Local Practices Managing CCRs

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wood.

Outline

- Leachate collection systems (chimney drain origins)
- Liner system performance
- Cover system lessons learned - infiltration water management
- CCR management trends

Leachate Collection Systems: Background

- MSW vs. Ash Landfills

MSW Landfill

Ash Landfill

Background: MSW vs. Ash Landfills

Physical Property	MSW	Ash
Grain Size	Highly Variable	80% + passing No. 200 = Non Plastic Silt
Porosity	0.4 to 0.62 (Qian, Koerner, Gray, 2002)	0.44
Permeability	4 x 10^{-2} to 9 x 10^{-4} cm/sec (Qian, Koerner, Gray, 2002)	1 x 10^{-5} cm/sec
Leachate Generation	600 to 1,400 gpad	500 to 900 gpad

Operations	MSW	Ash
Active Face	Small (1 Acre)	As large as allowed/reasonable
Operational Cover	Daily Soil (6 inches)	Initially weekly soil (6 inches) Modified to periodic soil Modified to soil alternative
Leachate Generation	Reduce	Initially (2000's) – Little Concern Now – Reduce

Ash Landfill Sump

Ash landfill circa 2009: Sump blinded by protective cover sedimentation during initial ash filling

Ash Landfill Sump

Ash landfill circa 2009: Sump blinded by protective cover and ash sedimentation during initial ash filling

Ash Landfill Sump and LCS Corridor

Ash landfill circa 2009: Sump blinded by ash sedimentation during initial ash filling

Ash landfill circa 2009: LCS laterals blinded by ash sedimentation during initial ash filling

Problem and Solution…

- Problem
  - Larger quantity of stormwater runoff from ash and protective cover (unlike MSW landfills)
  - Protective cover soil and ash eroding
  - Deposited downslope at leachate collection sumps
  - Blinded ordinary (MSW-style) sumps and leachate collection system (LCS) corridors
- Solution
  - Operations Plans
  - Grading Plans
  - Chimney Drains – combination of:
    - erosion and sediment control
    - graded filter design
    - Stormwater design

Evolution: The Next Ash Landfill…

Ash landfill circa 2010: Infiltration zone and chimney drain layout

Evolution: The Next Ash Landfill…

Chimney Drain (left) LCS Corridor center (raised with graded filter)

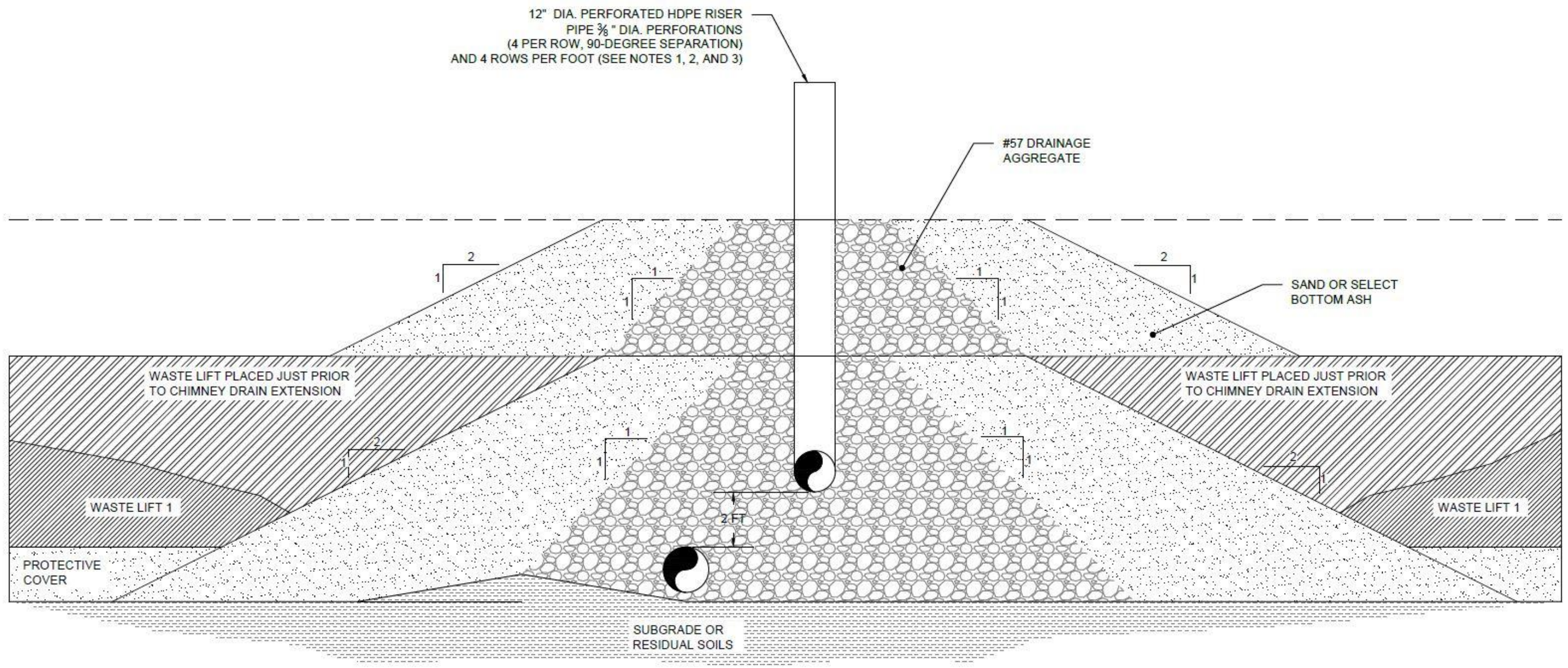
Graded Filters (Check Dams)

Evolution: The Next Ash Landfill…

Chimney Drain/Infiltration Zone – No. 57 Stone

Chimney Drain/Infiltration Zone – No. 57 Stone with Bottom Ash

Evolution: The Next Ash Landfill…



Ash landfill circa 2017: Chimney Drain Detail

Outline

- Leachate collection systems (chimney drain origins)
- Liner system performance

CCR Landfill Liner System Performance

- Purpose
  - Liners leak, but how much?
  - Unique situation to review data from double-lined CCR landfills
  - Evaluate leachate flow from leak detection layers
  - Available liner system performance data
- Driver for double-lined CCR landfills
  - Overfills – new CCR landfills over existing ash ponds
  - Groundwater monitoring isolation - new from old
  - Redundancy ~ belt and suspenders
- 4 Facilities – Southeastern US

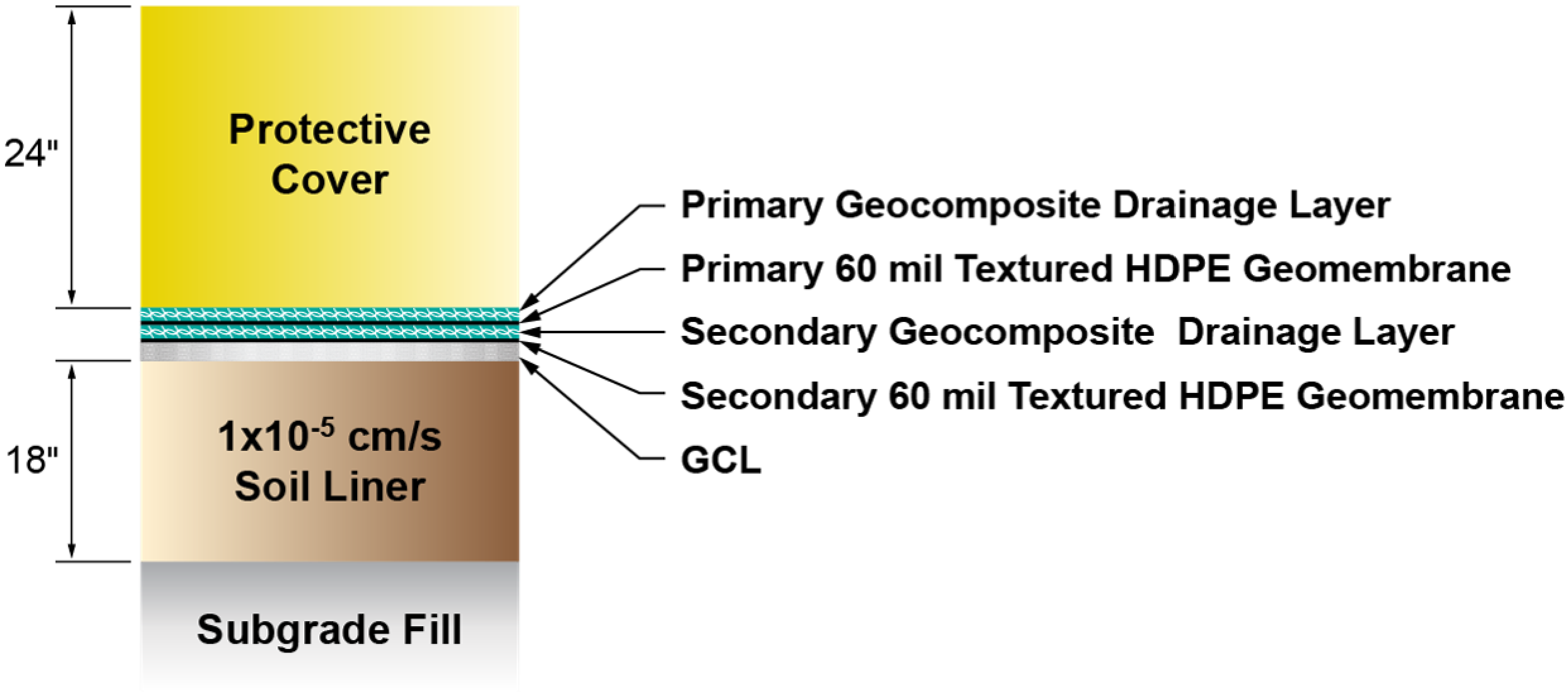
Source: Daly K., Ruhl, C., *“CCR Landfill Liner System Performance Evaluation”*, World of Coal Ash 2017, May 11, 2017.

