EBC Solid Waste Management Webinar

Landfill Post Closure Care
The Gift that Keeps on Giving
Welcome

David Murphy

Chair, EBC Solid Waste Management Committee

Vice President, Tighe & Bond
Introduction

Thomas A. Mackie

Program Co-Chair

Shareholder, Mackie Shea Durning, PC
The Regulatory Perspective

Paul Porada, P.E.

Program Co-Chair

Technical Manager, Woodard & Curran
Regulatory Perspective

LANDFILL CLOSURE RULEBOOK
Subtitle D

Effective Oct. 9, 1991

- Subpart F - Closure and Post-Closure Care
  (§§ 258.60 - 258.63-258.69)
- Subpart G - Financial Assurance Criteria
  (§§ 258.70 - 258.75)

Subtitle D - MSW Landfills - Where? How?

- Subpart A - General (§§ 258.1 - 258.5-258.9)
- Subpart B - Location Restrictions (§§ 258.10 - 258.17-258.19)
- Subpart C - Operating Criteria (§§ 258.20 - 258.30-258.39)
- Subpart D - Design Criteria (§§ 258.40 - 258.43-258.49)
- Subpart E - Ground-Water Monitoring and Corrective Action (§§ 258.50 - 258.59)
  - Subpart F - Closure and Post-Closure Care (§§ 258.60 - 258.63-258.69)
  - Subpart G - Financial Assurance Criteria (§§ 258.70 - 258.75)
- Appendix I to Part 258 - Constituents for Detection Monitoring
- Appendix II to Part 258 - List of Hazardous Inorganic and Organic Constituents
Subpart F - Closure and Post-Closure Care

- § 258.60 Closure criteria.
  - Install Final Cover
  - Written Plan for Closure
  - Certification of Closure

- § 258.61 Post-Closure Care Requirements.
  - Maintain the Final Cover
  - Operate Leachate and Gas Systems
  - Monitor for Contamination
  - Written Post-Closure Plan

- § 258.62 Approval of site-specific flexibility requests in Indian country.
  - Two Landfills in Montana, One in California

Effective date of this part, October 9, 1993
§ 258.61 Post-Closure Care Requirements

Following closure the owner or operator must conduct post-closure care. 

>>> Post-closure care must be conducted for 30 years <<<

EXCEPT...

The length of the post-closure care period may be:

- **Decreased** if the owner or operator demonstrates that the reduced period is sufficient.
- **Increased** if the State determines that a lengthened period is necessary.

...to protect human health and the environment
Ending Post Closure Care - §258.61(e)

Following completion of the post-closure care period for each MSWLF unit, the owner or operator must notify the State Director that a certification, signed by an independent registered professional engineer or approved by the Director of an approved State, verifying that post-closure care has been completed in accordance with the post-closure plan, has been placed in the operating record.
FINANCIAL ASSURANCE?

Funds Reserved For the Future

✓ For Closure

AND

✓ For the entire post-closure care period

AND

✓ For corrective action

While the landfill is Actively Operating
Subpart G - Financial Assurance Criteria

- § 258.70 Applicability and effective date.
- § 258.71 Financial assurance for closure.
- § 258.72 Financial assurance for post-closure care.
- § 258.73 Financial assurance for corrective action.
- § 258.74 Allowable mechanisms.
- § 258.75 Discounting.

The owner or operator must provide continuous coverage for post-closure care until released from financial assurance requirements.

Effective date of this section
October 9, 1997
April 9, 1997
April 9, 1998
FINANCIAL ASSURANCE

Estimating the Future

- Detailed estimate, in current dollars, of the cost of hiring a third party to conduct post-closure care.
- Must be based on the most expensive costs of post-closure care.
- Must annually adjust the cost estimate for inflation.
FINANCIAL ASSURANCE MECHANISM

Ensure that funds will be available in a timely fashion when needed.

- Trust Fund.
- Surety Bond Guaranteeing Payment or Performance.
- Letter of credit.
- Insurance
- Corporate financial test.
- Local government financial test.
- Corporate Guarantee.
- Local government guarantee.
- Use of multiple mechanisms.
APPROVED STATE PROGRAMS

DELEGATION OF AUTHORITY

Federal Rules
40CFR Part 258

State Solid Waste Rules
Post-closure maintenance and monitoring for a period of time which is adequate to protect the environment and is at least 30 years.

