CAFTA-DR Environmental Cooperation Program

Oceans and International Environmental and Scientific Affairs
U.S. DEPARTMENT of STATE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

BATTELLE

LANDFILL CONSTRUCTION AND OPERATIONS WORKSHOP

LANDFILL CONSTRUCTION AND OPERATIONS WORKSHOP

No.	Module	Presenter
1	Importance of Proper Landfill Management	P. Ruesch
2	Landfill Construction Part I	M. Elizondo
3	Landfill Construction Part II	J. Davila
4	Landfill Operations Part I	M. Elizondo
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6	LFG Basics and GCCS	J. Davila
7	LFG Utilization Technologies	J. Davila
8	Open Dump Closure	P. Ruesch

Module No. 6
LFG Basics & GCCS

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Independent Consultant

Content

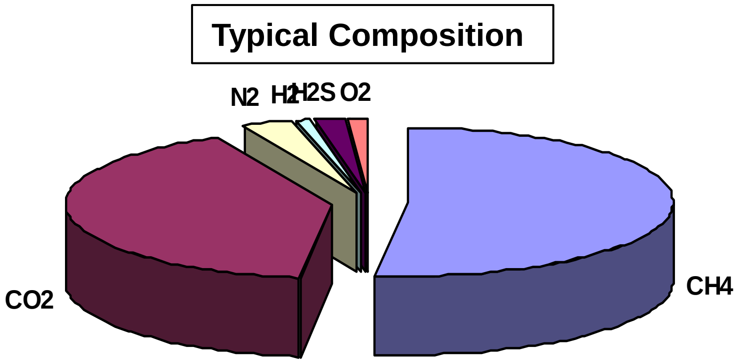
- Landfill Gas (LFG) basics
- Gas Control and Collection Systems (GCCS)

LFG

- Produced by degradation of organic waste
- Amount & composition depends on waste characterization
- Increase in organic matter = increase in LFG generation
- LFG generation ends when degradation ends
- Potential energy source

Typical Composition

- Methane (CH_4)
  - 50% - 60%
- Carbon Dioxide (CO_2)
  - 40% - 50%
- Non-Methane Organic Compounds (NMOCs)
  - Traces
- Heat value
  - 500 Btu/scf = 4166 kCal/Nm³
- Moisture content
  - Saturated



Methane (CH_4)

- Colorless
- Odorless & tasteless
- Lighter than air
- Relatively insoluble in water
- Highly explosive
  - LEL = 5% in air
  - UEL = 15% in air

Methane (CH_4)

Why is Methane a greenhouse gas (GHG)?

- Absorbs terrestrial infrared radiation (heat) that would otherwise escape back to space
- Methane as GHG is > 20x more potent by weight than CO_2
- More abundant in atmosphere now than in past 400,000 yrs and 150% higher than in 1750

LFG Generation Estimation

EPA's LANDGEM Model

LFG Generation = 2 k L0 M e^{-kt}

where:

k = Methane generation rate (1/yr)

L_0 = Methane generation potential (m^3/ton)