Facility Summary

Facility	Cell	Average annual rainfall in (mm)	GW separation distance ft (m)	Cell area acres (hectares)	Max waste height ft (m)	LDS collector spacing ft (m)	Base slope (%)	End construction
1	1	41.6	20 (6.1)	10.8 (4.4)	40 (12)	350 (107)	2.4 to 3.5	June 2009
1	2	41.6	9 (2.7)	13.8 (5.6)	45 (14)	350 (107)	3.5	June 2010
2	1	44.9	8 (2.4)	9.9 (4.0)	40 (12)	274 (83)	4	October 2010
2	2	44.9	8 (2.4)	9.6 (3.9)	40 (12)	274 (83)	4	October 2010
3	1	45.4	4 (1.2)	31.0 (12.6)	20 (6)	150 (46)	5	June 2014
4	1	45.5	30 (9.1)	23.5 (9.5)	35 (10.7)	220 (67)	5	June 2015

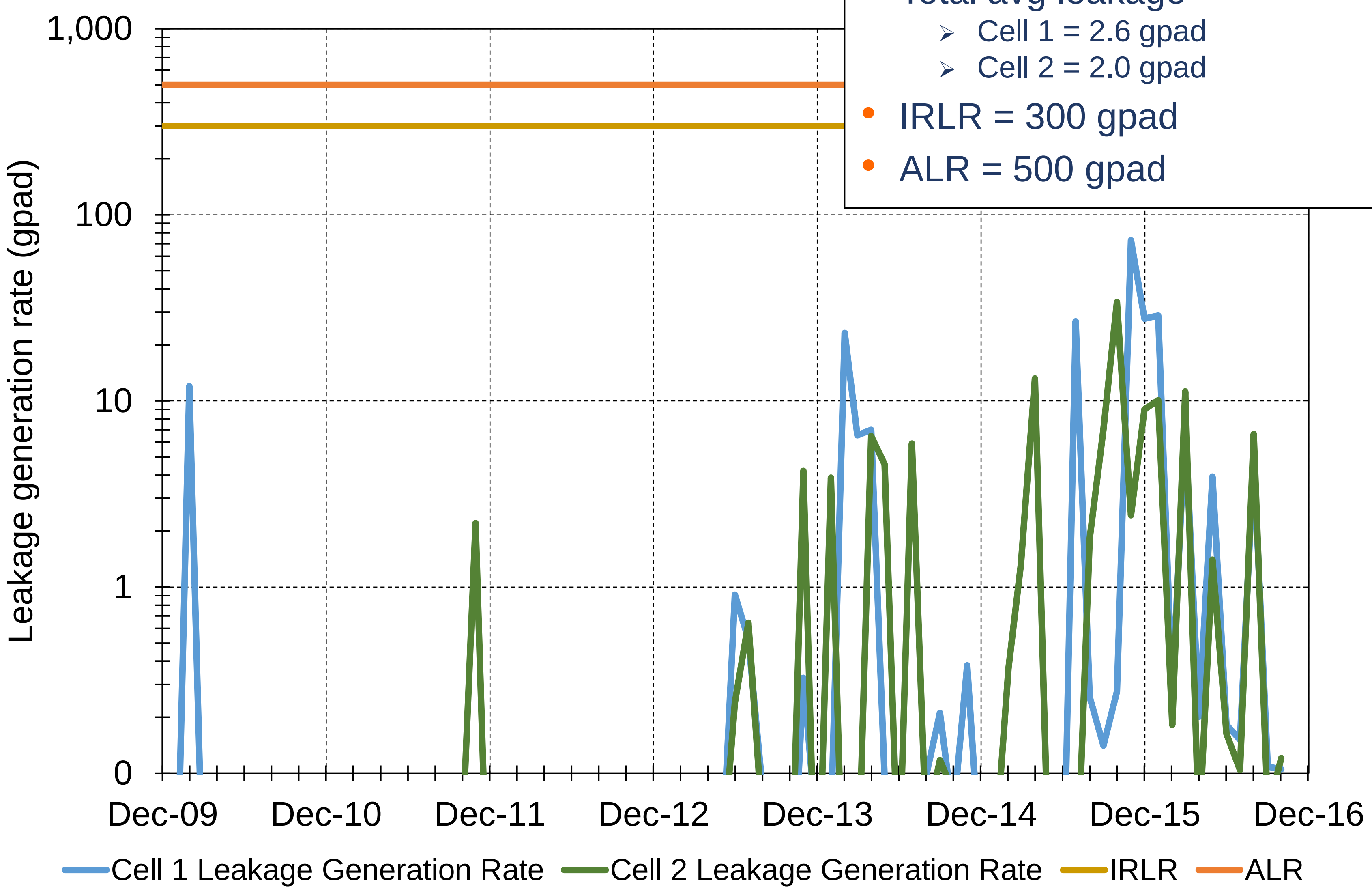
- Flow measurement by totalizing flow meters
- Data acquisition varied from manual recording to electronic
- Facilities constructed with third-party CQA