Two years prior to the conclusion of the post-closure and on the basis of that data and any other pertinent information shall determine whether such disposal area is causing or has the potential to cause pollution of the waters of the state or presents a threat to public health. Thereafter, may require that the owner or operator of such disposal area continue for a specified time and in a specified manner to inspect, monitor and maintain such disposal area.
Does not apply to a municipally owned or operated solid waste disposal facility that accepts exclusively special waste, construction and demolition debris, land clearing debris.

The cost estimates must be based on projections for the entire expected time that the facility is expected to be generating leachate, methane or other gases, contaminants or otherwise potentially creating an adverse environmental impact, but in no case less than 30 years after a landfill facility closes.
NEW HAMPSHIRE

- The post-closure period for landfills **shall be 30 years** from the date the complete capping system is installed.
- The post-closure period shall be subject to periodic adjustment.

**Performance Standards**

- effectively cease generating leachate;
- effectively cease generating decomposition gases;
- achieve maximum settlement, with the capping system intact and no reasonable expectation that integrity of the capping system will be at risk without regular maintenance;
- have no adverse impact to air, groundwater or surface water; and
- not otherwise pose a risk to human health or the environment.
Financial assurance

until released by the department from financial assurance requirements by demonstrating compliance with the applicable closure, post-closure care, custodial care, and corrective measures requirements pertaining to the facility, and demonstrating that the facility and any waste remaining at the facility do not pose a threat to public health or the environment.

Post-closure care and custodial care

a) post-closure care period continues until the owner or operator can demonstrate to the department’s satisfaction that the threat to public health and the environment has been reduced to a level where environmental monitoring and maintenance can be reduced.

b) custodial care period begins when the owner or operator demonstrates to the department’s satisfaction that the facility poses a significantly reduced threat to public health and the environment and that environmental monitoring and maintenance can be reduced.
RHODE ISLAND

- meet the requirements of this rule for a **minimum period of 30 years** after landfill closure.

- The cost estimate for post-closure care must be **based on the most expensive costs** of post-closure care during the post-closure care period.
VERMONT

Financial Assurance

- Closed after October 9, 1993: 30 years of post-closure care.
- Closed prior to October 9, 1993: 20 years of post-closure care.
- The post closure care period may be increased from the standard 20 or 30 years if the Secretary determines that a lengthened period is necessary to protect human health and the environment.

Termination of Post-Closure Care: A permittee may make a written request accompanied by satisfactory demonstration that:

- care requirements contained in the post-closure plan have been completed; and
- continued post-closure care is unnecessary to protect human health and the environment.
Paul Porada, PE
Technical Manager

pporada@woodardcurran.com
800.426.4262
207.558.3796
207.239.2252

woodardcurran.com
The Regulatory Perspective

Greg Cooper

Director, Hazardous and Solid Waste Division
Bureau of Air & Waste
Massachusetts Department of Environmental Protection
MASSDEP LANDFILL POST-CLOSURE

SEPTEMBER 29, 2020

GREG COOPER
DIVISION DIRECTOR – HAZARDOUS AND SOLID WASTE DIVISION
BUREAU OF AIR AND WASTE
Post-Closure 19.142

• Maintain, care for and monitor the site during the post-closure period ... prevent any adverse impacts of the site on public health, safety or the environment.

• Post-closure period shall extend for a minimum of a 30-year period.

• MassDEP can extend the post-closure period where necessary in order to ensure protection of public health, safety or the environment or to mitigate adverse impacts.

• Termination of post-closure period ends upon written determination by MassDEP
Financial Assurance – 19.051

- FA adequate to assure that owner/operator is, at all times, financially capable of complying with 310 CMR 19.
- FA may be increased upon determination that amount is inadequate
- FA may be decreased but must continue to be sufficient to cover post-closure maintenance
- FA must be in full force and effect until MassDEP notice of expiration of post-closure period.
MassDEP Regulation Revisions

- MassDEP has proposed to conduct a regulation review over the course of the next year – 310 CMR 16 and 310 CMR 19
- Stakeholder meetings this Fall to gather input
- Stakeholder meetings in Winter to discuss proposed changes
- Draft regulations for public comment – Summer 2021
The Scientific Perspective