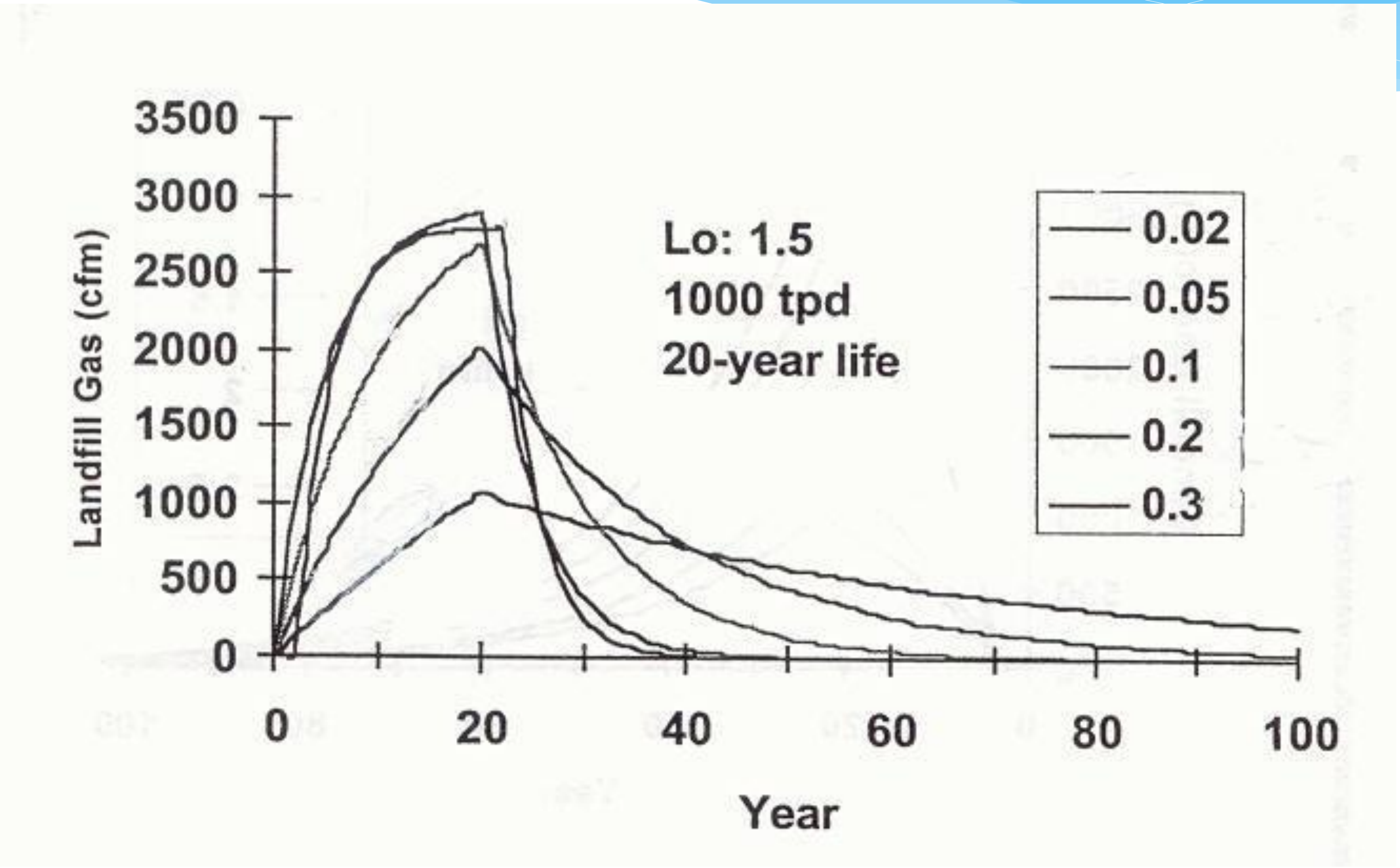
M = Amount of waste disposed per year (tons)

t = number of years (age) of waste (years)

Value of 'k'

- “k” = Methane generation rate (units = 1/yr)
  - Waste fraction that decomposes and generates methane in 1 year
- Value of k is a function of moisture, nutrients, pH and temperature
- Typical range = 0.01 - 0.10

Value of 'k'



