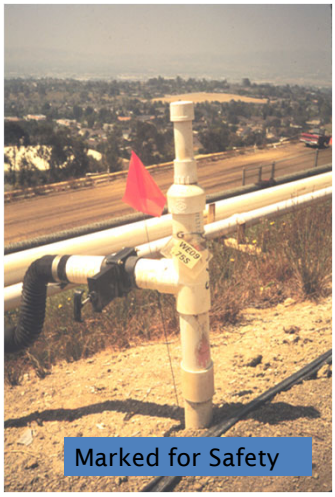

Marked for Safety

Gas Manifold Around Heavy Equipment

Erosion Issues at Landfills

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Landfill Gas Manifolds Everywhere

Gas Sample with Summa Canisters

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Control Measures

Flares

Energy production

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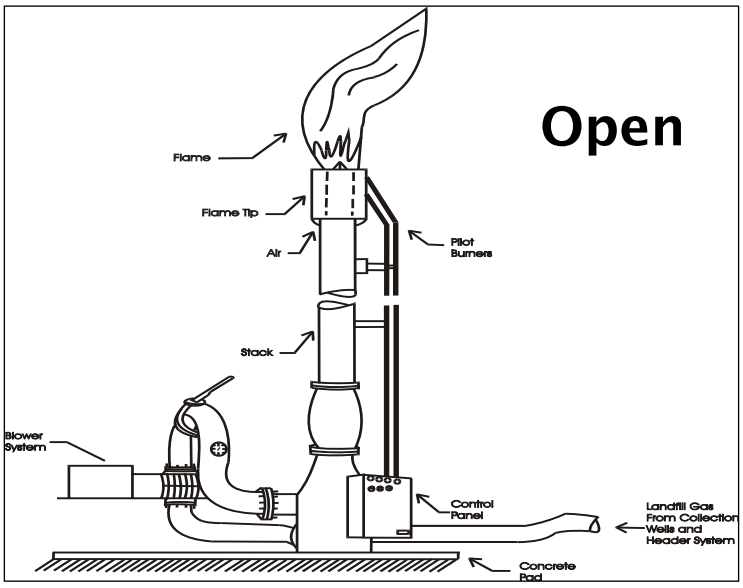
Flare Types



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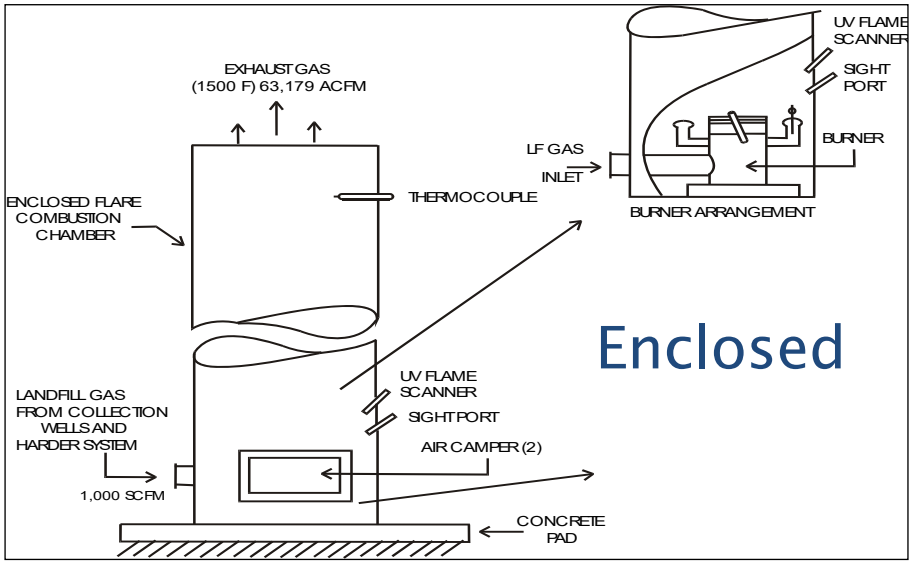
Flare Types