Jeremy Morris

Principal
Geosyntec Consultants, Inc.
Technical Basis and Approach for Evaluating the End of Post-Closure Care

Jeremy Morris, Ph.D., P.E.
29 September 2020
Agenda

• Components of Post-Closure Care
• Alternatives for Evaluating the End of PCC
  – Functional Stability (Performance-Based Approach)
• Technical Basis
• Overview of Evaluation Approach
  – Landfill Gas
  – Leachate
  – Final Cover
  – Confirmation Monitoring
• Summary and Closing
Components of Post-Closure Care

1. Leachate Management System
   - Leachate Recirculation
   - Leachate Collection System
   - Liner System
   - Leachate Treatment/Discharge

2. Groundwater Monitoring
   - Groundwater Monitoring Wells
   - Gas Probes

3. Gas Collection System
   - Gas Wells

4. Gas Migration Monitoring
   - Gas Probes

5. Cap Maintenance & Monitoring

6. Property Maintenance
   - Access Control

Typical PCC control systems per RCRA Subtitle D
What are the Alternatives?

- Time-Based (e.g., “walk away” after 30 years)
  → Arbitrary, Unlikely to be protective

- Perpetual Care
  → Arbitrary, Likely unnecessary, High financial cost to society, Not consistent with Subtitle D

- Target Criteria or Inert Endpoint (Organic Stability)
  → Impractical, Difficult (impossible?) to measure, Not linked to threat potential

- Performance-Based (Functional Stability)
  → Practical, Measurable, Protective, Technically defensible, Consistent with Subtitle D

40 CFR§258.61 example: “… stop managing leachate if the owner or operator demonstrates that leachate no longer poses a threat to human health and the environment”
Generalized Phases of Waste Degradation in Landfills

Phases:

I – Aerobic
II – Acid
III – Initial Methanogenic
IV – Stable Methanogenic
V – Methane Oxidation
VI – Air Intrusion
VII – Carbon Dioxide/Humic
VIII – Inert

Very long-term phases can be readily prevented by maintaining cover (passive control system)

Goal of functional stability

Organic stability

Performance-Based PCC: Step-Down Optimization to Functional Stability

Active PCC

Less Active

More Passive

Fully Passive, Self-Sustaining ("de minimis" level of effort)

Post-PCC Long-Term Management (generally focused on cap)

Organic Stability Line

Functional Stability Line

End of Regulatory PCC (Site is Functionally Stable)

Closure

Active Care

Passive Care

Level of Care Needed to Manage Threat to HHE

Care required decreases with time

Time

Active Care

Passive Care
Technical Basis for Evaluating Functional Stability

- Non-impacting relationship of closed landfill with receiving environment in the absence of active care
- Not concerned with organic stabilization of the waste, but with landfill emissions (defines non-impacting relationship with environment at POE)
  - The release of leachate and LFG constituents can be evaluated for potential impacts under conservative assumptions with defined end-use condition
  - Some level of cover maintenance is assumed
- Proactive data collection is essential
- Step-down reductions in PCC, and eventual termination, can be justified based on the outcome of these evaluations
  - Active → Mostly Passive → Fully Passive
- Monitor to confirm predictions before changes are finalized
LFG: Indicators of Functional Stability

- Demonstrate statistical downward trend in methane generation
- Define and meet functional stability target
- Eliminating active gas control on a trial basis does not result in impacts
  - Generally predicated by some level of cap maintenance
  - Gas management is compatible with beneficial reuse of the property
- Long-term passive/no gas management in place
  - Confirmed to be performing as designed
  - Can gas management be wrapped into a general property maintenance program?
Long-Term Landfill Behavior and Leachate Characteristics

• Bottom-most MSW layers become well decomposed and act as a biofilter
  – Important to maintain downward leachate flow regime
• Organics (including VOCs) are degradable in the landfill environment and show decreasing trend with degradation
• Metals precipitate as sulfides, carbonates, and hydroxides
  – Remobilization of metals in leachate over the long term is unlikely unless landfill condition changes dramatically
    • Maintain cover as barrier to air intrusion
• Ammonia and chloride tend to accumulate
• Good surrogates (“gateway indicators”) for predicting future leachate quality
  – BOD (<100 mg/l for well-degraded waste)
  – BOD/COD (< 0.1 for well-degraded waste)
Basis for Leachate Assessment