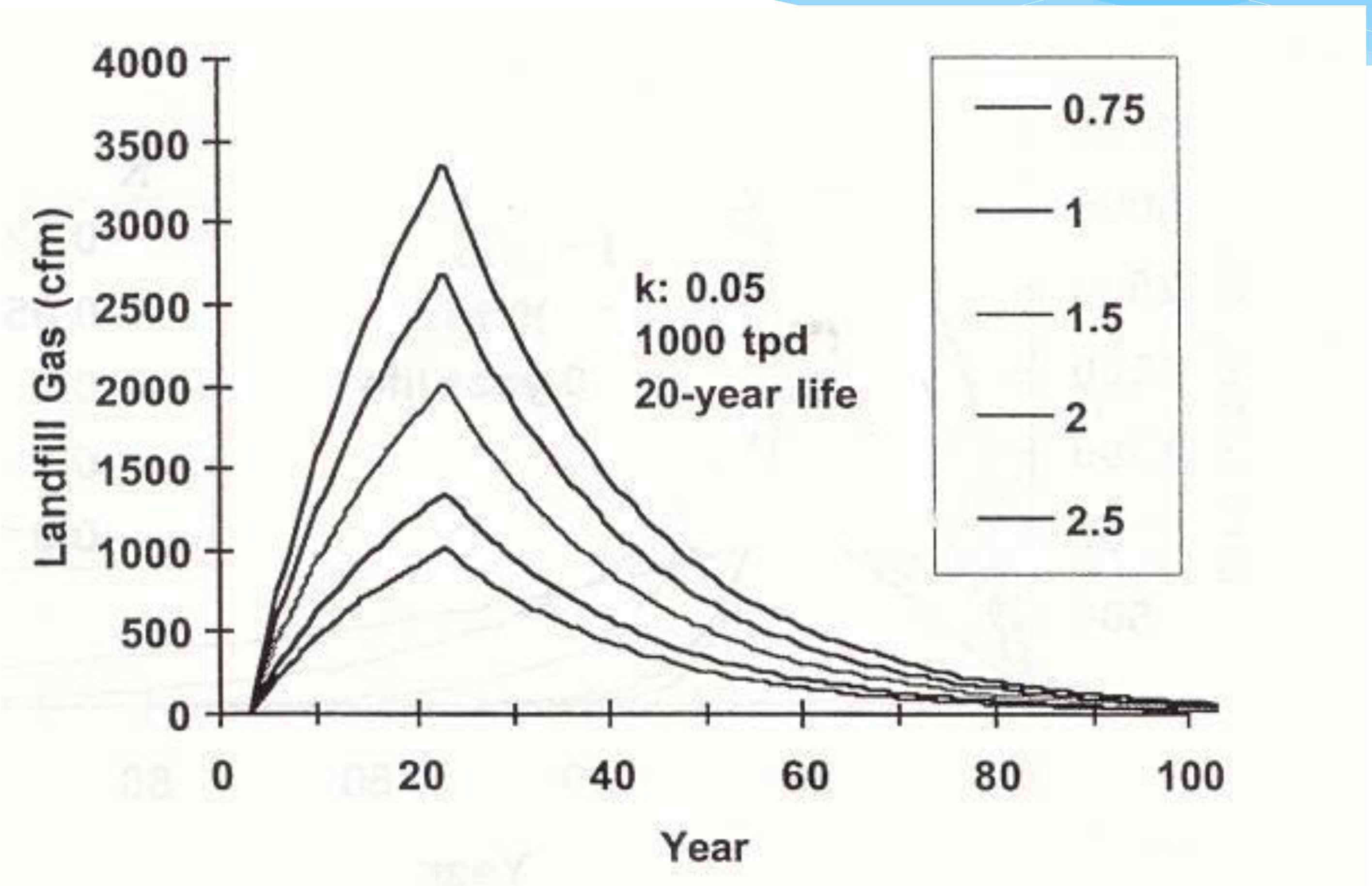
Landfill Gas (cfm)
3500
3000
2500
2000
1500
1000
500
0
Lo: 1.5
1000 tpd
20-year life
0.02
0.05
0.1
0.2
0.3
0
20
40
60
80
100
Year

Value of 'L_0'

L_0 = Methane generation potential (units = m^3 of methane / ton of waste)

- Estimated amount of Methane that a ton of waste can generate in a period of time
- Function of the organic content on the waste
  - Low moisture content limits L_0
- EPA estimates a value of 100 m^3/ton in United States

Value of L_0



4000
3500
3000
2500
2000
1500
1000
500
0
Landfill Gas (cfm)
0
20
40
60
80
100
Year
k: 0.05
1000 tpd
20-year life
0.75
1
1.5
2
2.5

Variable 'M'

Mass of waste disposed each operational year. If only volume data is available, data can be converted to mass units. Consider the following:

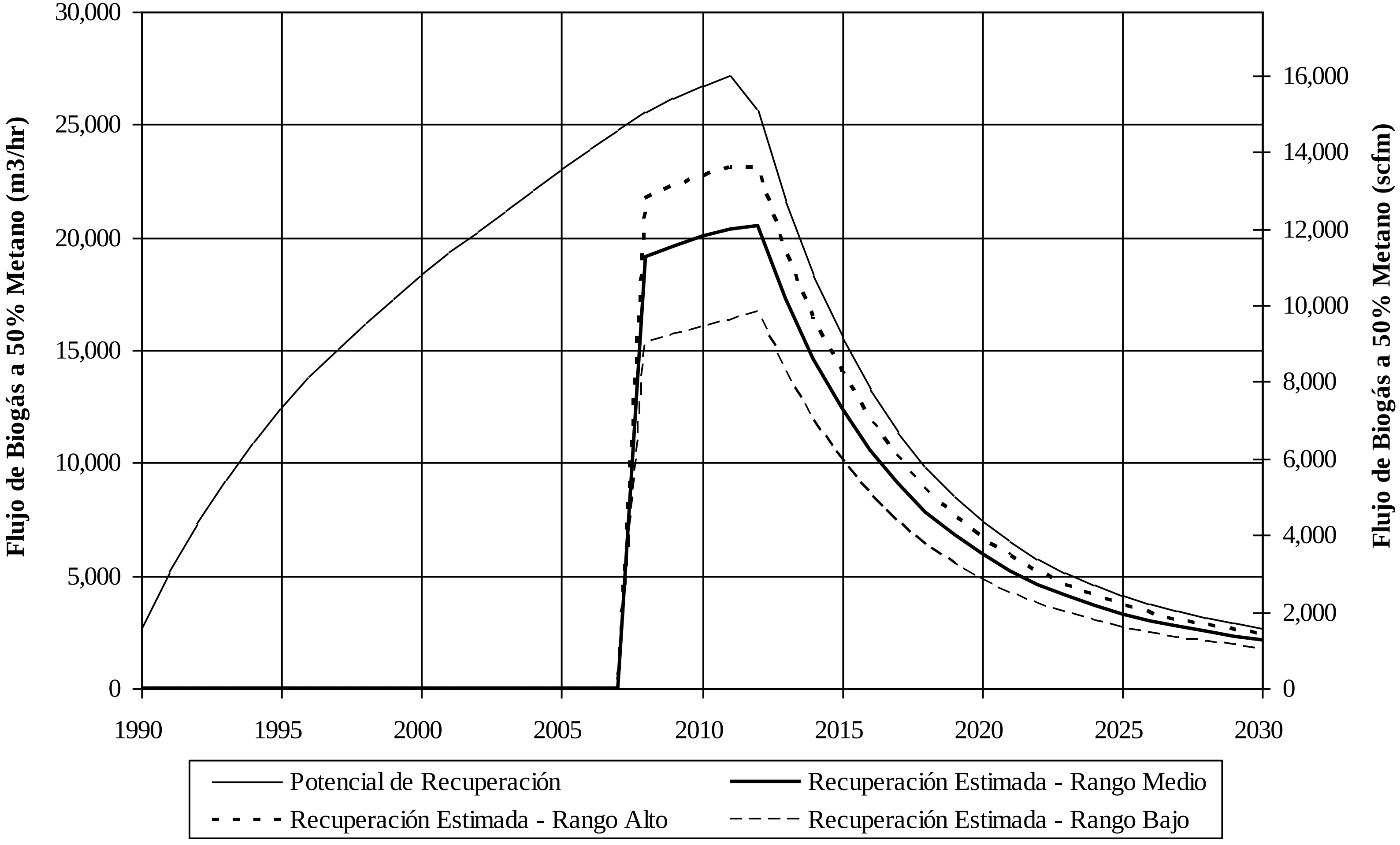
- Available historical data – weights measure or estimated volumes
- Annual disposal rate to estimate future disposal
- Consider waste disposal decrease as it will impact LFG generation
- If disposal rates are derived from volume data, need to consider an in-situ density ~ 0.7 ton/m^3

Variable "t"

- The LANDGEM model assumes LFG does not generate in 1st year after disposal

- Model assumes maximum LFG generation in 2nd year after disposal

LFG Recovery



Estimated LFG Generation - Models

- US EPA
  - LandGEM (v.3.02)
  - LFG Colombian Model, 1.0
  - LFG Mexican Model, 2.0
  - LFG Ecuadorian Model
  - LFG Central American Model
- IPCC (IPCC 2006)
- GasSim (UK)
- Scholl Canyon Model