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Flare Types Continued

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Blowers

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Energy Production

- ✓ Internal combustion engine
- ✓ Turbines
- ✓ Boilers
- ✓ Pipeline
- ✓ Fuel Cell

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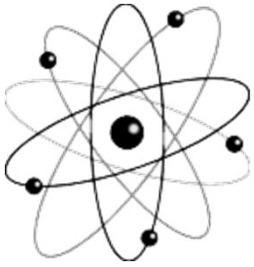
Methane - Energy Content



BTU / ft^3

- CH_4 maximum – 1,013
- Pipeline - 900
- LFG Avg. – 300-500

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Electricity Generation Technology

	IC Engines	Turbines	Boilers
Advantages	* Low cost * High efficiency * Common technology	* Corrosion resistant * Low O&M costs * Small physical size * Low Nox emissions	* Corrosion resistant * Can handle gas Composition variations * Low NOx emissions
Disadvantages	* Problems due to PM buildup * Corrosion of engine Parts and catalysts * High Nox emissions	* Inefficient at partial load * High parasitic loads Due to high compression req. * High capital costs	* Innefficient at smaller sizes * Requires large amounts of clean water

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Secondary Air Pollutants

NOx

Toxics

SOx

PM

CO

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Methane Monitoring Instruments

- ✓Infrared detector (GEM 2000)
- ✓Catalytic oxidation detector (%LEL)
- ✓Thermal conductivity meter (% Gas)
- ✓Flame Ionization Detector (FID)
- ✓Photo Ionization Detector (PID)

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Monitoring Equipment

Photoionization Detector

Foxboro
Flame Ionization Detector
(0-1000 PPM)
$4,000

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GEM 2000 Infrared and CGI Detection

GMI CGI Thermal Conductive (% Gas)
Combustible Gas Indicator (% LEL)
with CO and O2 Sensors

FID/PID

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Photoionzation

- Advantages
  - Good with low level detection
  - Is not temperature dependent
- Disadvantages
  - Not good in a high methane concentration environment
  - Must have proper eV lamp (13.0)
  - Wears out faster
  - Sensitive to humidity/dust
  - Electromagnetic interference

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Combustible Gas Indicator

Advantages

- Small and portable
- Internal battery
- Thermal mode for high or low O_2
- Easy to use
- "Safe"

Disadvantages

- Temperature dependant
- Calibration gas impacts results
- Catalytic mode problem with O_2
- Leaded gas, halogens, sulfur, silicon can harm filament
- CO_2 fouls O_2 cell

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Flame Ionization Detectors

Advantages

- Fast response
- Sensitivity (1 - 100,000 ppm)
- Accuracy
- Variety of probes
- Reads LEL in low O_2 environment

Disadvantages

- Short battery life
- False positives
- Few portable models
- Calibration gas impacts
- EXPENSIVE!

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Total Vapor Analyzer Combo FID/PID

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What Do We Do with These Instruments?

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Monitoring A Perimeter Well

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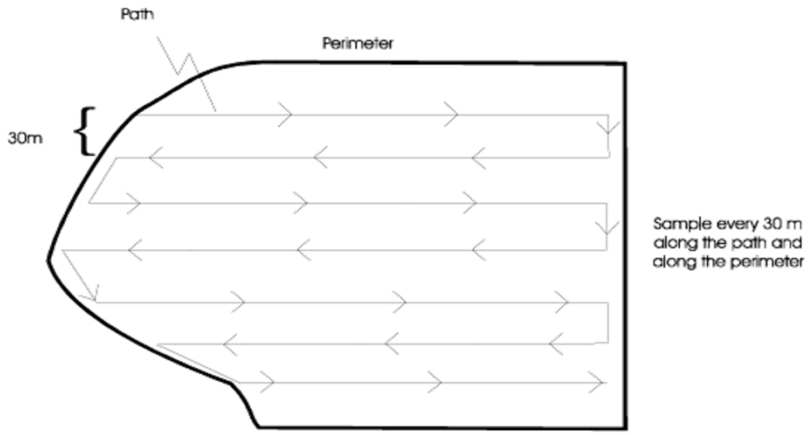
Traverse for Monitoring Methane Concentrations



