Engineered Barrier Performance: EnergySolutions Clive, Utah

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Outline

- Monitoring Technology
  - Short Term – pan lysimeters, Cover Test Cell
  - Long Term – shallow / nested wells
    groundwater quality
- Models Used
  - Infiltration / contaminant transport
  - Model Policy / Approach Issues
  - Sensitive Inputs / Assumptions

EnergySolutions – Clive, UT

(~70 mi West of Salt Lake City)

From: http://www.energysolutions.com/media-center/media-view.php?id=11

LLRW Cover Profile: Topslope

Prior to 1998	
thick	material
18 in	Riprap - Type B
6 in	Filter Zone - Type A
8 in	Sacrificial Clay
6 in	Filter Zone - Type B
12 in	Upper Radon Barrier
6 ft	Lower Radon Barrier
~ 43 ft	Waste
2 ft	Clay Liner

Prior to 2003	
thick	material
18 in	Riprap - Type B
6 in	Filter Zone - Type A
12 in	**Sacrificial Soil (silt loam)**
6 in	Filter Zone - Type B
12 in	Upper Radon Barrier
6 ft	Lower Radon Barrier
~ 43 ft	Waste
2 ft	Clay Liner

Begin in 2004	
thick	material
18 in	Riprap - Type B
6 in	Filter Zone - Type A
12 in	Sacrificial Soil (silt loam)
6 in	Filter Zone - Type B
12 in	Upper Radon Barrier
12 in	Lower Radon Barrier
~ 43 ft	Waste
2 ft	Clay Liner

Notes:

= Geotextile

= clay

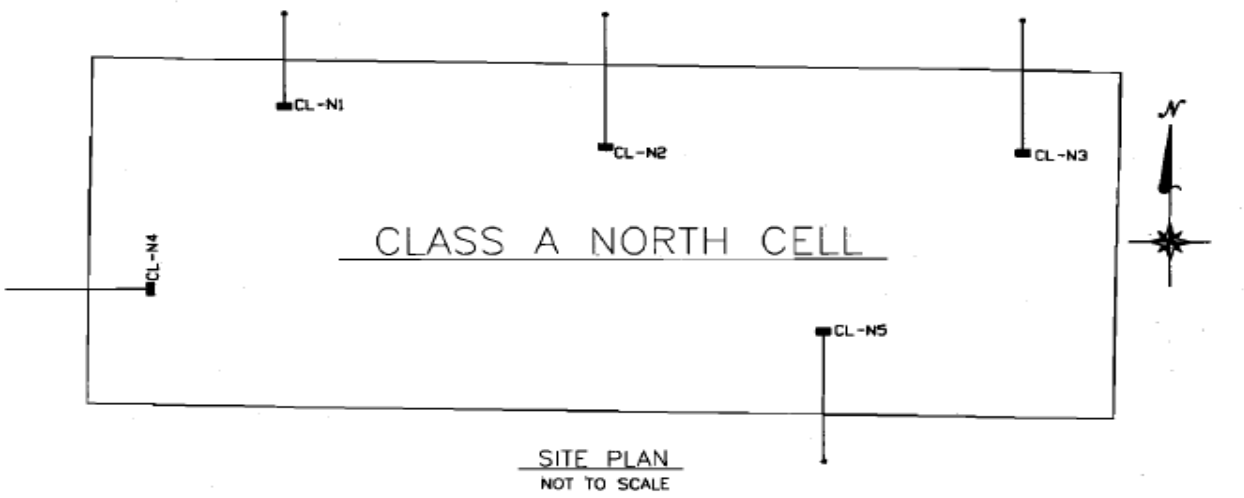
= graded sandy gravel

= graded pebble gravel

Filter B	K = 3.5 cm/sec
URB	K = 5.0E-8 cm/sec
LRB	K = 1.0E-6 cm/sec
CL	K = 1.0E-6 cm/sec

