Performance-Based Evaluation of Post-Closure Care at MSW Landfills

Jeremy Morris, Ph.D., P.E.
Geosyntec Consultants
Columbia, Maryland

on behalf of the
Environmental Research & Education Foundation
Thursday, 13 December 2012
1:00 pm - 2:30 pm, Eastern Time

EREF

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Outline (1)

ULTIMATE GOAL
End Regulated Care in a Safe and Defensible Manner

1. Overview and Context
   - PCC under Subtitle D
   - Landfill PCC and Sustainability
   - Problem Statement: U.S. Regulatory Context
2. Technical Basis for Performance-Based PCC
   - Functional Stability
   - End of Regulated PCC (Custodial Care)
3. Performance-Based PCC Reference Tools
   - EPCC Methodology (EREF)
   - ITRC Guidance

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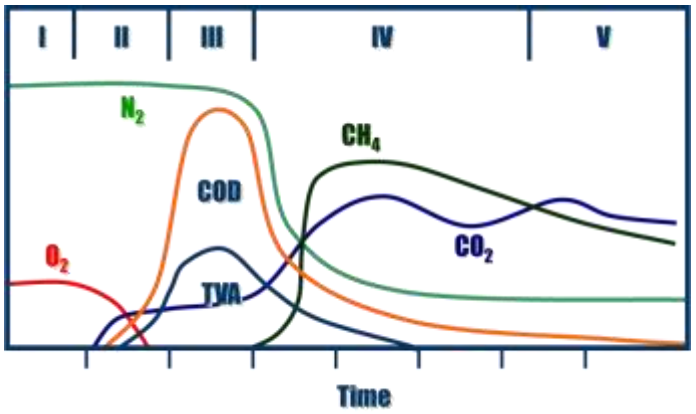
Outline (2)



4. Application of the Tools
5. Example: Site Evaluation
   - Leachate
   - Landfill Gas
   - Groundwater
   - Final Cover
6. Cost Considerations
7. Closing Summary
8. References

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Reminder: Process for Questions

POLLING DURING PRESENTATION

USE CHAT FUNCTION

Q&A SESSION AT END OF PRESENTATION

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1. Overview and Context

Why End PCC?

- Resource optimization
- Beneficial land reuse
  - Recreational
  - Commercial
  - Agricultural

- Cost certainty
- Liability management
- Community goodwill

- Keeping up with historical landfills
- Avoid an ever increasing workload
  - Ever-increasing number of sites being closed
  - Focus regulation and attention where most needed

Country	Operating landfills (1990s)	Operating Landfills (late 2000s)
USA	6300	1800
Germany	560	330
UK	2000+	465

Ref: Laner, et al. (2012)

Duration of PCC: Current State of the Practice

- Subtitle D (40 CFR Part 258)
  - The general assumption is a prescriptive 30-year term for PCC
    - Used as the basis for financial assurance (FA)
    - Presumptive term varies by State
  - Where does this come from?
    - 30 year minimum PCC duration is founded in Subtitle C

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Review of Subtitle D

40 CFR § 258.61 Post Closure Care Requirements

(a) Following closure of each MSWLF unit, the owner or operator must conduct post-closure care. Post-closure care must be conducted for 30 years, except as provided under paragraph (b) of this section,

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

(1) 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 and this demonstration is approved by the Director of an approved State; or

(2) Increased by the Director of an approved State if the Director of an approved State determines that the lengthened period is necessary to protect human health and the environment

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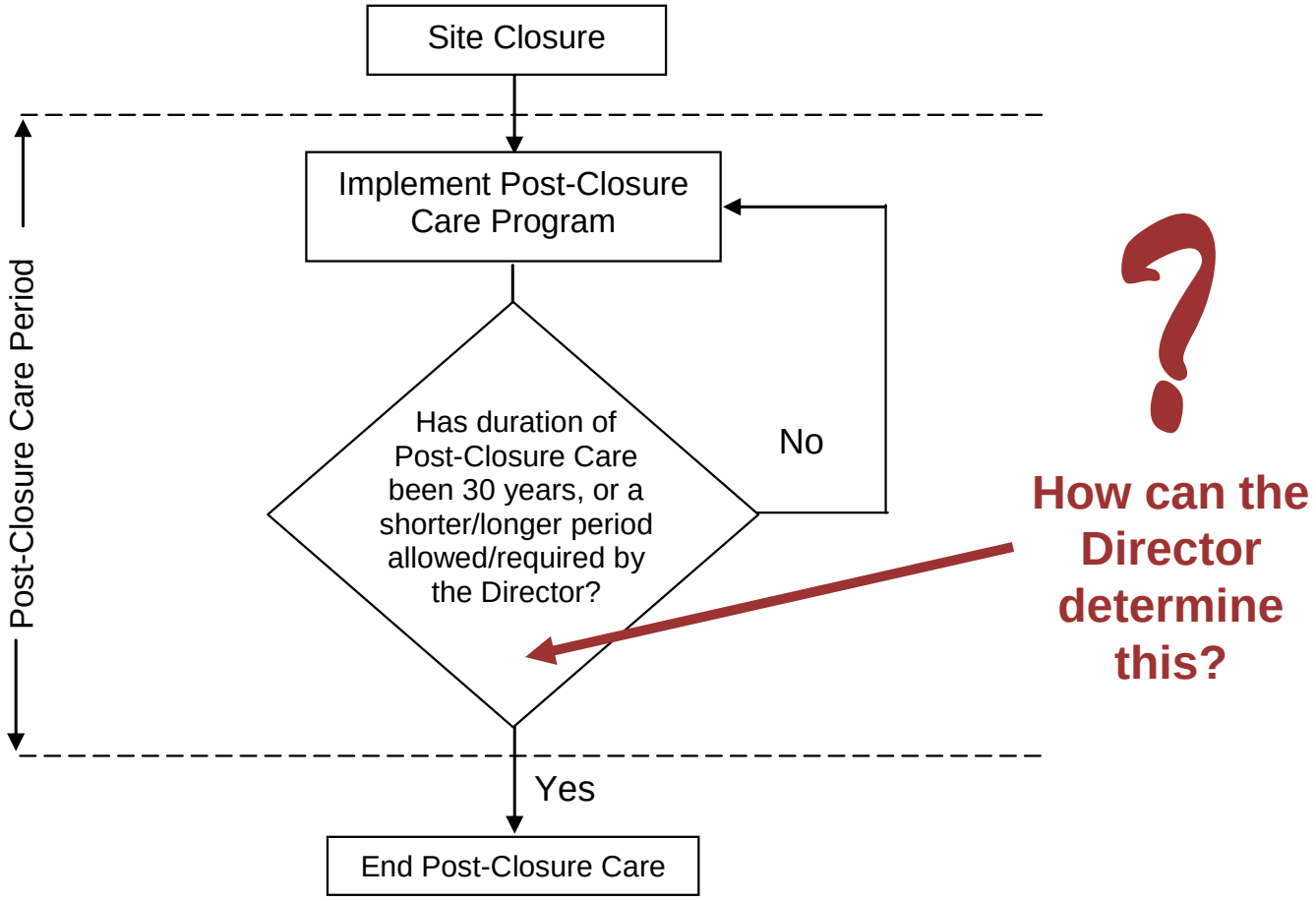
Current PCC Model under Subtitle D