• Adequate monitoring data to confidently characterize the leachate source
  – Regulated list in groundwater, surface water
• Demonstration that the historical concentration trend for gateway indicators is decreasing or steady
• Define long-term cover conditions, POC, POE
• Strategy for long-term leachate management
  – Can LCS operation be scaled back or eliminated?
  – Is the “bathtub effect” a concern?
  – Can more passive leachate management measures be considered?
  – Where will leachate/effluent be discharged?
• Demonstrate the acceptability of the proposed strategy based on evaluation of the potential threats at POE as measured at POC
  – Define hydrogeological fate and transport model
Establishing the Site Hydrogeologic Model

- **STORMWATER INFILTRATION**
- **LEACHATE RISER**
- **SUBSURFACE POTENTIAL LEAKAGE**
- **GROUNDWATER WELL (POC)**
- **LEACHATE STORAGE/TREATMENT**
- **PROPERTY BOUNDARY (POE)**
- **SUBSURFACE**
- **LATERAL MIGRATION**
- **SENSORS**
- **OUTFALL (POC)**
- **RUNOFF**
- **SEEPS**

Red = Leachate
Blue = Groundwater
Green = Surface Water
Leachate: Indicators of Functional Stability

• “Gateway” indicators
  – Downward trend; Concentrations below FS targets

• Future leachate release would not cause impacts
  – Generally predicated by some level of cap maintenance
  – Leachate management is compatible with beneficial reuse of the property

• Long-term passive/no leachate management in place
  – Confirmed to be performing as designed
  – Can leachate management be wrapped into a general property maintenance program?
Indicators of Functional Stability: Cap Maintenance

• Regulatory requirements for Cap are met
  – Containment

• Performance requirements for Cap are met
  – Geomechanical stability demonstrated
  – Significant settlement completed (future settlement is *de minimis*, <5% annual change)
  – Long-term performance requirements for leachate and LFG management

• Main Questions:
  – What management is required to maintain containment (cover integrity)?
  – Could a landscaper perform this task?
Confirmation Monitoring (CM)

• Specific, fixed-term monitoring program designed to demonstrate that making a change to PCC was appropriate
  – Eliminates reliance on modeling as the basis for decision making
• Independent of compliance monitoring
• Final component of CM is demonstration that complete transition to passive controls does not result in impacts
• Leachate example:
  – Demonstrate that groundwater quality is not impacted by eliminating LCS operation
  – Calculate time of travel (TOT) from low-point on liner to downgradient GW well (POC)
  – Select fast-moving conservative indicator parameter (e.g., chloride)
  – Monitor for indicator parameter at POC well for TOT duration
• LFG example:
  – Demonstrate that eliminating active LFG system does not result in methane migration
• In all cases, active controls should remain in place until CM is completed
Pressure monitoring and migration monitoring system

Passive cut-off trench installed

CM duration based on max. TOT from landfill toe to gas probes calculated as approx. 9 months

Geosyntec consultants

Geomembrane Capped, Unlined Landfill in New York (Closed 1990s)
Pressure Readings under Geomembrane Cover
Migration Probe M-1B Landfill Gas Readings

- Readings collected by CBSI Environmental Infrastructure, Inc.
- Data obtained using a GEM 2000 landfill gas meter.
Summary

• Under a data-driven, performance-based approach, PCC is continued for as long as necessary with tangible targets for completion
  – Defined in terms of Functional Stability
  – Quantified in terms of leachate and LFG emissions

• Proactive data collection is essential

• Progress to Functional Stability generally involves making step-down reductions to optimize leachate and LFG controls
  – Active → Mostly Passive → Fully Passive
  – Consistent with defined end-use condition

• Changes demonstrated to be effective using Confirmation Monitoring

• Cap inspection and maintenance will remain

• Once all controls are passive, regulated PCC should end
  – Beneficial reuse helps pay for residual care
What Happens After Completion of PCC?