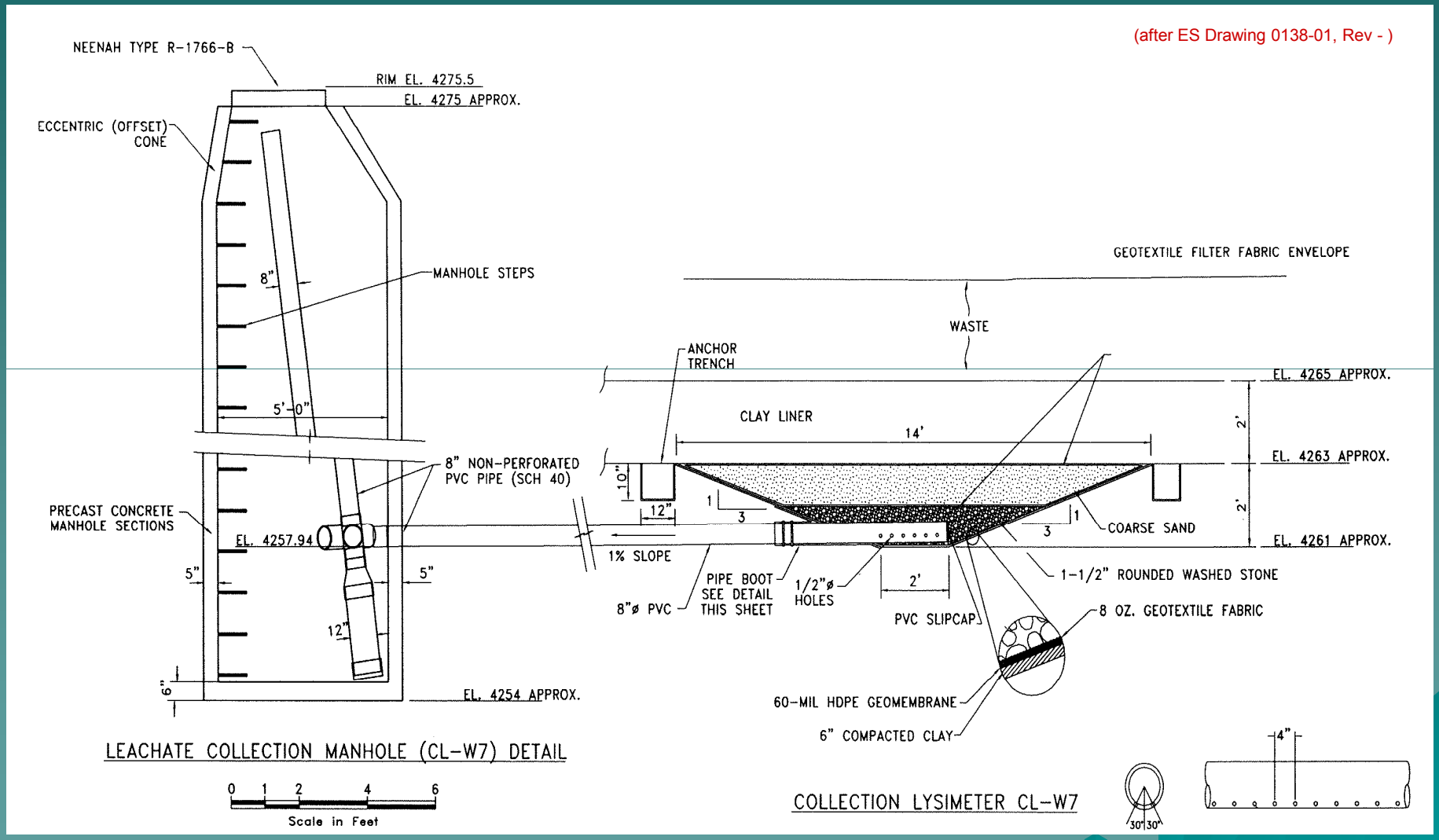
Short Term Monitoring

- Pan Lysimeters (qualitative)
  - Depth to Groundwater ~ 15 ft below clay liner



(after ES Drawing 08012 V-001, Rev 3)