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Regulatory Flexibility under Subtitle D

(1) Maintaining the integrity and effectiveness of any final cover, …;

(2) Maintaining and operating the leachate collection system …if applicable. The Director of an approved State may allow the owner or operator to stop managing leachate if the owner or operator demonstrates that leachate no longer poses a threat to human health and the environment…;

(3) Monitoring the ground water in accordance with the requirements of subpart E of this part, …if applicable

→Ending PCC is defined in terms of performance, but little/no official technical guidance has been promulgated

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Alternatives for Defining PCC Duration

- Time Based:
  - "Walk Away" at 30 years or at some specified time
  - Unrealistic, but essentially the current basis of FA
- Define a Range of Post-Closure Timeframes Based on Facility Characteristics and Assigned Risk Levels
  - Receptor proximity, Site conditions, Landfill design/operation
  - Difficult to define and characterize landfills in this way
- Perpetual Care or "Very Long Term" PCC
- Inert Endpoint (i.e., Waste "Stabilization")
  - Ontario (contaminating lifespan), Europe (final storage quality)
  - Wisconsin DNR (2007)
- Performance-Based Timeframe
  - Basis in Subtitle D
  - DoD and some States are already there

Problem Statement: U.S. Regulatory Context

- USEPA Subtitle D
  - Post-closure care period must be 30 years, unless shortened or lengthened by State Director
  - Ending PCC is defined in terms of performance, but little/no official technical guidance has been promulgated

- States with Specific PCC Regulations
  - Virginia: Guidance for Terminating PCC (2006)
  - Wisconsin: Landfill Organic Stability Plans (2007)
  - California: Proactive Monitoring for PCM and Step-Down FA (2010)
  - Washington: Performance Based Criteria (2012)

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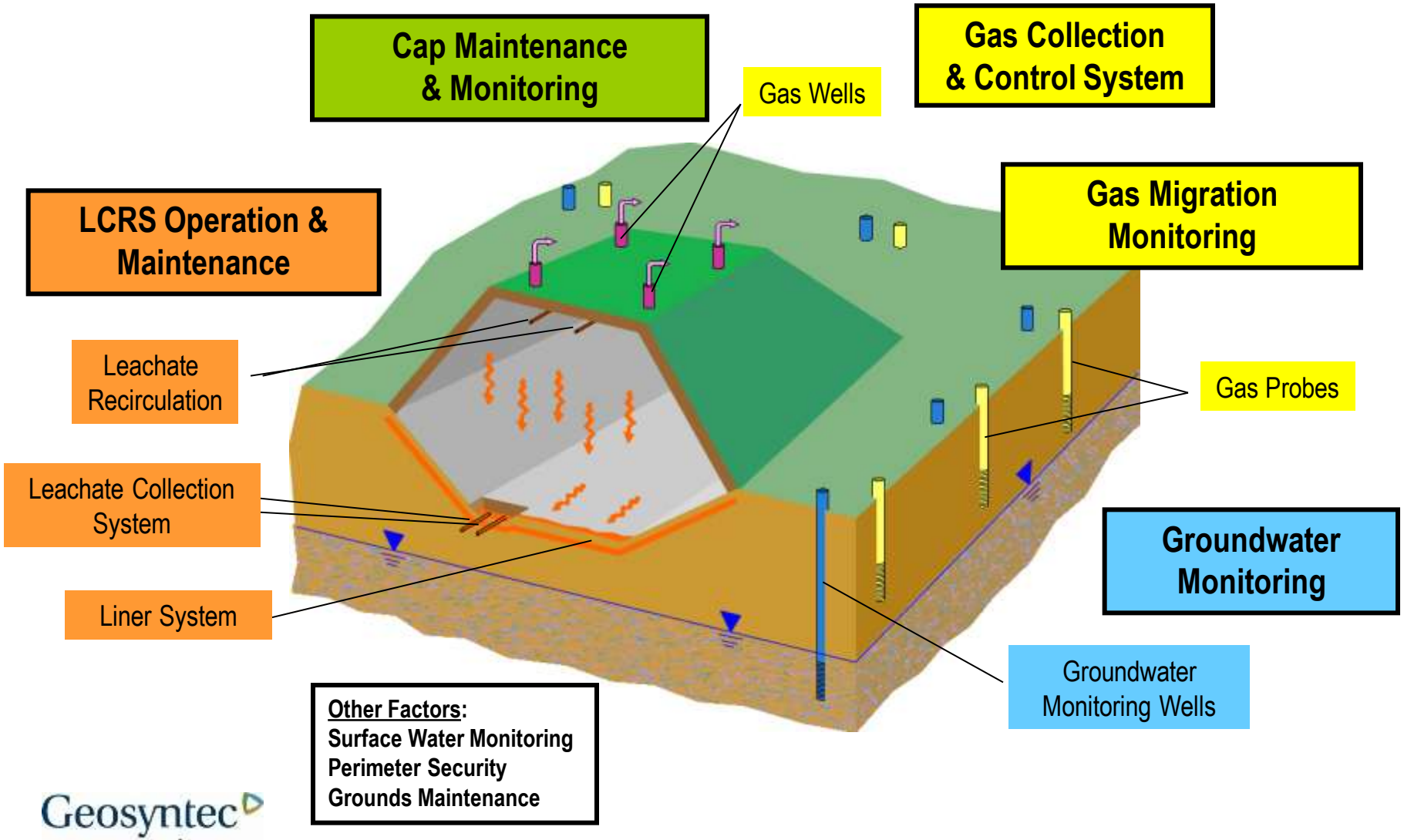
2. Technical Basis for Performance-Based PCC

PCC Control Systems (per Subtitle D)



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Technical Basis for Performance-Based PCC (Demonstrate Functional Stability)

- Define the intensity and duration of PCC systems and activities in terms of "Functional Stability"

- Identify reliable indicators of Function Stability on a site-specific basis

- DATA

- Perform evaluation(s) to demonstrate Function Stability

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Definition of Functional Stability

Functional stability is a term used to define a closed landfill's non-impacting relationship with its receiving environment in the absence of active PCC

"*A landfill is functionally stable (in a stable condition) when it no longer poses a threat to human health and the environment… Potential threats should be assessed in the context of a proposed end use and a proposed level of care…*"

Originally proposed by SWANA's Bioreactor Committee, June 2004

Basis of EREF and ITRC Methodologies, Sept 2006

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Indicators of Functional Stability

- Define the intensity and duration of care in terms of "Functional Stability"
- Reliable indicators of Functional Stability:
  - ✓ Landfill source can be characterized in terms of emissions (leachate and landfill gas)
  - ✓ Trends in concentrations and quantities at the source can be defined according to a prescribed site management strategy
  - ✓ The release of constituents can be evaluated for potential impacts to HHE
  - ✓ Changes to, or ending, PCC can be justified based on the outcome of these evaluations
  - ✓ We can monitor to confirm our predictions

→ Function Stability implies we understand a lot about a landfill!