Double Liner System



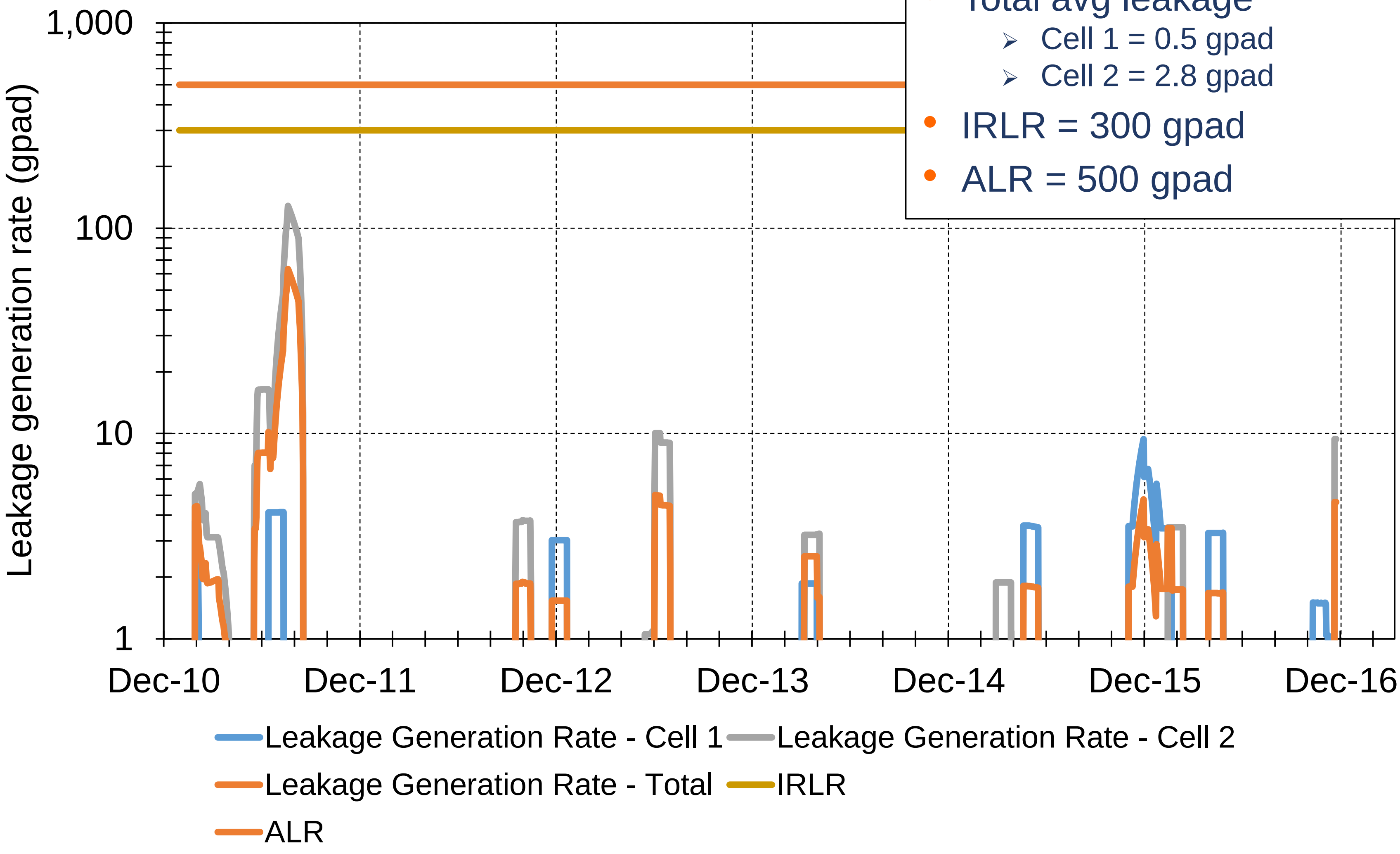
Site 1 – Leak Detection System Flow

- Total avg leakage
  - Cell 1 = 2.6 gpad
  - Cell 2 = 2.0 gpad
- IRLR = 300 gpad
- ALR = 500 gpad



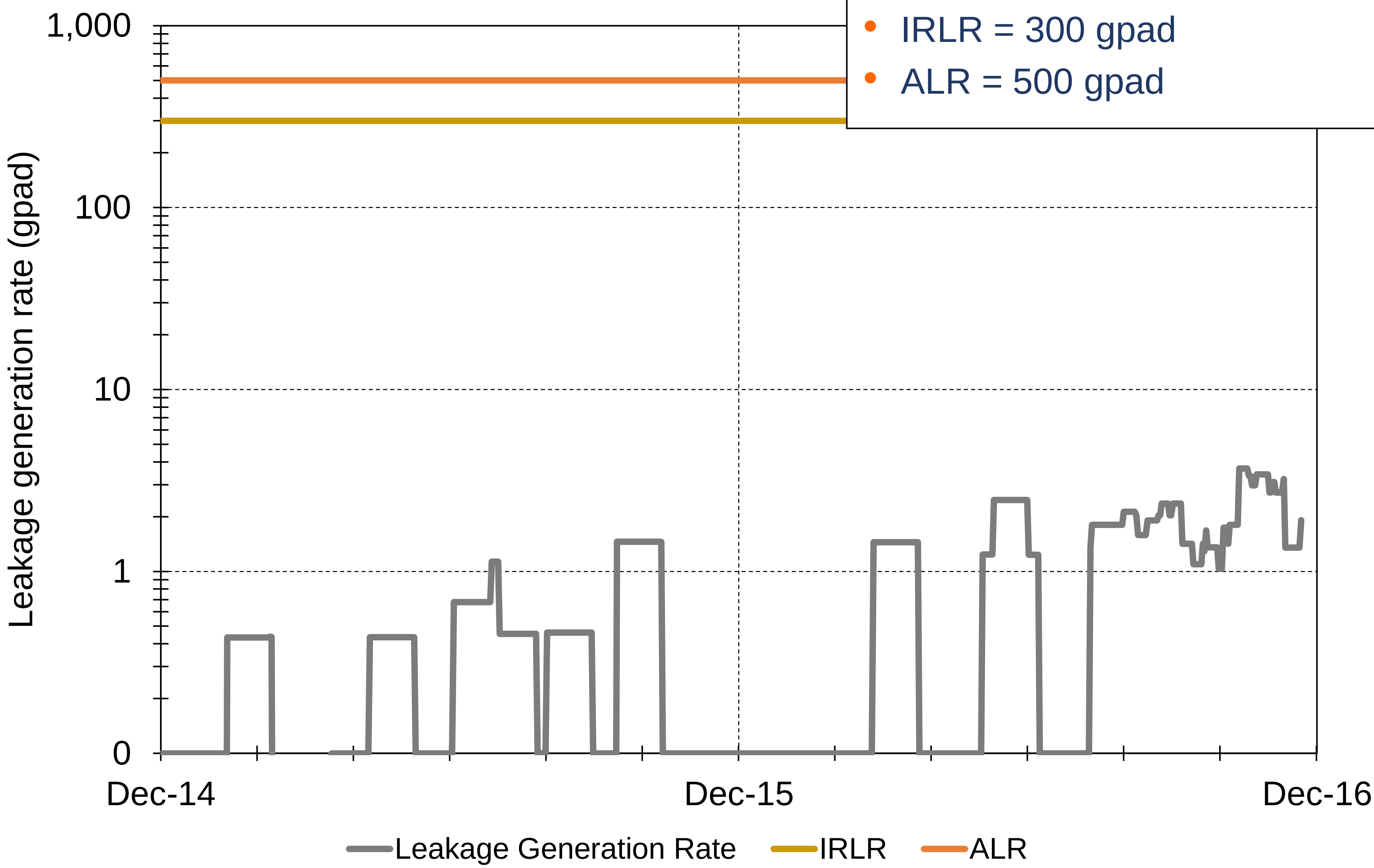
Site 2 – Leak Detection System Flow

- Total avg leakage
  - Cell 1 = 0.5 gpad
  - Cell 2 = 2.8 gpad
- IRLR = 300 gpad
- ALR = 500 gpad