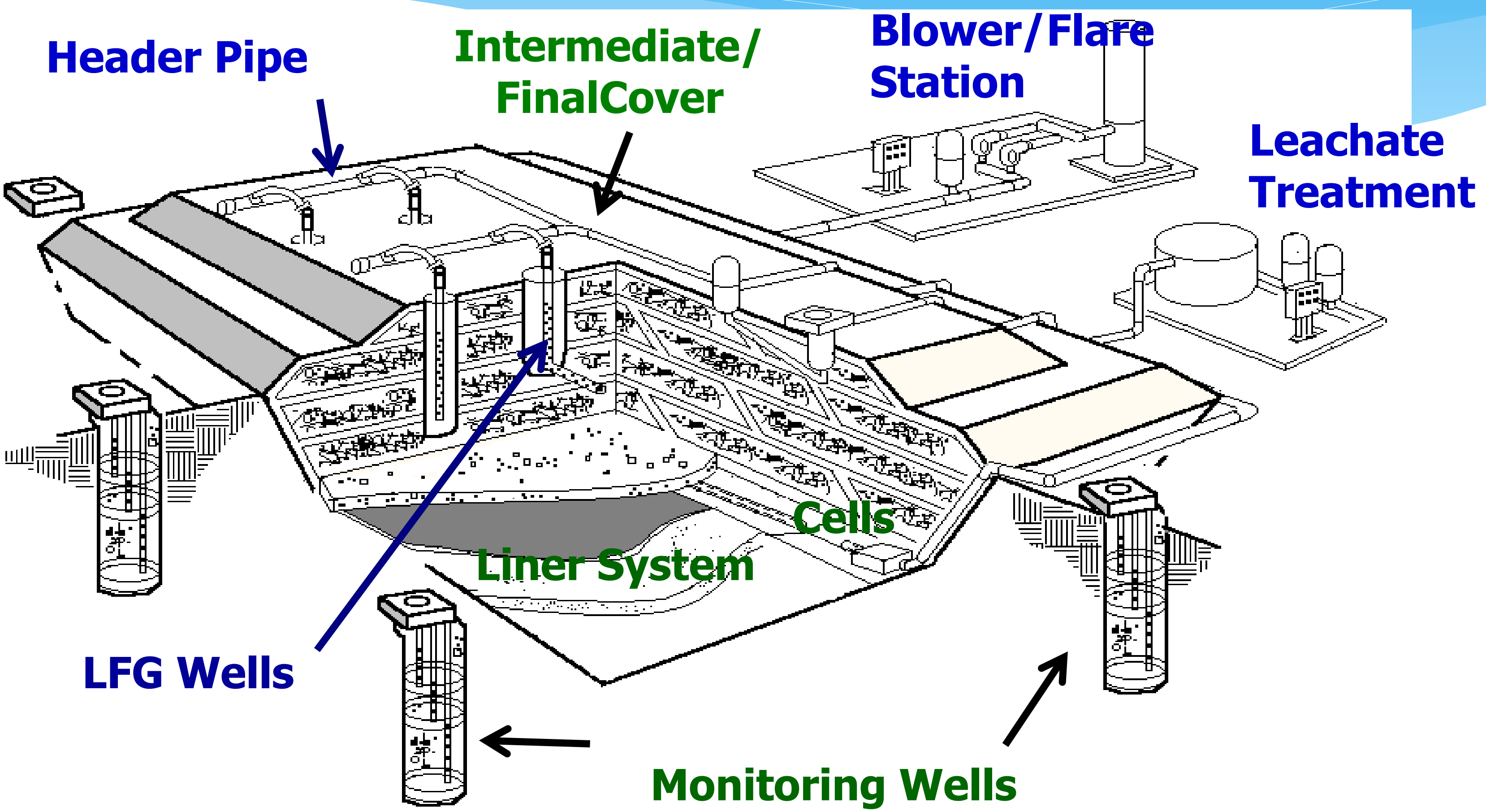
Use of LFG Models

- LFG evaluations and projections
- Pre-feasibility studies
- LFG system design
- LFG utilization system design
- Compliance purposes