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Demonstrating Functional Stability Implies that We Understand…

- Sideslope, cover, and liner stability and settlement
- Site geology and hydrogeology
- Potential receiving media
- Risk to ecosystem and human exposure
- Climate
- Leachate quantity and quality, downtrends
- Landfill gas composition and generation, downtrends

This Means Data!!

And…we must have a clear long-term strategy for leachate management, gas management, and site end use that reflects all the above

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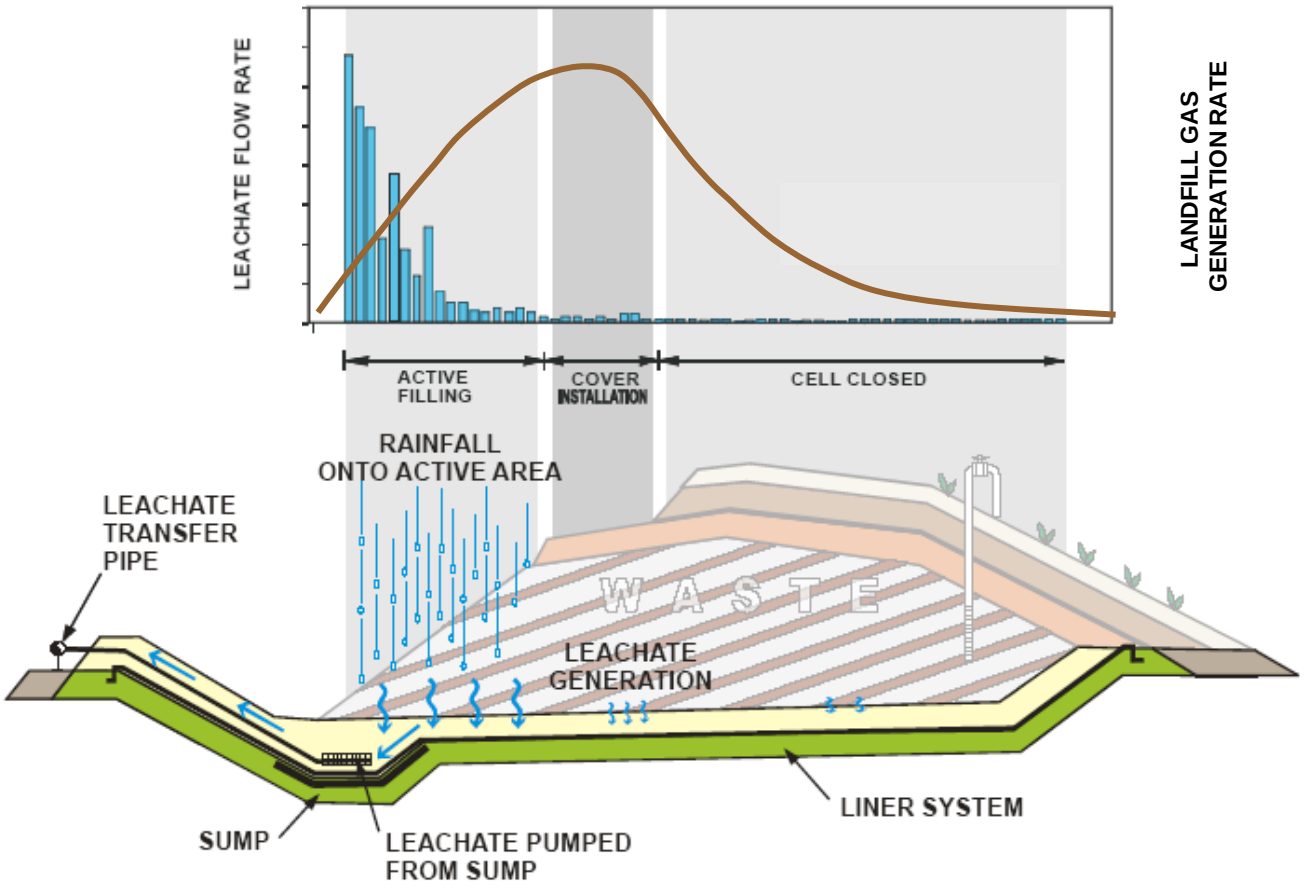
Landfill Life Cycle (Design)



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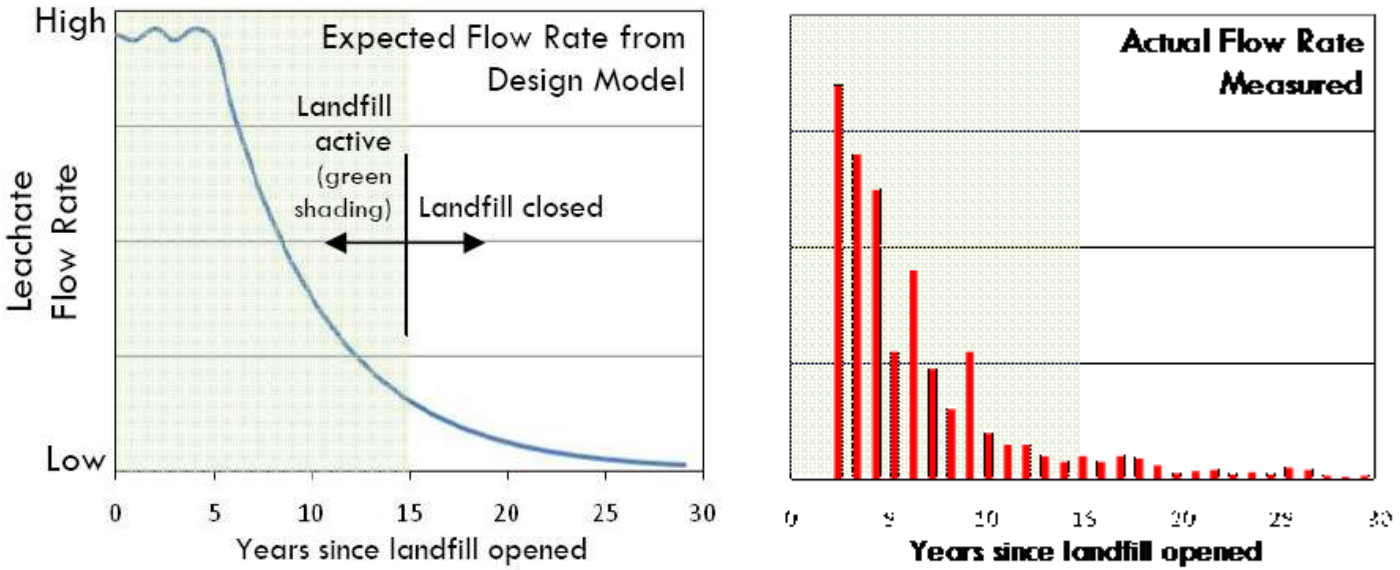
Leachate Generation