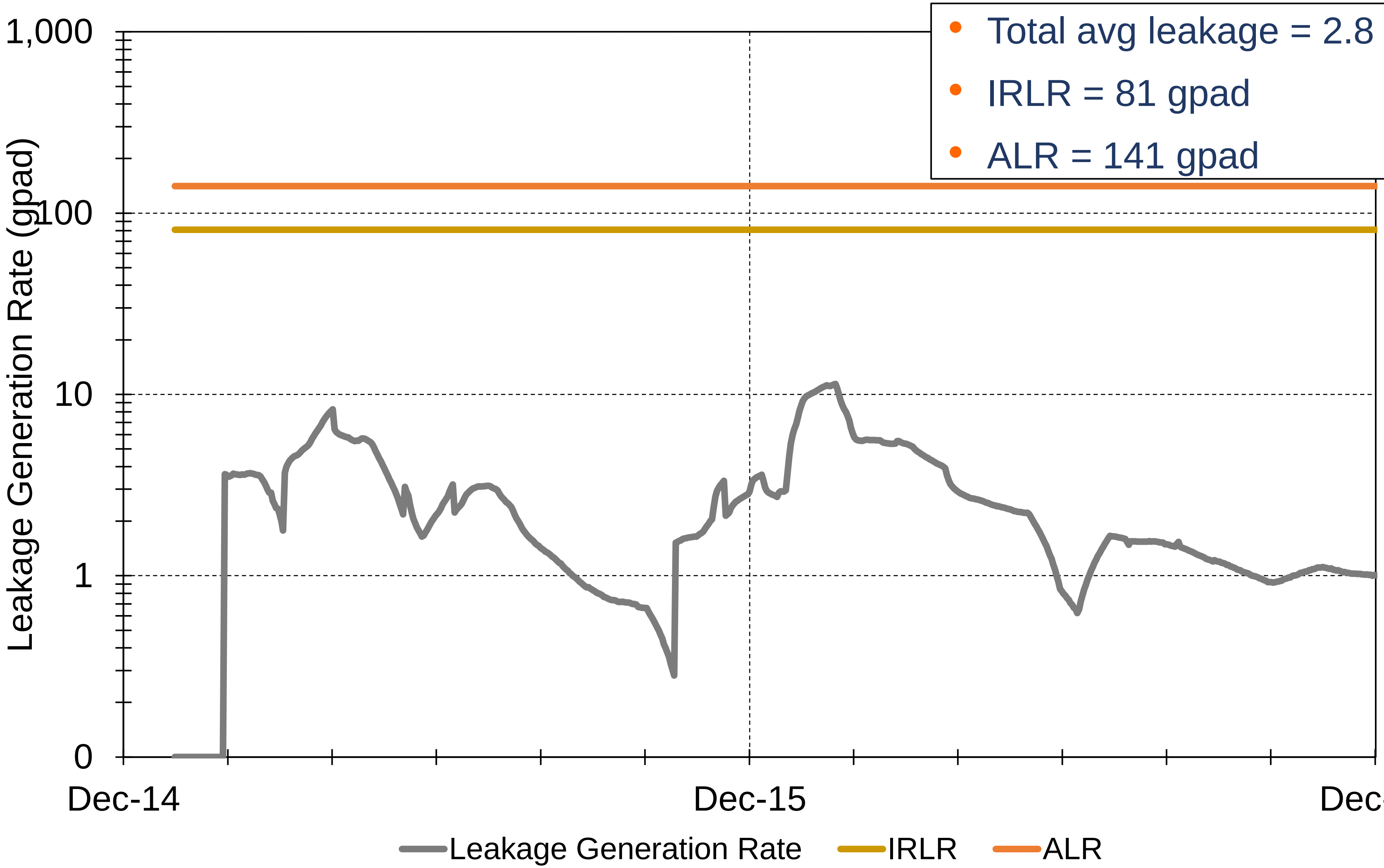
Site 3 – Leak Detection System Flow

- Total avg leakage = 0.7 gpad
- IRLR = 300 gpad
- ALR = 500 gpad



Site 4 – Leak Detection System Flow

- Total avg leakage = 2.8 gpad
- IRLR = 81 gpad
- ALR = 141 gpad



Leak Detection System Flow Summary

Facility	Cell	Time months	Average flow (gpad)	Average flow (lphd)	Max flow (gpad)	Max flow (lphd)
1	1	83	2.6	24.4	73	683
1	2	64	2.0	18.3	34	318
2	1	71	0.5	4.9	9.4	88
2	2	71	2.8	25.8	128	1,200
3	1	25	0.7	6.5	56	525
4	1	24	2.9	26.7	61	571

- Average flows (gpad)
  - Min = 0.5 gpad
  - Max = 2.8 gpad
  - Avg = 1.9 gpad
- Max flows (gpad)
  - Min = 9.4 gpad
  - Max = 128 gpad
  - Avg = 60 gpad

Design Application

- Inform action leakage rate determination
  - Initial Response Leakage Rate (IRLR) = 300 gpad
  - Action Leakage Rate (ALR) = 500 gpad
- Typical approach
  - Designer's assume a certain number and size of defects to evaluate liner performance
  - Typical assumption is 1 to 4 defects/acre for good CQA
  - Defect size 1mm = leakage of 105 gpad/defect (at 1 ft head)
- Back-calculated defect frequency from LDS flows
  - $Q = C_b \cdot a \cdot (2 \cdot g \cdot h)^{0.5}$ (Qian, X., Koerner, R., Gray, D., 2002)
    - Q = flow rate through geomembrane
    - C_b = flow coefficient (0.6 for circular hole)
    - a = area of circular hole
    - g = acceleration due to gravity
    - h = liquid head above the liner

Design Application

Facility	Area (ac)	Measured Leakage (gpad)	Head Condition (ft)	Leakage per Defect (gal/defect/day)	Equivalent No. of Defects (N/ac)	Estimated Total No. of Defects
1	24.6	2.30	1	105	0.022	0.5
			0.023	16	0.146	3.6
2	19.50	3.30	1	105	0.031	0.6
			0.028	17	0.189	3.7
3	31.00	0.70	1	105	0.007	0.2
			0.021	15	0.046	1.4
4	23.50	2.80	1	105	0.027	0.6
			0.023	16	0.177	4.2

- Two head conditions (h) considered
  - h = 1 ft → regulatory maximum
  - h = 0.021 to 0.028 ft → geocomposite drainage (geonet) thickness
- Based on 2 cm diameter circular defect

Conclusions

- Low leakage rates
  - two orders of magnitude below IRLR and ALR
- Data shows that CCR landfill primary liner systems perform well
- Results comparable with other studies
  - USEPA 1992 (Bonaparte & Gross, LDCRS flow from double-lined landfills and surface impoundments)
  - three landfills = seven cells (group 1 = GM top liner and geonet LDS)
  - average flow rates = 0 to 22 gpad (0 to 220 lphd)
  - max flow rates = 11 to 86 (110 to 860 lphd)
  - with CQA leakage less than 100 gpad (1,000 lphd)
  - without CQA leakage greater than 100 gpad (1,000 lphd)

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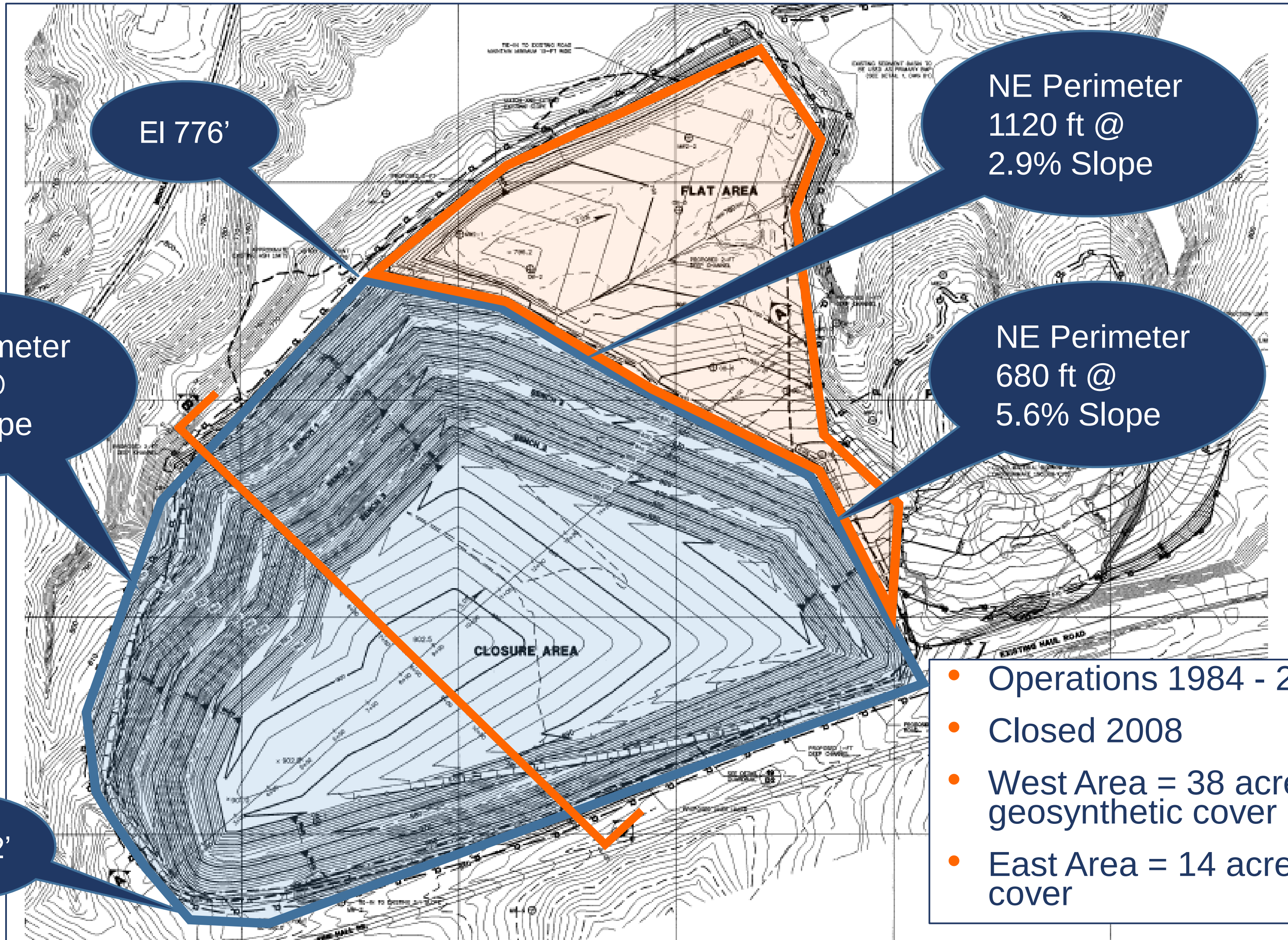
- Cover system lessons learned - infiltration water management