Pan Lysimeters



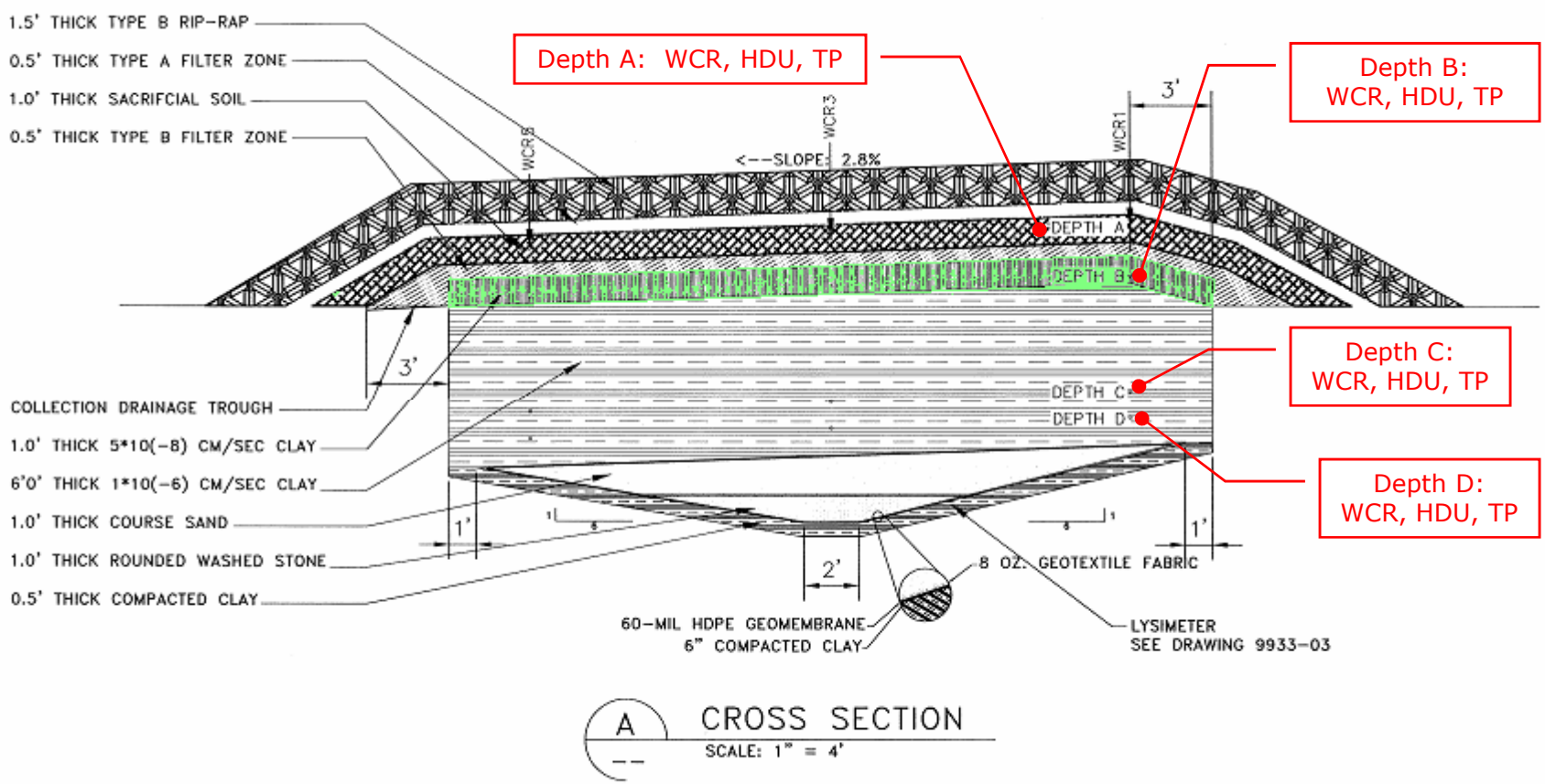
Pan Lysimeters

- Findings (to date)
  - Water Drainage Trends
    - Transient (early time) / small volumes
    - Source: clay liner compaction?
  - Water Quality Sampling:
    - Limited volumes = priorities
    - 1st Priority = Mobile Isotopes (Tc-99, I-129, etc)
    - Few samples collected (historically)
    - Source term characterization potential

Cover Test Cell (CTC)

- Construction ~ 2001
- Replicate Cover System – off cell
  - Measure (transient):
    - Soil Moisture content in profile
      - Water Content Reflectometers (WCR)
      - Heat Dissipation Units (HDU)
    - Soil Temperature (TP)
    - Unsaturated seepage flux
      - Pan lysimeter / dosing siphon / tipping bucket

CTC Design (~ 2001)



(after ES Drawing 9933-02, Rev -)

CTC Conclusions (to date)

- Practical Findings
  - WCRs: 3 of 4 failed (Depths B, C, D) – salinity corrosion?
  - HDUs: 1 of 4 failed (Depth A) - installation / freeze damage
  - Seepage: early drainage / clay liner compaction
  - Data Loss: voltage loss / lightening strike
  - Annual Report - needed
- Cover Performance Findings
  - No frost in Upper Radon Barrier
  - 2008 Measured Seepage (0.2 mm/yr)
  - PA Model Seepage Predictions (1.83 to 3.64 mm/yr)

Long Term Monitoring

- Shallow Wells
  - 5 Disposal Cells:
    - LARW, Class A, Class A North, Mixed Waste, 11e.(2)
  - 80+ wells
  - Shallow Groundwater (GW) Quality
    - Total dissolved solids (TDS)
      - o Spatial Variation: 24,000 – 53,000 mg/l
      - o Some Temporal Variation Observed
    - Highest Salinity: SW corner of Site (Section 32)