Expected Flow (left, blue line) and Measured Flow (right, red bars) in a Leachate Collection System (based on data from Bonaparte, et al, 2002)

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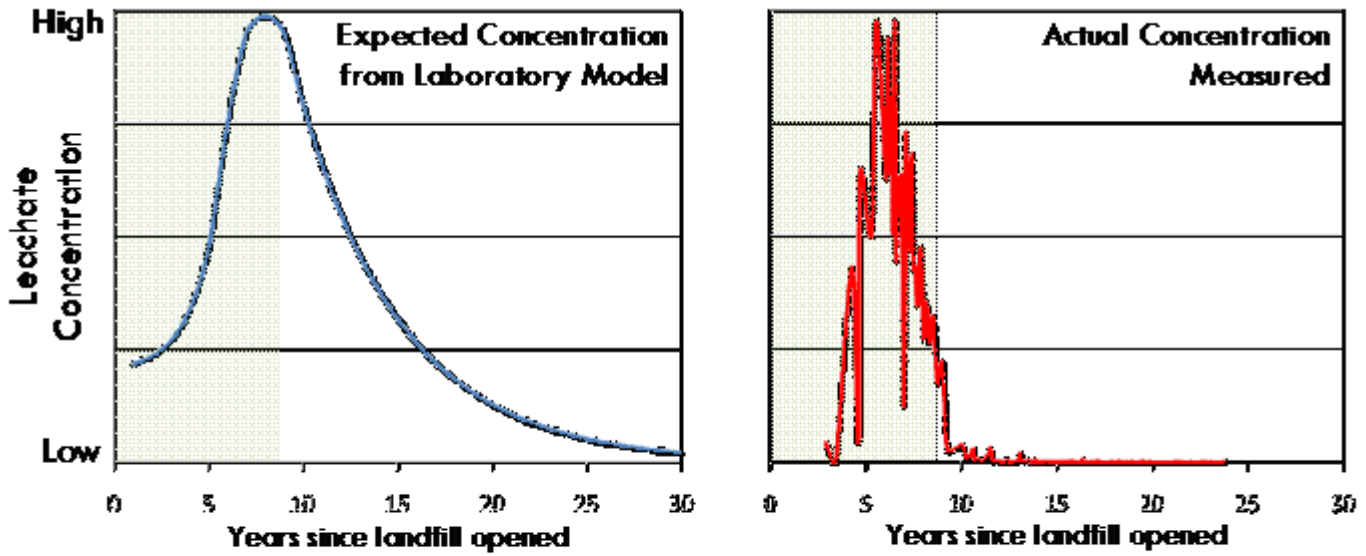
Leachate Quality



Expected Concentration (left, blue line) and Measured Concentration (right, red line) of Organic Indicators in Leachate (based on data from Morris, et al, 2003)

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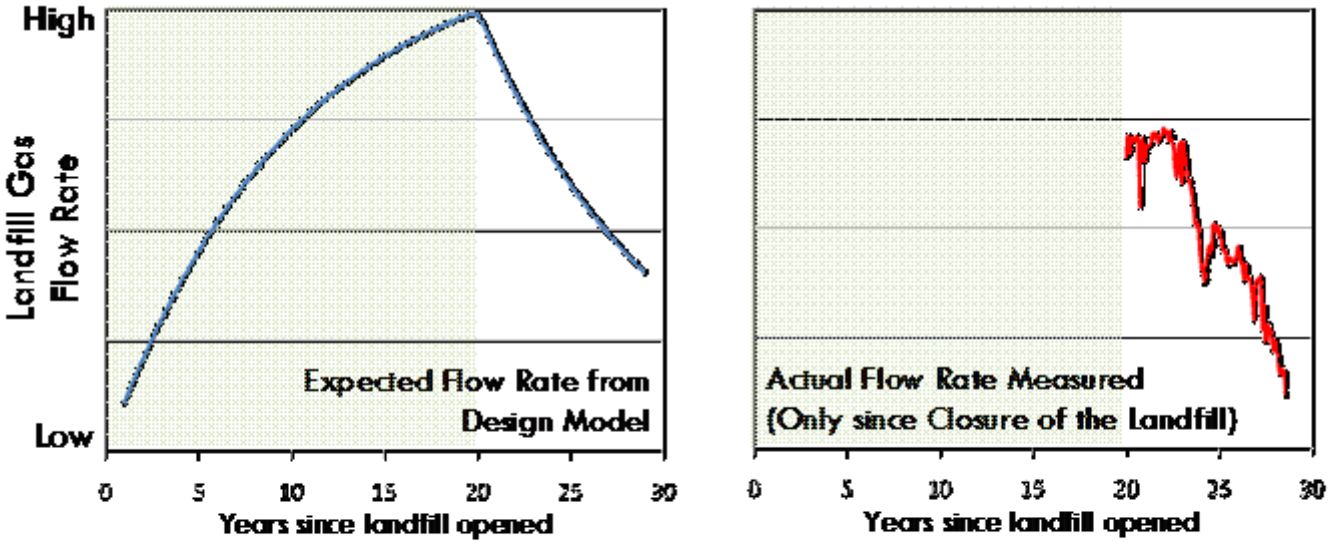
Landfill Gas Generation



Expected Flow (left, blue line) and Measured Flow (right, red line) in a Gas Collection System (based on data from Geosyntec, 2001)