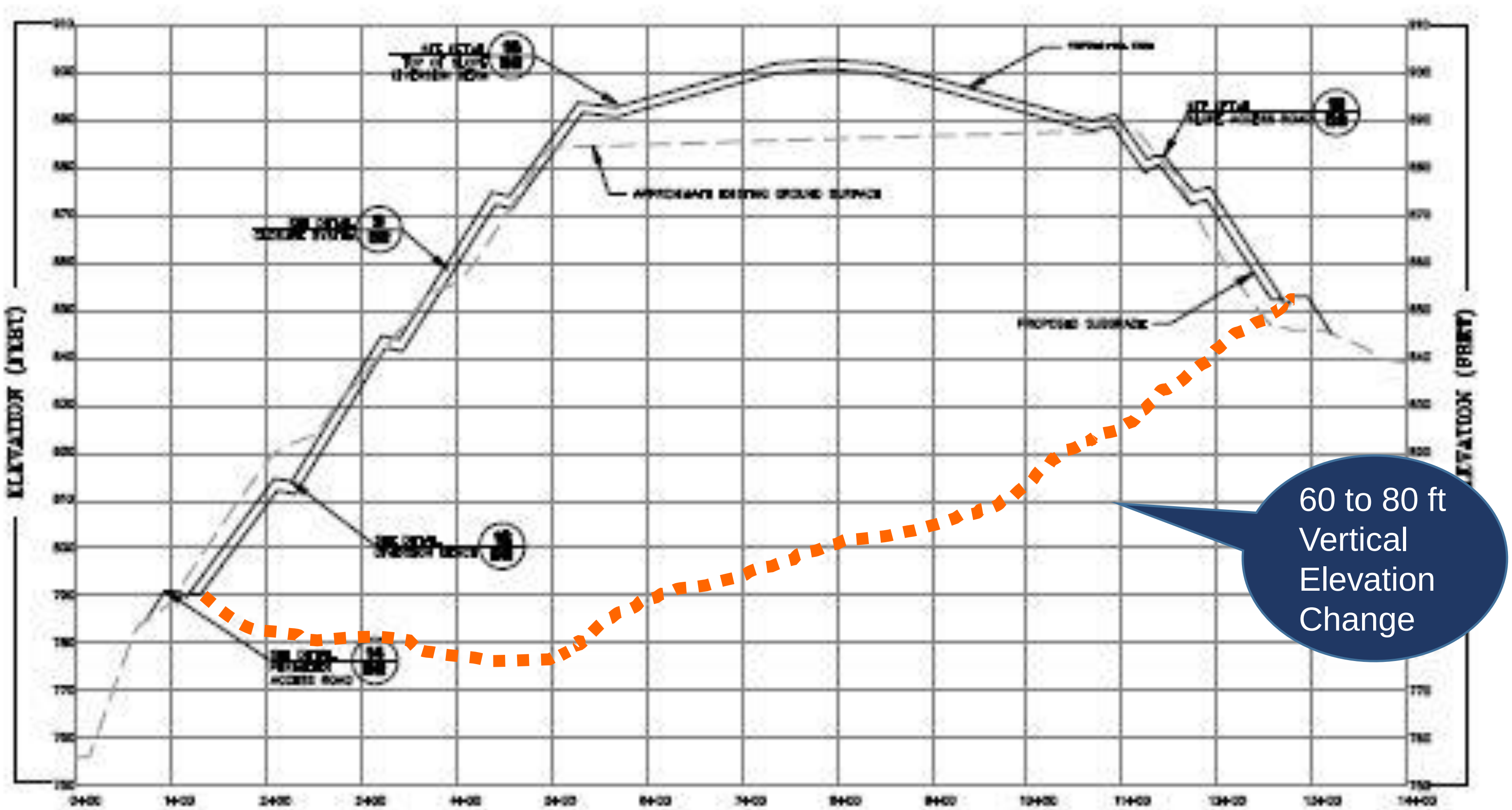
Cover System - Infiltration Water Management: Background



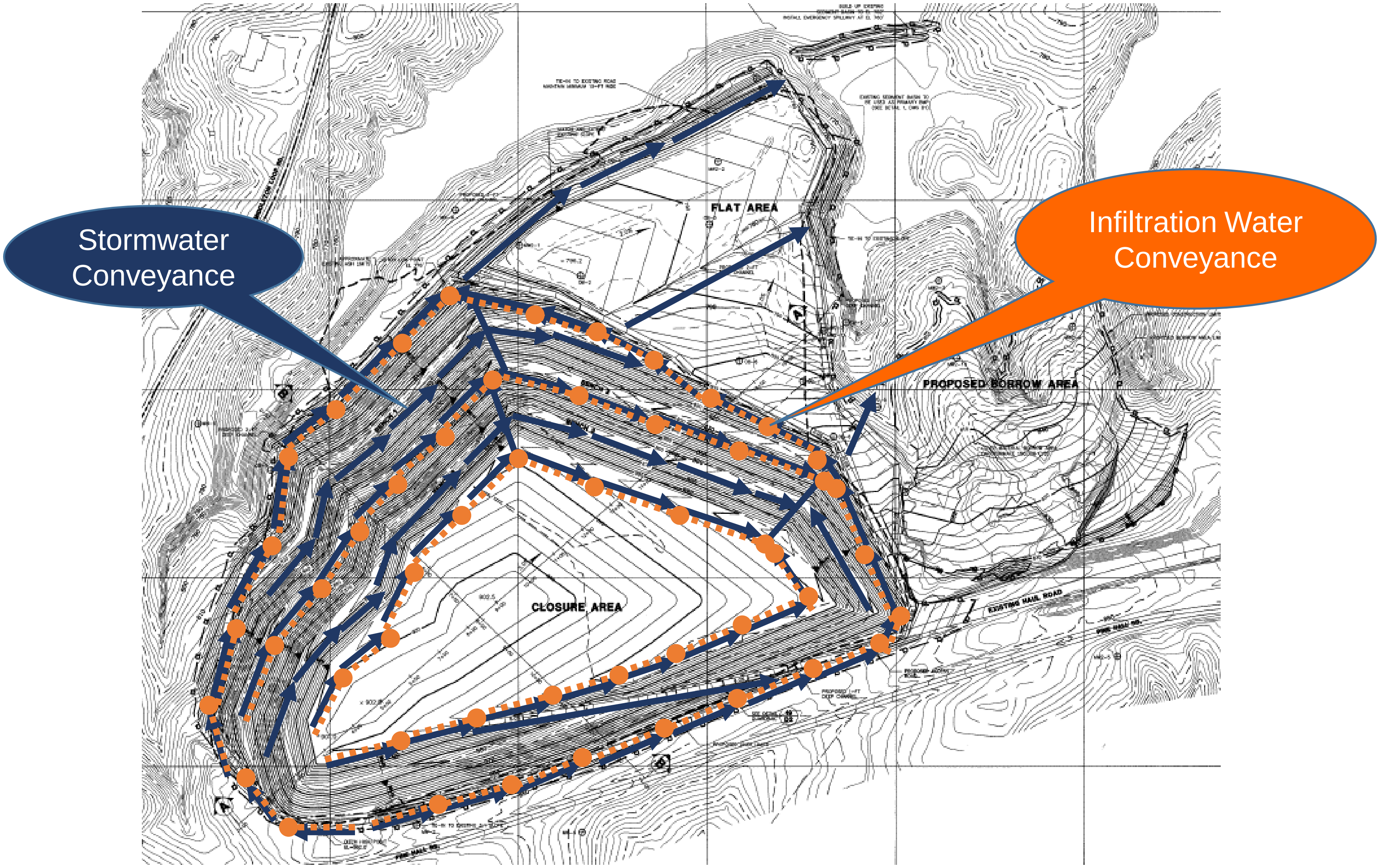
- Operations 1984 - 2004
- Closed 2008
- West Area = 38 acres soil-geosynthetic cover
- East Area = 14 acres soil cover

Source: Daly K., Ruhl C., Shumpert, M., “*Case history – CCR landfill cover system stormwater and infiltration water design and management*”, World of Coal Ash 2017, May 11, 2017.