Key Factors Affecting LFG Generation

- Amount of waste disposed per year
- Waste Composition
  - Organic waste content (decomposable fraction)
  - Moisture
  - Decomposition rate
  - Temperature
- Annual rainfall
- Operation & maintenance activities
  - Compaction
  - Daily cover
  - Leachate control
  - Final cover

Landfill



Header Pipe
Intermediate/
FinalCover
Blower/Flare
Station
Leachate
Treatment
Cells
Liner System
LFG Wells
Monitoring Wells

GCCS Objectives

- Migration control
- Odor control
- Emissions control
- Groundwater protection
- Landfill slope stability
- Energy recovery
- Compliance

LFG Control and Collection

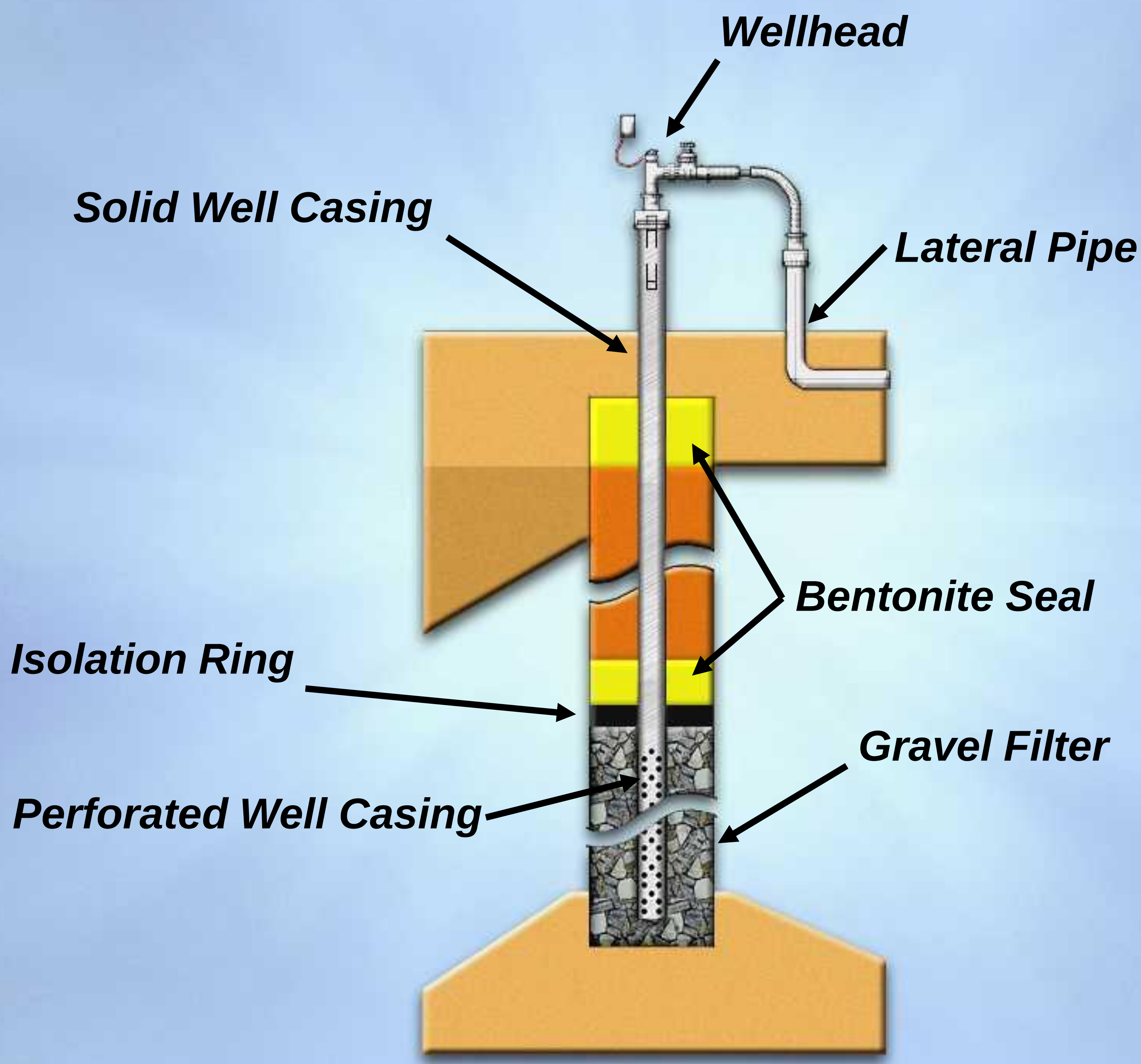
- Type of control
  - Passive
  - Active
- Monitoring system and LFG control at site perimeter