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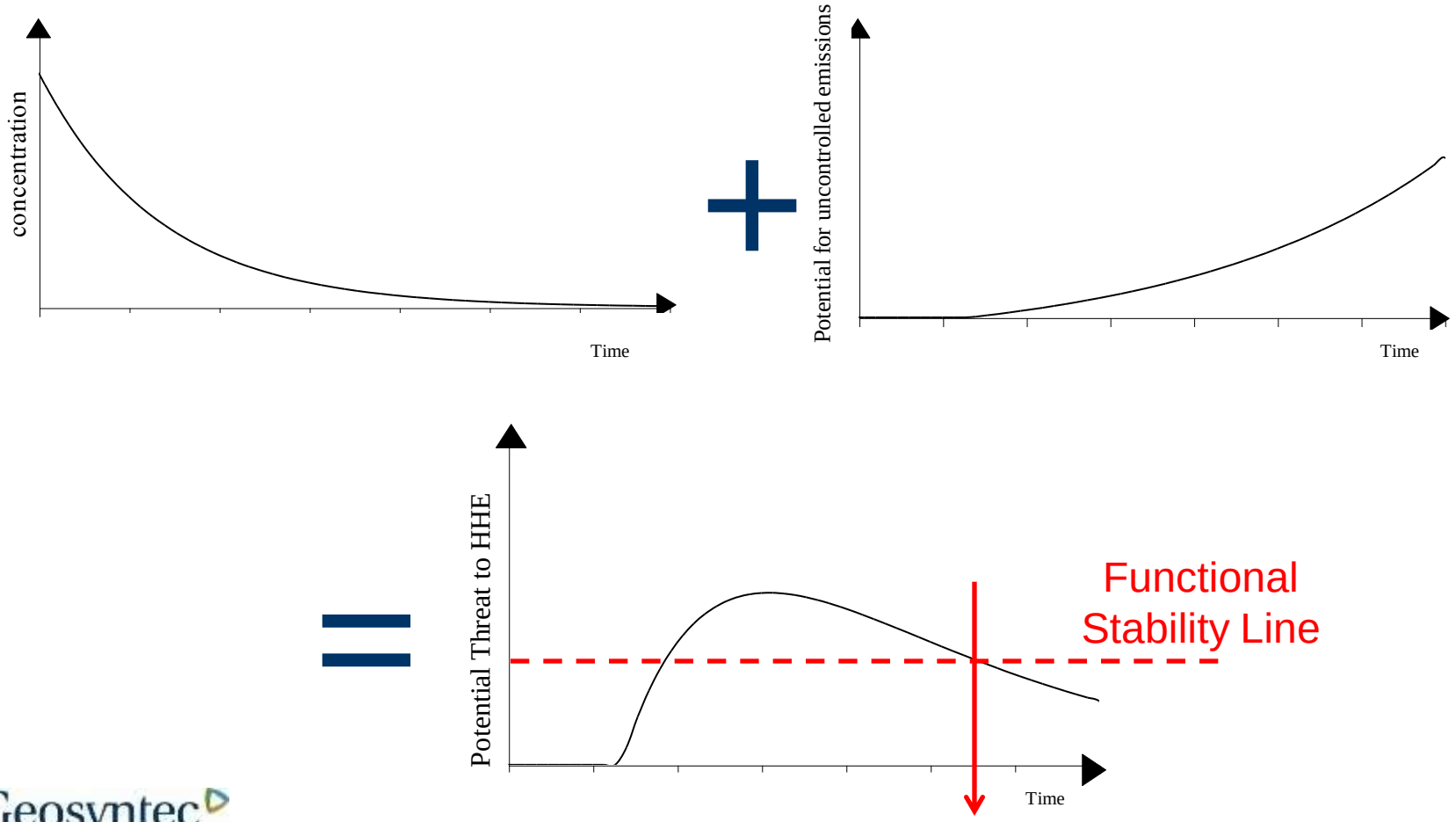
Qualitative Long-Term Behavior of Post-Closure Landfill Emissions



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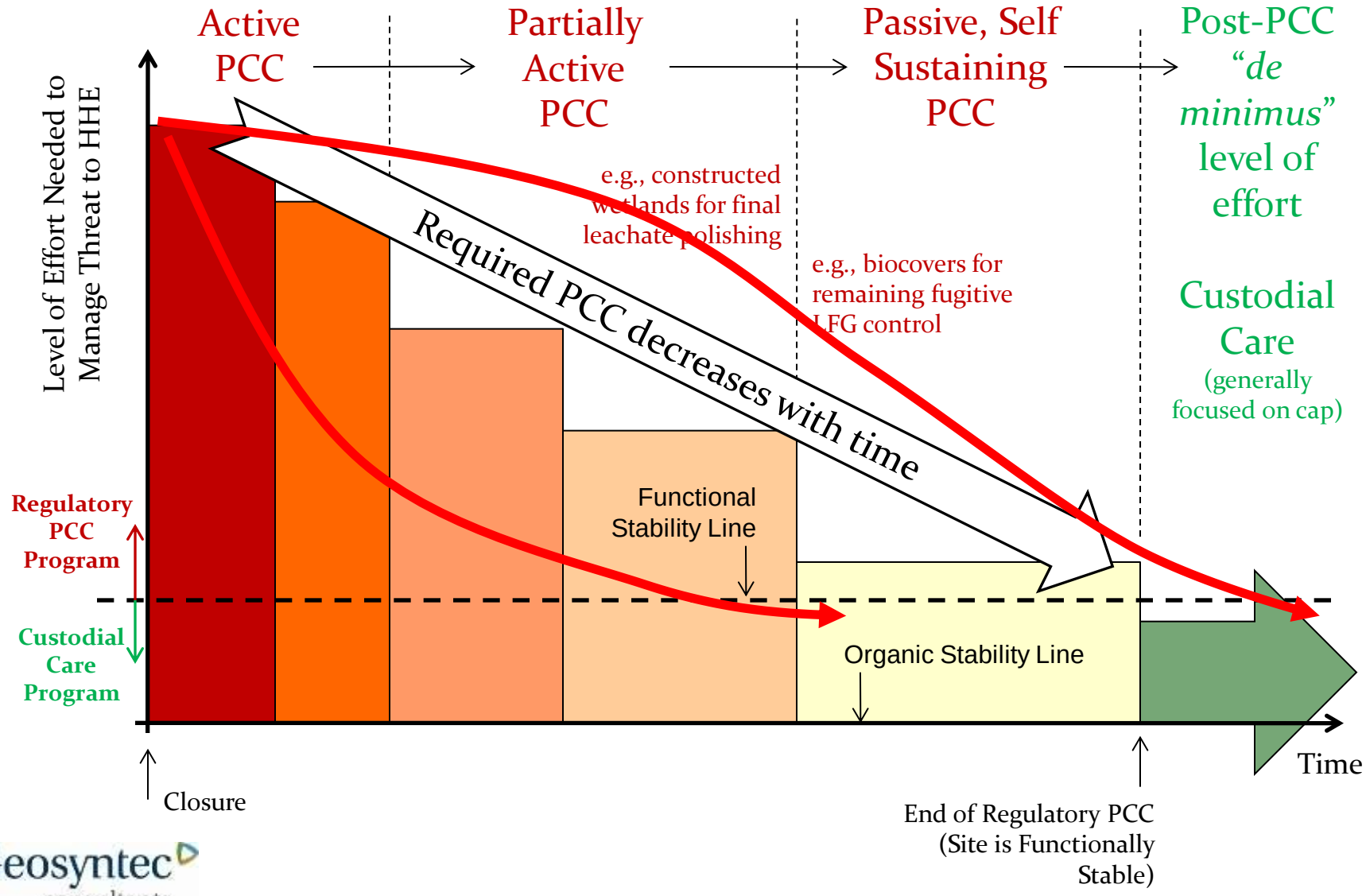
Performance-Based PCC = Reduced Level of Effort and Optimized Maintenance for Continued Protection of HHE



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What is Custodial Care?