- **Long-Term Management (LTM)** as defined under SWANA Technical Policy T-9.4
  - “*De minimis*” level of care needed after regulatory PCC obligations are completed
  - Achieved by demonstrating *Functional Stability*
  - Passive controls in place, incl. cover system

- **Likely consists of:**
  - Cover maintenance
  - Maintenance of other site features and access controls
  - Control of nuisances

- **Mandated through land use controls:**
  - Deed restrictions, covenants, other legal instruments
  - Uniform Environmental Covenants Act (UECA)

Owner retains responsibility
No “walk away”
References

• Solid Waste Association of North America (SWANA)

• National Waste and Recycling Association (NWRA)
  – Performance-Based Approaches to Evaluate the Termination of Landfill Post-Closure Care Requirements (Dec 2018)

• Environmental Research and Education Foundation (EREF)
  – Transitioning from Active to Passive Care at Municipal Landfills: Full-Scale Site Evaluations using the EPCC Methodology (Prepared by Geosyntec, Apr 2016) https://bit.ly/2A5Y7gM

• Peer Review Publications
Jeremy Morris
Principal, Geosyntec Consultants
Columbia MD

410-381-4333
jmorris@geosyntec.com
The Owner’s Perspective

David Moreira

Area Director
Environmental Legacy Management Group
Waste Management
From PCC to Beneficial Re-Use: An Owner’s Perspective

Dave Moreira
WM Director, Environmental Legacy Management Group

Acknowledgements:
Jeff Murray, PE, Former President, SWANA
Dr. Bryan Staley, PE, President and CEO | EREF
Mike Caldwell, Director Environmental Protection, WM

EBC Solid Waste Management Webinar
September 29, 2020
Why Now?

- 30 year Post-Closure Care obligations for some solid waste landfills will soon expire
- Industry stakeholders are seeking “certainty” to facilitate long-term planning and potential re-utilization of closed assets, including:
  - Ensuring continued protection to HHE
  - Clearly defined roles and responsibilities during beneficial re-use project evaluation and their subsequent implementation
  - Consideration of appropriate property limitations (e.g. deed restrictions, AUL, etc.) that align with beneficial re-use
Goal

- Re-use of landfills is hindered, in party, by uncertainty of post post-closure care requirements and associated liability management.

- An objective, technically based process to evaluate closed landfills and identification of potential re-use limitations would ensure “transparency” with State regulators, the community, as well as potential re-use entities.

- A technically based approach would facilitate beneficial re-use evaluations and increase the range of redevelopment opportunities, presumably expanding beyond current successes of “open space” and “solar farms.”
What is the Federal Framework?

The length of the post-closure care period may be:

• (A) decreased by the Director of an approved state if the owner or operator demonstrates that the reduced period is sufficient to protect human health and the environment; or

• (B) increased by the Director if it is determined that the lengthened period is necessary to protect human health and the environment.

Of note; EPA on evaluating threat of MSW Leachate:

• “Concentrations at the point of exposure, rather than concentrations in the leachate in the collection system, may be used when assessing threats.” - EPA 1998, Section 6.6.3
SWANA’s New Technical Policy T-9.3 (1/11/19)

- “T-9.3 Termination of MSW Landfill Post Closure Care Requirements”
  - Developed in Collaboration with NWRA
  - Reviewed and Approved by Technical Divisions and 70 Member International Board

- **Policy Statement:**
  - PCC Term is finite
  - Term should be defined using site-specific data and a performance-based approach
  - Technical evaluation methodology and performance-based criteria should be agreed upon in advance
Approaches for Performance Based PCC

- **Organic Stabilization (WI)**
  - demonstration of a relatively inert waste mass (unrealistic)

- **Functional Stability (FL & WA)**
  - considers long-term emissions in context of threat potential WITHOUT active controls
  - measured at a point between landfill and a potential POE

Goal in either case is going from active post-closure care to a point of custodial or ‘*de minimus*’ care where HHE is protected.
Functional Stability

- Relies on conservative impact assessments to define PCC monitoring and management (Morris and Barlaz, 2011)
- “A landfill is functionally stable when it does not pose a threat to human health and the environment at a point of exposure in the absence of active control systems.”