GCCS Main Components

- LFG extraction points
  - Vertical
  - Horizontal collectors
- Wellhead
- Lateral pipes
- Condensate traps
- Header pipe
- Condensate sumps
- Blower/flare station

Vertical Extraction Wells

- Most common approach
- Installed in closed, waste-filled areas
- Preferable on waste depth > 10m



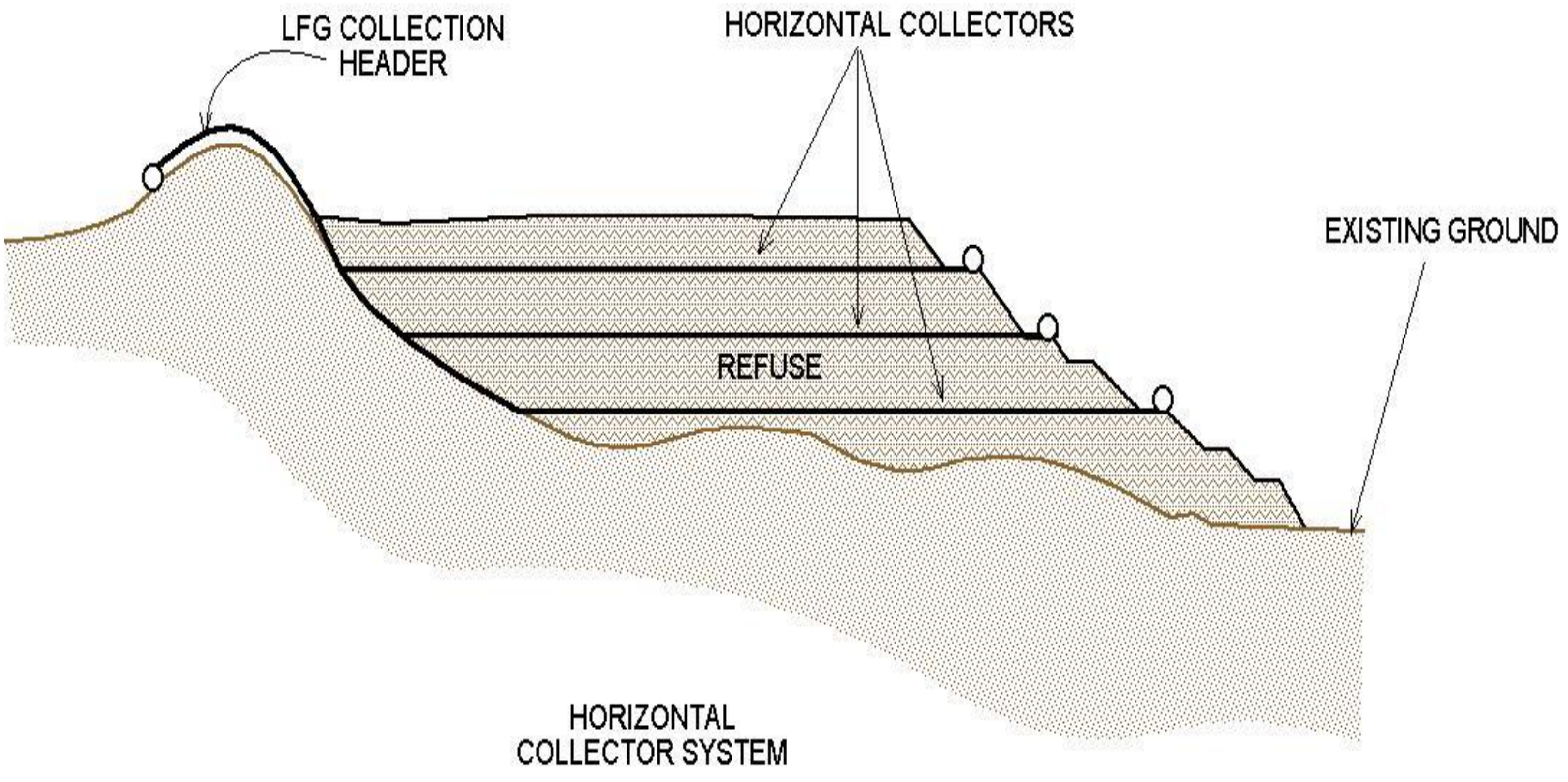
Wellhead
Solid Well Casing
Lateral Pipe
Bentonite Seal
Isolation Ring
Gravel Filter
Perforated Well Casing