- "De minimus" level of care needed after regulatory PCC obligations are completed
- Linked to Functional Stability, which is site-specific
- Same as care needed to manage any property
- Likely consists of:
  - Maintenance of site features, Access controls, Control of nuisances
- Mandated through:
  - Deed restrictions, Covenants, Other legal instruments

- Not overseen or enforced by regulatory agency

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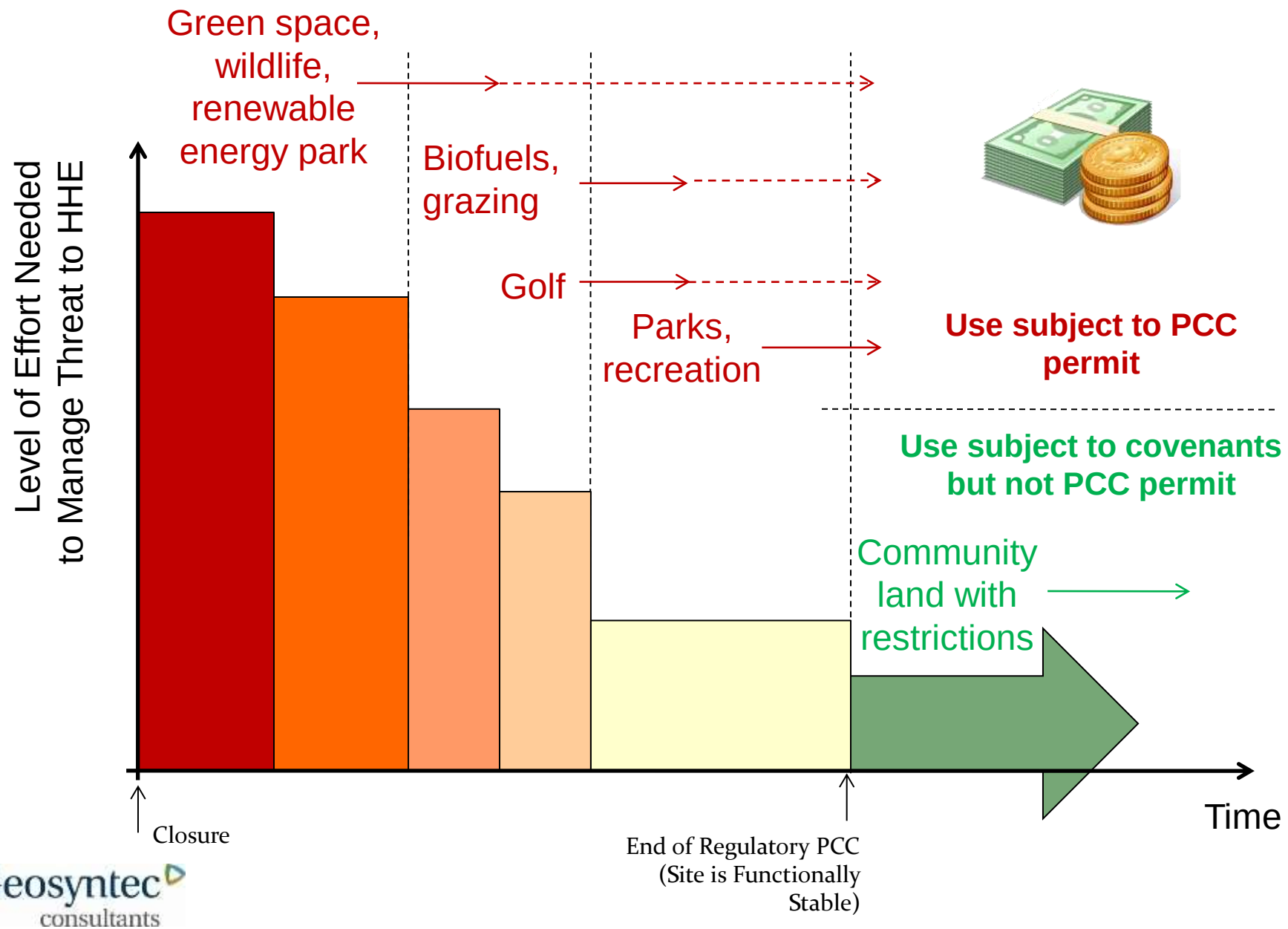
Examples of Beneficial Reuse Compatibility



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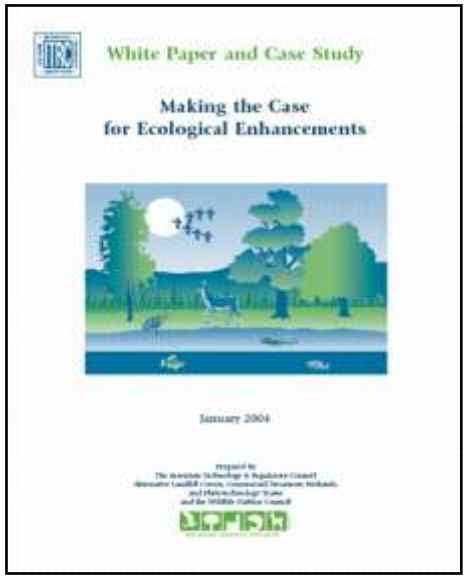
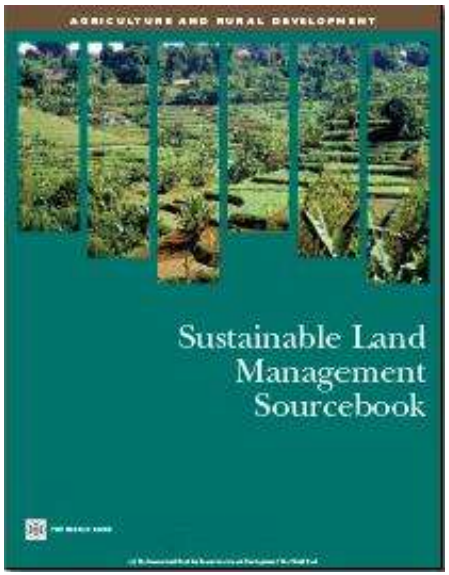
Challenges Related to this Approach: Custodial Care