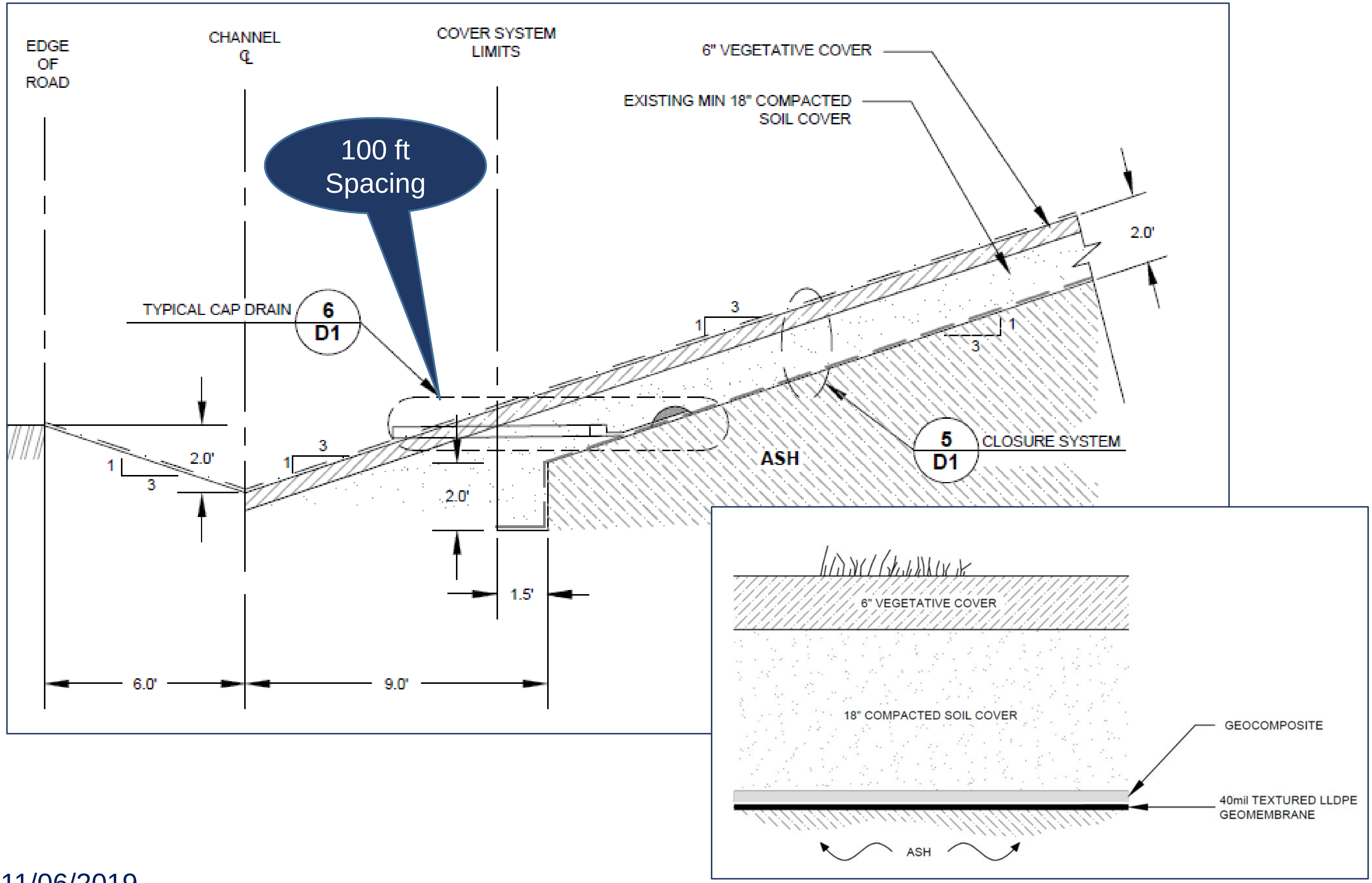
Cover System - Infiltration Water Management: Background



Cover System - Infiltration Water Management: Background



Infiltration water: cover system termination – key trench and outlet pipe (2007 design)



Infiltration water: cover system termination – key trench (2007 design)

Finished cover subgrade before key trench excavation

Key trench excavation – “rough” key trench corners

Infiltration water: cover system termination – key trench (2007 design)

Geomembrane deployed in key trench

Geocomposite deployed in key trench

Infiltration water: cover system termination – key trench (2007 design)

Backfilling key trench: geosynthetic cover to the right; "flat area" (ash) to receive soil cover to the left

Backfilling key trench

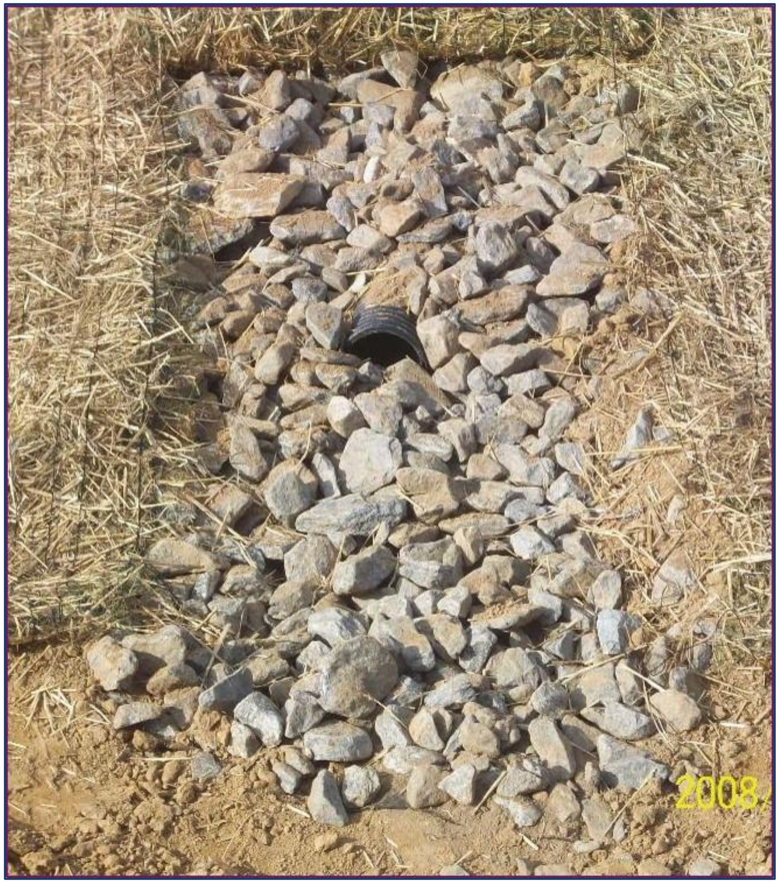
Infiltration water: panel drain outlet (2007 design)

Pavement edge-drain used as panel drain: aggregate and geotextile wrap added

Connection for pipe outlet – spaced 100 ft on center

Infiltration water: panel drain outlet (2007 design)

Assembled panel drain (prior to pipe connection)



Completed panel drain installation

Ash boil at northeast perimeter (2009)

Ash boil (facing southwest)

Ash boil (facing southeast)

- Construction completed Fall 2008
- November 2009 boils developed after significant rainfall event

Settlement and deformation northeast perimeter (2009)

Settlement area (facing north)