Long Term Monitoring

- Shallow Wells – continued
  - Need to normalize heads
    - Allows comparisons in time and space
  - Specific Gravity Measurements - field
    - Each well / event
  - Freshwater Equivalent Head – calculate
    - Total Head = elevation + pressure head
  - Average Horizontal Velocity: 1 – 2 ft/yr

Long Term Monitoring

- Shallow Wells – continued
  - Monitoring Frequency
    - Head - monthly
    - GW Quality - annual
  - Horizontal Flow Direction – Northward?
  - Artificial Recharge Mounds - observed
    - Apparent Causes?
      - Stormwater surface accumulations (3 cases)
      - Buried wastewater pipe leak (1 case)

Long Term Monitoring

- Nested Well Pairs (5 pairs on-site)
  - Deep / shallow wells: co-located
  - Deep Aquifer TDS: ~ 20,000 mg/l
  - Vertical Flow: Upward (pre-construction)
  - Gradient Reversal (apparent)
    - SW corner of Section 32 (wells GW-19A/B)
    - Stormwater Pond Leakage (non-contact)
    - Shallow GW de-watering now underway

Long Term Monitoring

- Site GW Quality Protection
  - Policy Decision ~ 1991
    - High TDS – Class IV Aquifer
    - Protect shallow aquifer as if drinking water:
      - Encourage Best Available Technology
        - via performance assessment modeling
      - Protect Long-term Public Health / Environment
      - Added Disposal Costs
        - Go to out-of-state generators

Long Term Monitoring

- Site GW Quality Protection – continued
  - GW Protection Levels (GWPLs) - well specific
    - Basis - greatest of:
      - State GW Quality Standards (GWQS)
        - e.g. EPA drinking water MCLs - **OR**
      - Background GW Quality (mean conc. + 2 SD)
    - Natural Contaminants (Background > GWQS)
        - Some wells, not all
        - Metals: As*, Mo*, Ra, Se*, U*
        - Gross Alpha

* Redox sensitive

Long Term Monitoring

- Site GW Quality Protection – continued
  - Artificial / Mobile Isotopes
    - I-129, Tc-99, Cl-36, Np-237, etc
    - Detected Concentrations < GWQS
  - Occasional GWPL Adjustments - made
    - Improved background GW quality data
    - Redox Sensitive Analytes
      - Artificial GW mounding?

Performance Assessment Models

- Infiltration - EPA HELP (quasi 2-D)
- Vadose Zone - Unsat-H (1-D)
  - Moisture Content Distribution
  - Velocity
- Contaminant Transport - EPA Pathrae (1-D)
  - Uranium decay series
- Model Types
  - Deterministic
  - Steady-state

Performance Assessment Models

- Model Domains
  - Early 1990's (1-D)
    - Cell cover + vadose zone only
    - POE = water table immediately below cell
  - Mid-1990s to today (2-D)
    - Cover + vadose + shallow aquifer
    - 2-D: 2, 1-D Pathrae models linked
      - Waste to water table
      - Water table to well
    - POE = Shallow monitoring well (~ 90 ft to waste)

Performance Assessment Models

- Period of Performance – 500 yrs
  - 1991 - no NRC guidance
  - State Decision Basis:
    - NUREG 1199 / 1200
    - Engineering Stability
  - After 500 Yrs:
    - Site characteristics control transport
    - Currently un-analyzed

Performance Assessment Models

- Sensitive Model Inputs / Assumptions
  - Infiltration – HELP Model
    - Evaporative Zone Depth
    - Permeability (K) Contrast @ Lower Filter / URB
  - Contaminant Transport
    - Velocity – vadose zone & shallow GW
    - Soil-Water Partitioning (K_d)Coefficients
      - o Waste leaching
      - o Vadose / Aquifer retardation
    - Waste Source Term Concentrations

Conclusions

- Short Term Monitoring
  - Pan Lysimeters
    - Drainage to date - appears construction related
  - Cover Test Cell
    - 2008 seepage < PA Model predictions
- Long Term Monitoring
  - Shallow and Deep Wells
    - Head gradient changes – early warning
      - Horizontal & Vertical
      - Artificial Recharge – wastewater / stormwater
    - Background Shallow GW Quality
      - High TDS
      - Several Metals > GWQS (GW mounding?)

Conclusions

- GW Monitoring
  - Mobile Isotopes < GWQS
- Models Used (1 and 2-D)
  - Infiltration (HELP & Unsat-H)
    - Sensitive: Evaporative Zone Depth
      K Contrast @ Lower Filter / URB
  - Contaminant transport (Pathrae)
    - Sensitive: Soil-Water K_d
      Velocity (vadose & shallow GW)
      Waste Source Term Concentrations