- Financial assurance termination (future obligations)
- Lack of familiarity (requires institutional change)
- How to use the regulatory flexibility
  - Creativity – all parties not just regulators
  - Land management tools





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DEPARTMENT OF ECOLOGY
State of Washington

http://www.ecy.wa.gov

Ecology Home > Laws & Rules > Current Rule Making > Chapter 173-351 WAC

Current Rule Making

Chapter 173–351 WAC - Criteria for Municipal Solid Waste Landfills

Filing Date	Type of Activity
11/8/12	**Rule adoption** • Rule-making Order - CR-103 • Adopted rule text • Summary of rule changes • Final cost benefit analysis • Concise explanatory statement • Rule implementation plan • Rule adoption notice

http://www.ecy.wa.gov/laws-rules/activity/wac173351.html

SUMMARY:

- Performance-based timeframe
- PCC required until Functional Stability is achieved
  - Need to estimate time to Functional Stability
- Criteria for environmental covenants
  - Basis for establishing Custodial Care after a solid waste permit is no longer applicable

Problem Statement: U.S. Regulatory Context

- USEPA Subtitle D
  - Post-closure care period must be 30 years, unless shortened or lengthened by State Director
  - Ending PCC is defined in terms of performance, but little/no official technical guidance has been promulgated

- Proposal
  - Define Performance-Based PCC in terms of Functional Stability and Custodial Care

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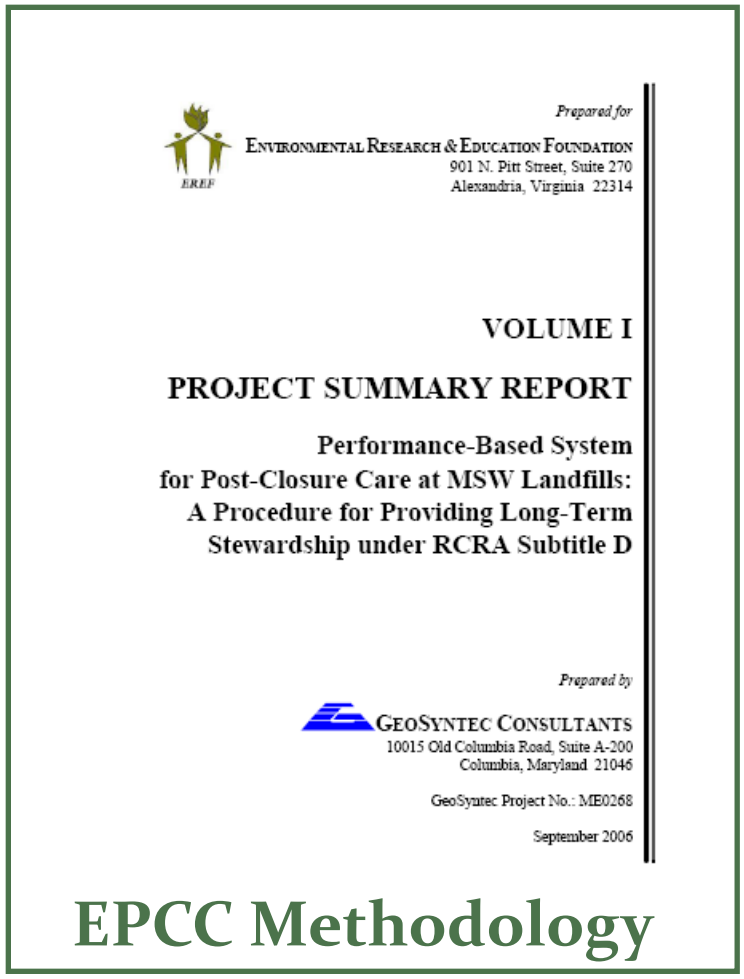
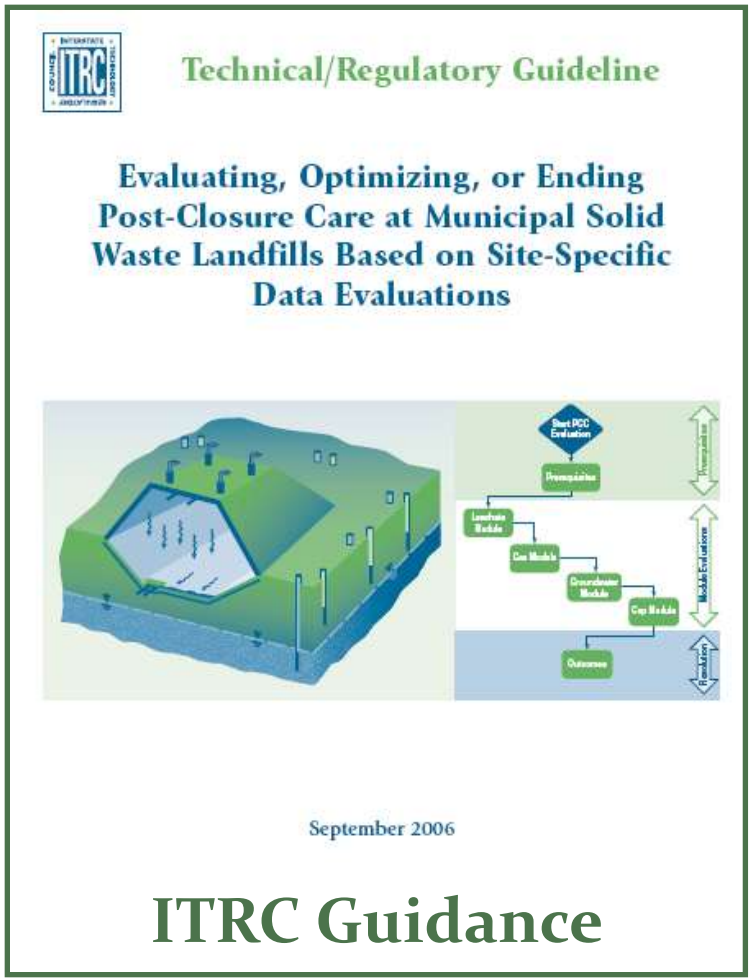
3. Performance-Based PCC Reference Tools

Key References



EPCC Methodology



ITRC Guidance

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Tool Development

- Developed primarily for solid waste landfills
  - Subtitle D
  - Also pre-subtitle D and historic landfills
  - Could be applied to other types of site with some modifications
- EPCC Methodology developed in response to Industry needs:
  - Technical guidance
  - Cost certainty and liability management
- ITRC Guidance developed in response to State needs:
  - End PCC in a safe and defensible manner
  - Avoid an ever increasing workload