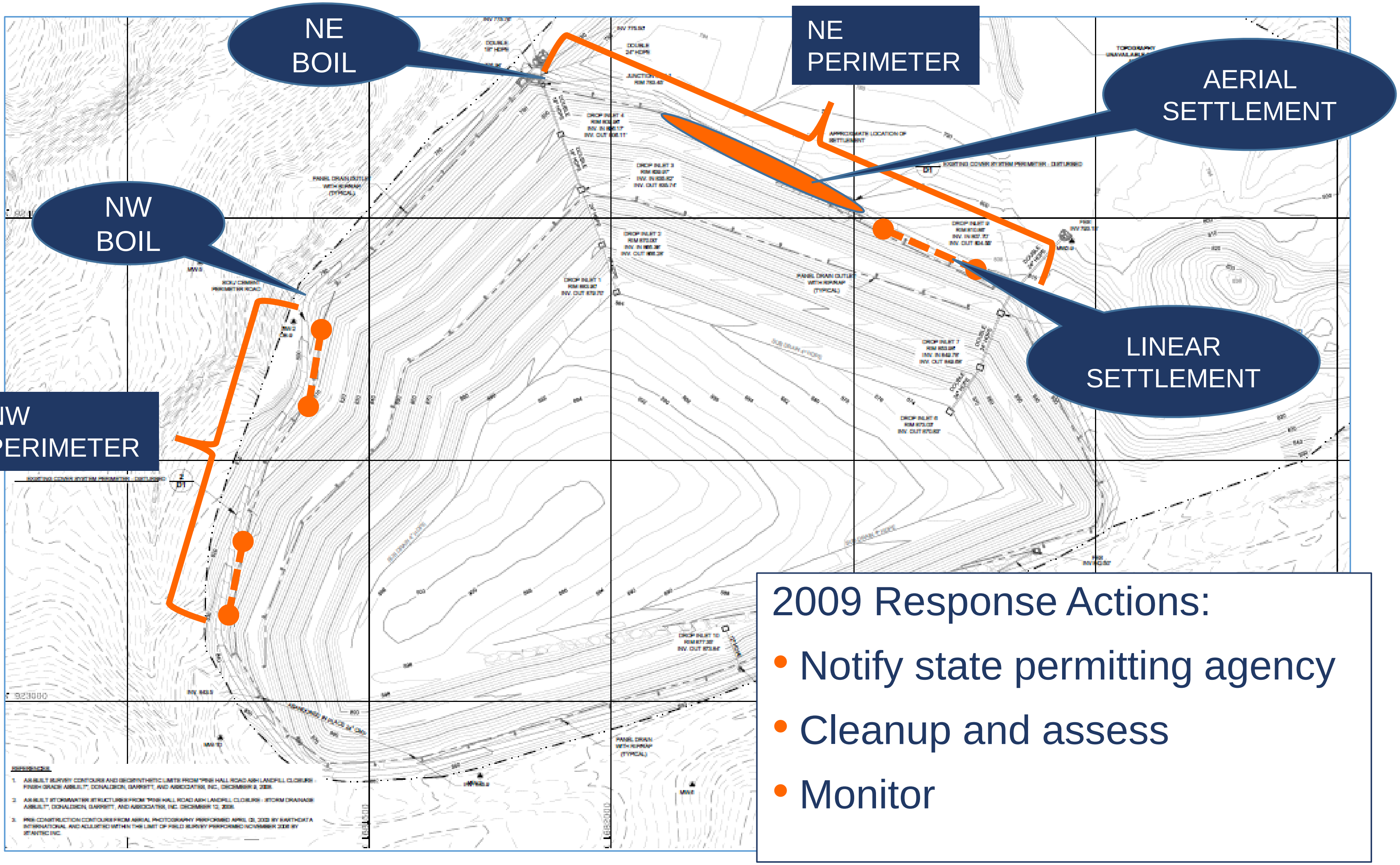
Settlement area (facing south)

Settlement and deformation northeast perimeter (2009)

Linear settlement feature

Linear settlement feature – up close

Perimeter cover settlement and boils (2009)



2009 Response Actions:

- Notify state permitting agency
- Cleanup and assess
- Monitor

Key trench – uncovered (2011)

Evidence of water flow and ash transport in key trench side wall

Subgrade void spaces filled with ash at key trench inside crest

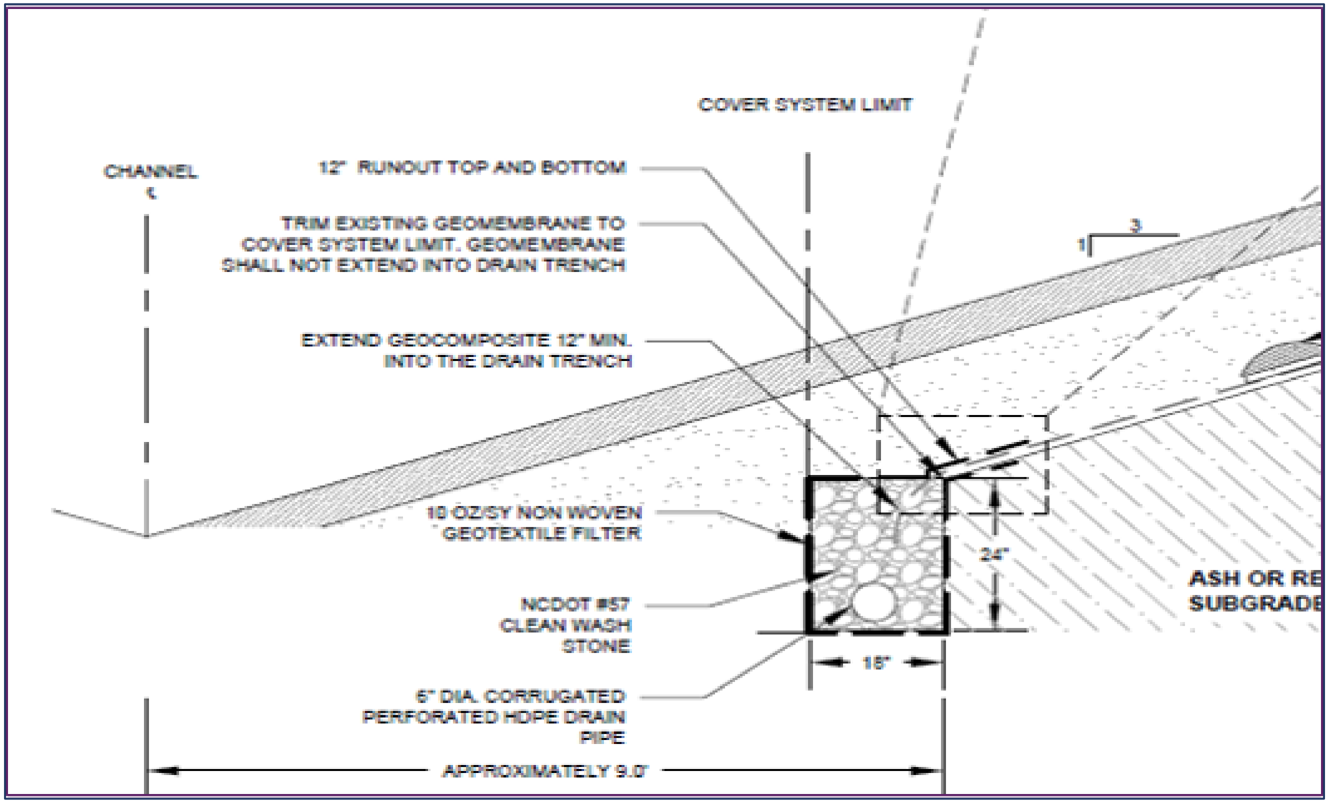
Settlement and deformation uncovered northeast perimeter (2011)