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Inspections

- Pre-inspection
  - ✓File review
  - ✓Rule review
  - ✓Inspection forms
  - ✓Equipment check
- Inspection
  - ✓Pre-entry and entry
  - ✓Pre-inspection meeting
  - ✓Facility procedures
- Post inspection

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Safety

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- ✓Hard hat
- ✓Eye protection
- ✓Hearing protection
- ✓Safety boots
- ✓Monitoring device
- ✓Safety vest

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Pre-Inspection General Guidelines

- ✓Regulation review
- ✓Equipment check
- ✓Pre-entry and entry
- ✓Pre-inspection meeting
- ✓Permit check

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Pre-Inspection Meeting

- ✓Facility name and ownership
- ✓Address w/ city and zip
- ✓Contact name and title
- ✓Phone number w/area code
- ✓Production rate
- ✓Operating schedule
- ✓Operation season
- ✓Date of last source test
- ✓Fuel usage & sulfur content

What's new?

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Inspection Report

- ✓Description of the facility and process(es)
- ✓Flowchart with equipment location and emission points
- ✓Process diagram (materials handled, flow rates, temperature, pressure)
- ✓Statement as to compliance/ non-compliance
- ✓Recommendations

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Usage Records

- ✓Review usage records
- ✓Alternative compliance plan records
- ✓Obtain necessary copies

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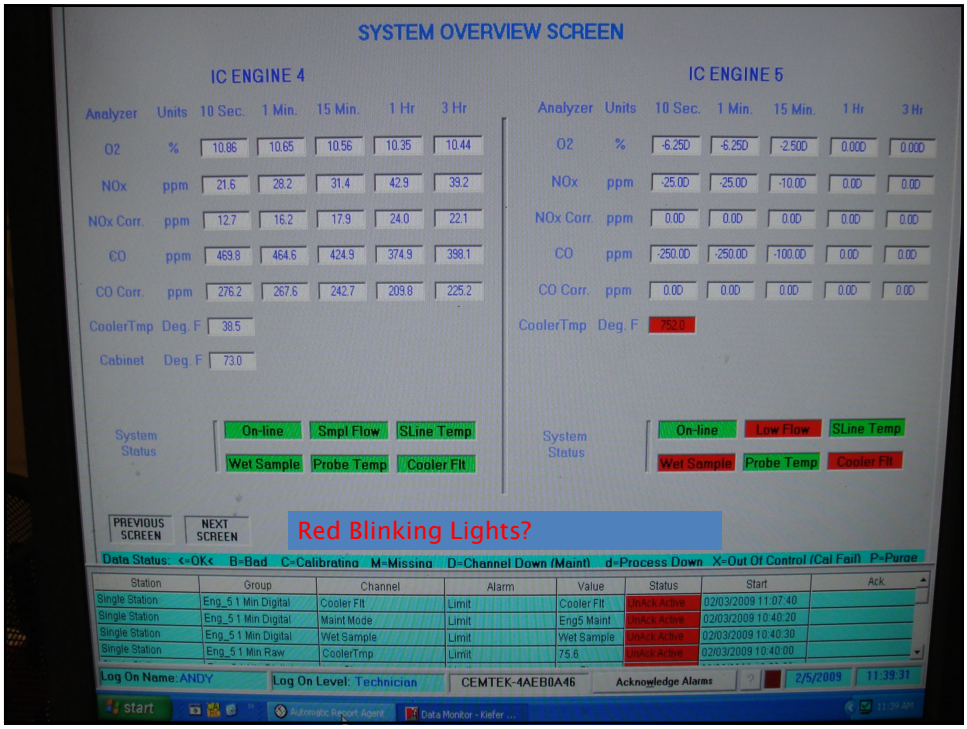
SYSTEM OVERVIEW SCREEN
IC ENGINE 4
IC ENGINE 5
Red Blinking Lights?

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Control Device

✓Are there any visible leaks?

✓Is it functioning?

✓Can the device handle the job?

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Subsystem

What is the ultimate fate of captured or concentrated emissions?

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The End!!

Time for the Field Trip

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