- **Key Control Elements:**
  - Active: Leachate and LFG control systems
  - Passive: Cover system

- **Key Confirmation Monitoring Elements:**
  - Focused Groundwater and Methane migration monitoring to “confirm” Functional Stability assessment

- *Condition Precedent* – Owner must ensure collection of sufficient site specific information to perform impact assessments thru Functional Stability analysis
Performance-Based Post-Closure Care and Functional Stability

- **Active PCC**
- **Partially Active PCC**
- **Passive, Self Sustaining PCC**

**Functional Stability Line**

**PCC Completion, end of Regulatory PCC**

- Custodial Care
  - ("de minimus" level of effort, generally focused on cap)

- Required PCC decreases with time

- Level of Effort Needed to Manage Threat to HHE

- Time*

- *(No presumptive scale; time needed to move from Closure to Completion is site specific)*

- e.g., biovents for remaining fugitive methane control

- e.g., constructed wetlands for leachate polishing prior to discharge

- e.g., constructed wetlands for leachate polishing prior to discharge

- Organic Stability Line

- Closure

- Custodial Care Program

- Regulatory PCC Program

- Site is Functionally Stable

- Performance-Based Post-Closure Care and Functional Stability

- *(No presumptive scale; time needed to move from Closure to Completion is site specific)*
Where Can We Go?

- SWANA/NWRA Policies final
- State Guidelines can be used as templates:
  - Functional Stability – FL or WA
- Begin the data collection process
FDEP developed the first substantive state guidance document that provides metric-driven objectives for ending regulatory post-closure care and a framework for compliance.

A final determination of “functional stability” can facilitate beneficial re-use of the property with the end-use defining the potential POE.
Guidance Document SWM-04.45
LTC AT SOLID WASTE DISPOSAL FACILITIES
February 20, 2016

The performance-based approach focuses on helping regulators and owner/operators decide when a disposal facility has reached "functional stability" rather than, for example, becoming completely stabilized. For the purposes of this guidance, functional stability for a disposal facility means the facility no longer poses an unacceptable threat to human health or the environment (HHE) at the point of exposure in the absence of active controls. Once a disposal unit has reached functional stability, then the regulatory LTC period for that facility is complete and it can be moved into non-regulatory, custodial care. Custodial care could include activities

7 Florida's concept of LTC is identified as post-closure care (i.e., PCC) in EPA's Subtitle D regulations and essentially means the same thing for the purposes of this guidance.
8 For example, case studies using this methodology are presented in EREF (2011), and Morris, et al. (2013).
Alignment of Stakeholder Goals: Beneficial Re-Use of Closed Landfills

- Engage stakeholders on how landfills are properly managed during Post Closure period.
- Demonstrate thru Functional Stability process that site specific conditions have been fully evaluated and protective of HHE (i.e., “no threat”)
- Maximize consideration of varied and assorted opportunities upon exiting Post Closure, specific to site setting, community planning, etc.
Benefits of Performance-Based Goals

• Regulators
  • Defensible Data-Driven Outcomes

• Owner/Operators
  • PCC Certainty for financial planning purposes and asset re-utilization

• Neighbors
  • Engagement in beneficial re-use land management options for development planning
## Existing East Coast Solar Projects – Closed WM Landfills

<table>
<thead>
<tr>
<th>Site</th>
<th>Acreage</th>
<th>Power Generation (MW DC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berkley, MA</td>
<td>14</td>
<td>3.6</td>
</tr>
<tr>
<td>Cinnaminson, NJ</td>
<td>40</td>
<td>13.1</td>
</tr>
<tr>
<td>Hudson, MA</td>
<td>12</td>
<td>5.83</td>
</tr>
<tr>
<td>Amesbury, MA</td>
<td>27</td>
<td>5.96</td>
</tr>
<tr>
<td>Chicopee, MA</td>
<td>7</td>
<td>2.54</td>
</tr>
<tr>
<td>Bordentown, NJ</td>
<td>45</td>
<td>10.9</td>
</tr>
<tr>
<td>Burlington County, NJ</td>
<td>53</td>
<td>12.95</td>
</tr>
</tbody>
</table>
Partnership in Land Development – Beneficial Re-Use of a Closed Landfill

Functional Stability and Land Development – Case Study of a cooperative effort between Waste Management, the City of Ft. Worth and TCEQ
Mr. Andrew Shafer  
District Manager  
Waste Management of Texas, Inc.  
9590 Clay Road  
Houston, Texas 77080

Re: Eastside Landfill – Tarrant County  
Municipal Solid Waste (MSW) – Permit No. 1004C  
Completion of Post-Closure Care Period and Permit Revocation  
Tracking No. 19525583; RN100218437/CN602613069

Dear Mr. Shafer:

On July 22, 2015, Ms. Jennifer Wells of the Texas Commission on Environmental Quality (TCEQ), Region 4, Office in Fort Worth, inspected the referenced MSW facility. The purpose of the inspection was to verify that all on-site activities necessary for the site to exit the post-closure care maintenance period had been completed. In a follow up report, our representative determined that all post-closure care maintenance requirements stated in Title 30 of the Texas Administrative Code (TAC), Section §330.463 (relating to Post-Closure Care Maintenance Requirements) had been satisfied and the site has completed the post-closure care maintenance period. This office is also in receipt of the Request for Voluntary Revocation form signed by you. A certified copy of an “Affidavit to the Public” for this site was received on July 17, 2015.
Summary

- 30 year Post-Closure Care obligations will soon expire
- Industry seeking a process to facilitate long-term planning and re-utilization of closed assets
- The Functional Stability evaluation of a closed landfill ensures transparency with State regulators and the community regarding continued protection of Human Health and the Environment
- Includes a “confirmation monitoring” component to verify Functional Stability conclusions
- Creates a technical framework within which potential beneficial re-use opportunities can be evaluated
Contact:

Dave Moreira | Waste Management
dmoreira@wm.com
T: (603) 929 5446
The Path to a Functionally Stable Landfill

Kirstie Shurie

Project Manager
Tetra Tech
The Path to a Functionally Stable Landfill

Presented at the EBC Solid Waste Management Webinar
Landfill Post Closure Care, *the Gift that Keeps on Giving*
Post Closure Care Challenges

- **Current Regulations**
  - 30 Year duration of PC period is uncertain
  - No specific criteria for completion
  - Not consistent from state to state

- **Financial Assurance Plan**
  - Required of all Subtitle D facilities
  - Cost estimates of all future O&M activities
  - Must be accurate and defensible
Post-Closure Activities

- **Active Landfilling**
- **Post Closure Care**
- **Extended/Custodial Care**

Time: 0 years → 30 years → ??
“A landfill is functionally stable when it does not present a threat to human health and the environment at the point of exposure.”

Source: SWANA Bioreactor Committee, Stability Subcommittee

- Landfill Dormancy:
  - no further settlement
  - steady leachate generation rate
  - little variability in leachate quality
  - no LF gas production
“...........it is not possible to accurately predict landfill leakage rates because of the complexity and diversity of many waste sites, as well as other factors difficult to control. Therefore, EPA currently lacks the scientific basis to develop specific criteria to determine the adequacy of 30 years of post-closure care at Sub-title D facilities.”

Unpredictable (nearly) Factors

• Financial
  ▪ Interest rate
  ▪ Inflation

• Regulatory
  ▪ Cleanup standards
  ▪ Policy changes

• Technical
  ▪ Leachate treatment processes
  ▪ Mining/alternate disposal options
  ▪ Organics management
  ▪ Local demographic changes
Performance Based Approach

- Collect Data Through Active and Post-Closure Periods
- Extrapolate through Post-Closure and Custodial Care
- Cleanup Standard
- Functionally Stable
Real-Life Examples – Extended/ Custodial Care

- **Landfill in extended Post Closure/ Custodial Care**
  - 140 acre “modern” landfill facility
  - Active GCCS – sustained LFG flow of approximately 300 scfm
  - Active leachate collection system direct discharge to local water treatment facility
  - Ongoing settlement/cover maintenance
  - End of 30 year PC period: 2017
Real-Life Examples – Release from PC care

- Landfill released from care
  - Small 36 acre LF – “Open field”
  - No baseliner or leachate collection
  - Passive vents
  - Multiple DEP inspections
  - Final maintenance required prior to release
  - PC period: 41 years
In the Mean Time.......Need to Predict....