Cover soil removed and geomembrane exposed

Geomembrane removed – ash loss/undercutting at perimeter exposed

2011: Retrofit - install perimeter drain

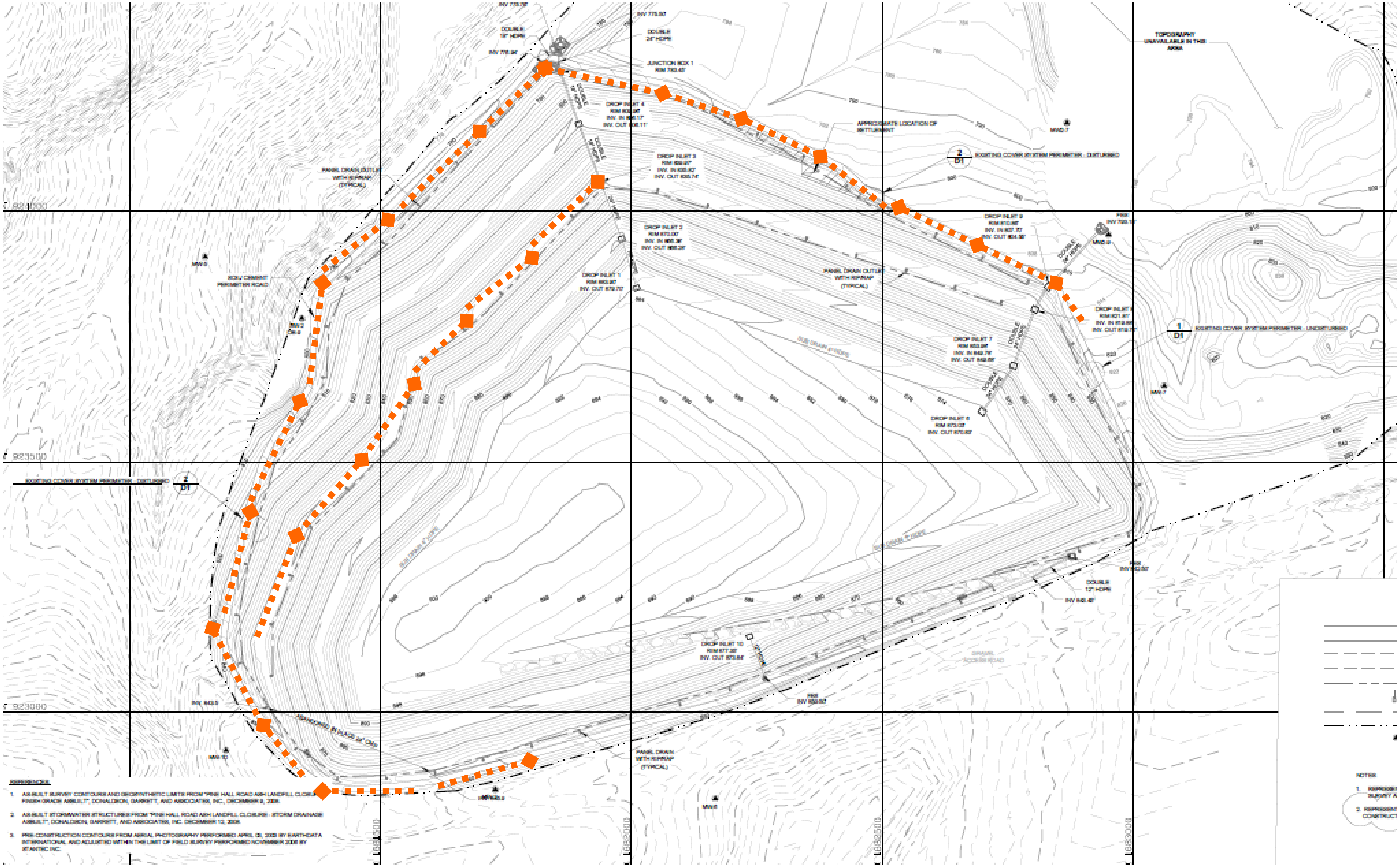
- Perforated pipe
- Drainage aggregate
- Non-woven geotextile
- 2 outlets at NW and NE downslope



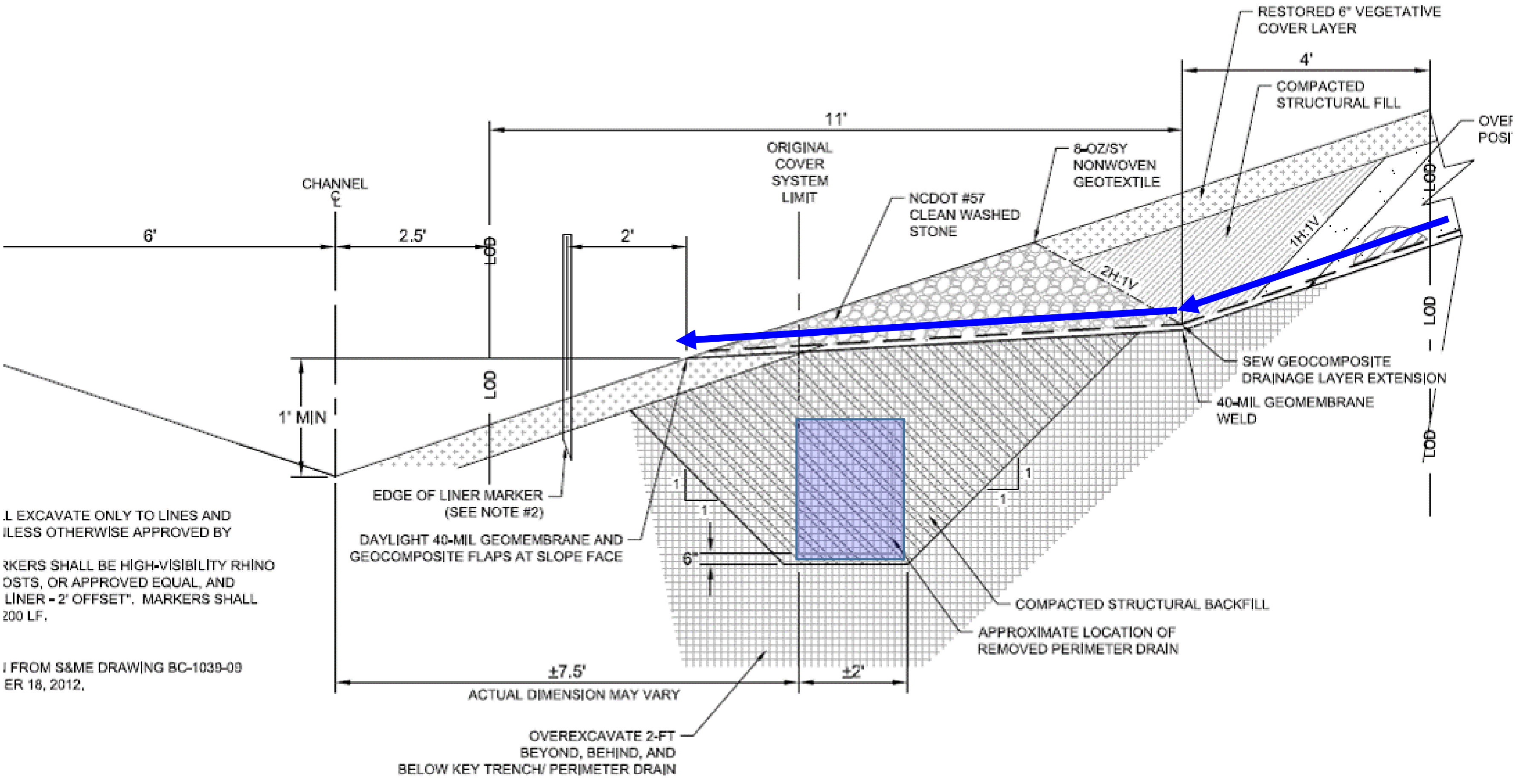
Recurrences and retrofit

- 2012:
  - Boil and linear settlement recurred NW
  - NE stable with clear water discharge
  - Retrofit NW with additional perimeter drain outlets
- 2015: Boil at NW
- 2016: Retrofit – Continuous outlet
  - Geocomposite/aggregate extending to toe
- 2019 – Satisfactory performance

2016 Retrofit – Continuous outlet



2016 Retrofit – Continuous outlet



2016 Retrofit – Continuous outlet

Remove and backfill the key trench – restore subgrade

Geomembrane flap – to direct infiltration water to perimeter

2016 Retrofit – Continuous outlet

Continuous outlet – after construction (2016)

Continuous outlet – April 2017

Cover System - Infiltration Water Management: Conclusions

- Original cover termination was susceptible to water intrusion
- Flow conduits existed, were created, and expanded
- Ash transport and deformation only along slopes of 3 to 6%
- Boils emerged at the low (downstream) end of the slope
- Take-aways…
  - Cover system perimeter terminations are critical
  - Infiltration water must be outlet with confidence
  - Construction quality is important – intimate contact between geomembrane and subgrade matters for cover system too
  - Applicable to ash pond closures

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CCR management trends

- Beneficial reuse
  - State law requiring beneficial reuse (NC and VA)
  - Sluiced ash differs from generation ash
    - Mixed fly and bottom ash
    - Carbon content
    - Organics
  - Demand dictates pace of removal – 300,000 to 400,000 tons/year
    - Removal rate influence closure duration
    - Longer closure durations may not be regulatory deadlines
  - Longer duration closure consider…
    - Increased contact water and wastewater treatment volumes
    - Longer dewatering efforts
  - Future mining? Consider characterizing ash during closure

CCR management trends

- Ash pond instrumentation & monitoring
  - Equipment access and construction stability
  - Design performance
- Closure in place to closure by removal
  - Site proposed/planned for in place closure…
  - Required to close by removal (VA and NC)
  - Voluntary closure by removal
  - Removal takes more time and increases costs
- Geomembrane applications
  - Lined retention ponds
  - Lined leachate tanks
  - Temporary rain cover
- Alternative cover systems

Questions?

Thank You For Attending!

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