Vertical Well Examples

Horizontal Collectors

- Alternative approach in:
- Areas with shallow waste depths
- Filled areas that are closed or capped
- May be placed in active disposal areas
- Sites with elevated leachate levels
- Can install at different depths while landfill operations are advancing

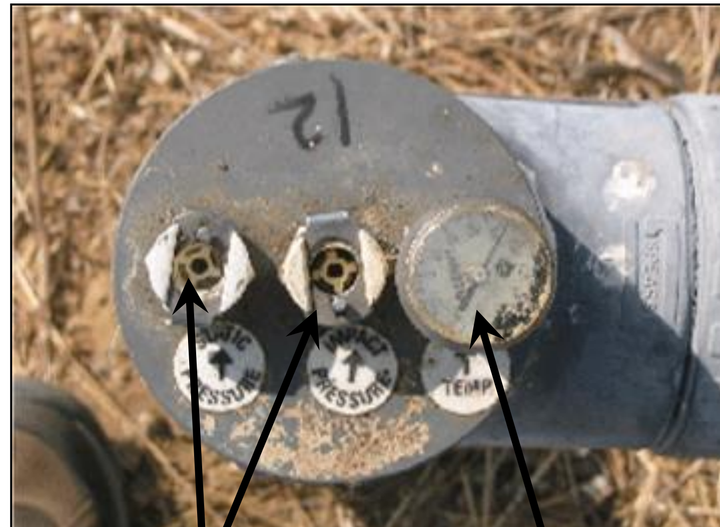
Horizontal Collectors - Typical Arrangement



Wellhead

Valve

Monitoring Ports



Pressure

Temperature

Lateral Pipe

Header Pipe

Condensate

- Liquid product of LFG moisture condensation cause by change on temperature, velocity or direction
- If not managed correctly:
  - Inundates wells
  - Reduces/prevents suction
  - Obstructs
  - Increases operational costs

Condensate Sump

Blower/Flare Station

- Demister
- Blower
- Flare
- Controls
- Monitoring system

Components

Main Components

Header Pipe

Demister

Blowers

Main Components

Condenstate Sump

Control Panel

Monitoring System

Flare Types

Enclosed

Candlestick

Additional Info

- USA EPA
  - www.epa.gov/lmop
- International Solid Waste Association
  - www.iswa.org
- World Bank
  - https://documents.albankaldawli.org/ar/publication/documents-reports/documentdetail/954761468011430611/handbook-for-the-preparation-of-landfill-gas-to-energy-projects-in-latin-america-and-the-caribbean

LFG Models

- LandGEM (v.3.02) – EPA
  - http://www.epa.gov/ttn/catc/products.html#software
- LFG Colombian Model 1.0 – EPA
  - http://www.epa.gov/lmop/international/tools.html#a08
- LFG Ecuadorian Model – EPA
  - http://www.epa.gov/lmop/international/tools.html#a03
- LFG Centro American Model – EPA
  - http://www.epa.gov/lmop/international/tools.html#a01
- LFG Mexican Model, 2.0 – EPA
  - http://www.epa.gov/lmop/international/tools.html#a04
- IPCC Model (IPCC 2006),
  - http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html
- GasSim (UK), http://www.gassim.co.uk/
- Scholl Canyon Model

Thank You

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