• LF Gas Generation Rate.............LandGEM Model  
• Leachate Generation Rate......HELP Model  
• Leachate Quality.........Rowe Model  
• Groundwater Quality Impacts........MODFLOW Model
Now on to Modeling...
Landfill Gas Prediction
Landfill Gas Emissions Model (LandGEM)

- Developed by the USEPA – [www.epa.gov](http://www.epa.gov)
- Basis in Scholl Canyon Studies (1970’s)
- Used for Regulatory Assessment – NSPS/Emissions Guidelines
- Fairly Simplistic
- Easy to Use
- Few Modifier Inputs – Limits Flexibility
Factors in LFG Modeling

- Accurate Disposal History
- Waste Characteristics
- Volume of Cover Soils Placed
- Things Change and Models Will Need to be Updated
- Actual LFG Recovery Data
- Relative Moisture of the Waste Mass
  - Known Leachate Mounding
  - Leachate Recirculation
Example Site

- Remaining Operational Life of 76 Years (from 2015)
- Closure in 2091
- MSW Landfill
- 38,022,000 CY Total Airspace
- 27,219,900 CY Remaining Airspace (from 2015)
- Standard EPA defaults
  - $k = 0.04$
  - $Lo = 100$
Predicted LFG Collection – Example Site

Adjusted Total Landfill Gas Collection (1973-2091)

- 76 years Remaining life
- 30 years Post-Closure
- 56 years Custodial Care

Year:
- 2015
- 2091
- 2121
- 2178

Total Landfill Gas (cubic ft/min):
- 0
- 500
- 1000
- 1500
- 2000
- 2500
- 3000
- 3500

Adjusted Total Landfill Gas Collection (1973-2091)
Leachate Management Components:

Leachate Generation

Leachate Quality
Leachate Generation
Actual Leachate Generation Rates – Example Site

Total Annual Leachate Generation = 7,562,437 gallons

Month: January, February, March, April, May, June, July, August, September, October, November, December
Estimating Leachate Generation Rates

In = Out +/- change in storage

• Precipitation Rate

• Landfill Cover:
  – Type of Liner
  – Area Covered
  – Age

• Bottom Liner
  – Area Covered
  – Method of Leachate Recovery
“HELP” MODEL

Hydrologic Evaluation of Landfill Performance

• Tool developed and required by USEPA for LF closure design
• Applies to active or closed sites
• Calculates average values of:
  • runoff
  • evapotranspiration;
  • drainage;
  • leachate collection; and
  • liner leakage.
Leachate Quality
Five Phases of a Landfill’s Life

**PHASE 1. Waste Placement**
- Aerobic decomposition until trapped O$_2$ used up

**PHASE 2. Transition Phase**
- Oxygen depleted, ORP goes negative, organic acids lower pH

**PHASE 3. Acid Phase**
- Fermentation of SW, H$_2$ forms, heavy metals mobilized

**PHASE 4. Methane Fermentation Phase**
  - Methane is formed, pH rises to neutral, BOD/COD decrease

**PHASE 5. Maturation Phase**
  - Active degradation moves toward dormancy, gas prod. drops
Ammonia Nitrogen in Leachate – Example Site

Concentration (ppm)

Date

May-13  Nov-13  Jun-14  Dec-14  Jul-15  Jan-16  Aug-16  Mar-17  Sep-17
analytical model for soluble, non-biodegradable compounds in leachate (e.g. ammonia, chloride)

• Inputs:
  – Current leachate concentration
  – Total mass within landfill:
  – Leachate generation rate
  – Current water quality standard

• Output:
  – Time required to meet selected water quality standard
Groundwater Management
Unlined Capped Landfill – Example Site

- Vertical Extraction Wells
- Treatment Plant
- Shallow Underdrain
Benzene Plume @ 38’ (ppb) – Example Site
MODFLOW Model Prediction of Groundwater Quality – Example Site

Concentration vs. Time

47 Years

Time [days]
SUMMARY

- Modeling can be used to estimate the time to reach “Functional Stability”
- Modeling results are only as good as inputs
- Financial planning requires estimates of long-term landfill gas, leachate, and groundwater management costs.
- Predicting the financial and regulatory environment 30+ years into the future is difficult at best.
RECOMMENDATIONS

- Site data should be collected during active and initial post-closure periods for extrapolation into the future.
- Financial plans and modeling should be revisited and updated often to account for financial, regulatory and technical changes.
Contact Information

Kirstie Shurie

Tetra Tech

kirstie.shurie@tetratech.com

Office: (845) 695-0278

Cell: (818) 903-2387
Moderated Discussion

Moderator: Paul Porada, Woodard & Curran

Panelists:
- Greg Cooper, MassDEP
- David Moreira, Waste Management
- Jeremy Morris, Geosyntec Consultants, Inc.
- Kirstie Shurie, Tetra Tech