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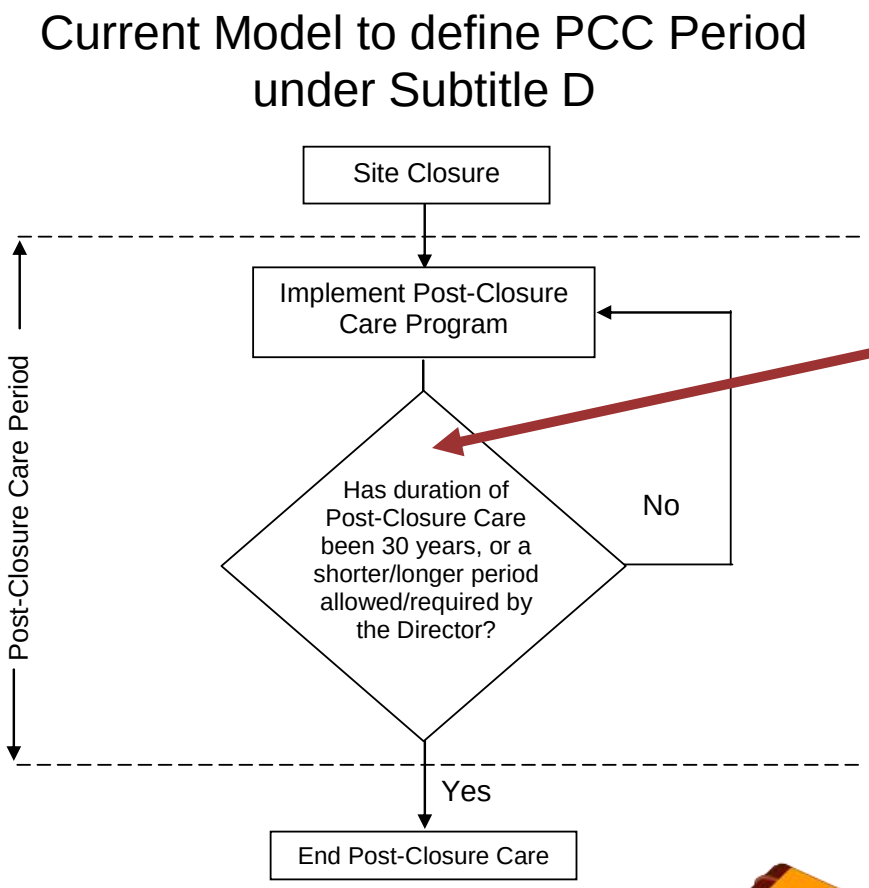
How these Documents Work



How can the Director determine this?

What to look for

"How to" Technical Manual

EPCC

ITRC

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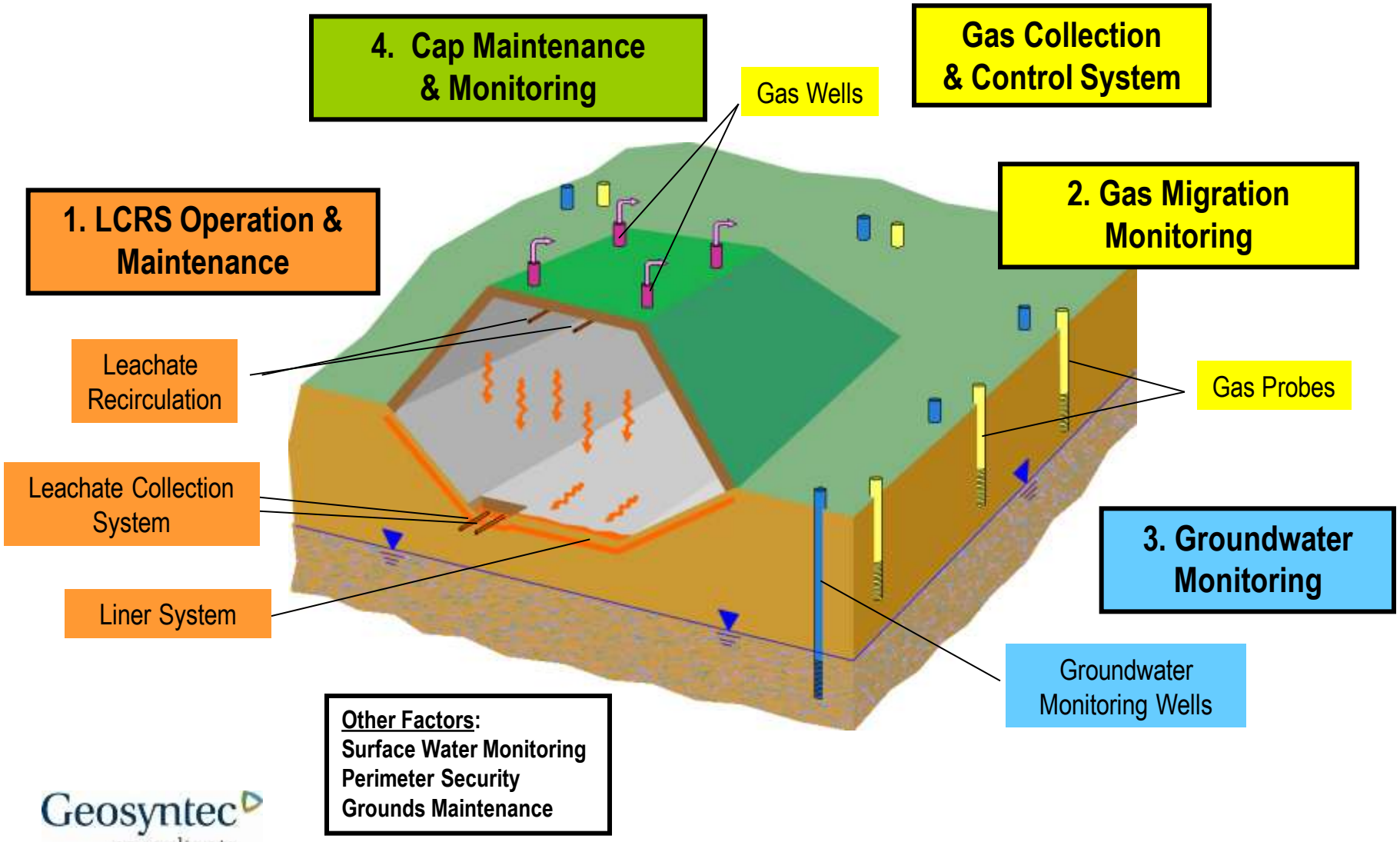
Fundamentals (1):
Modular Approach to PCC (per U.S. Subtitle D)



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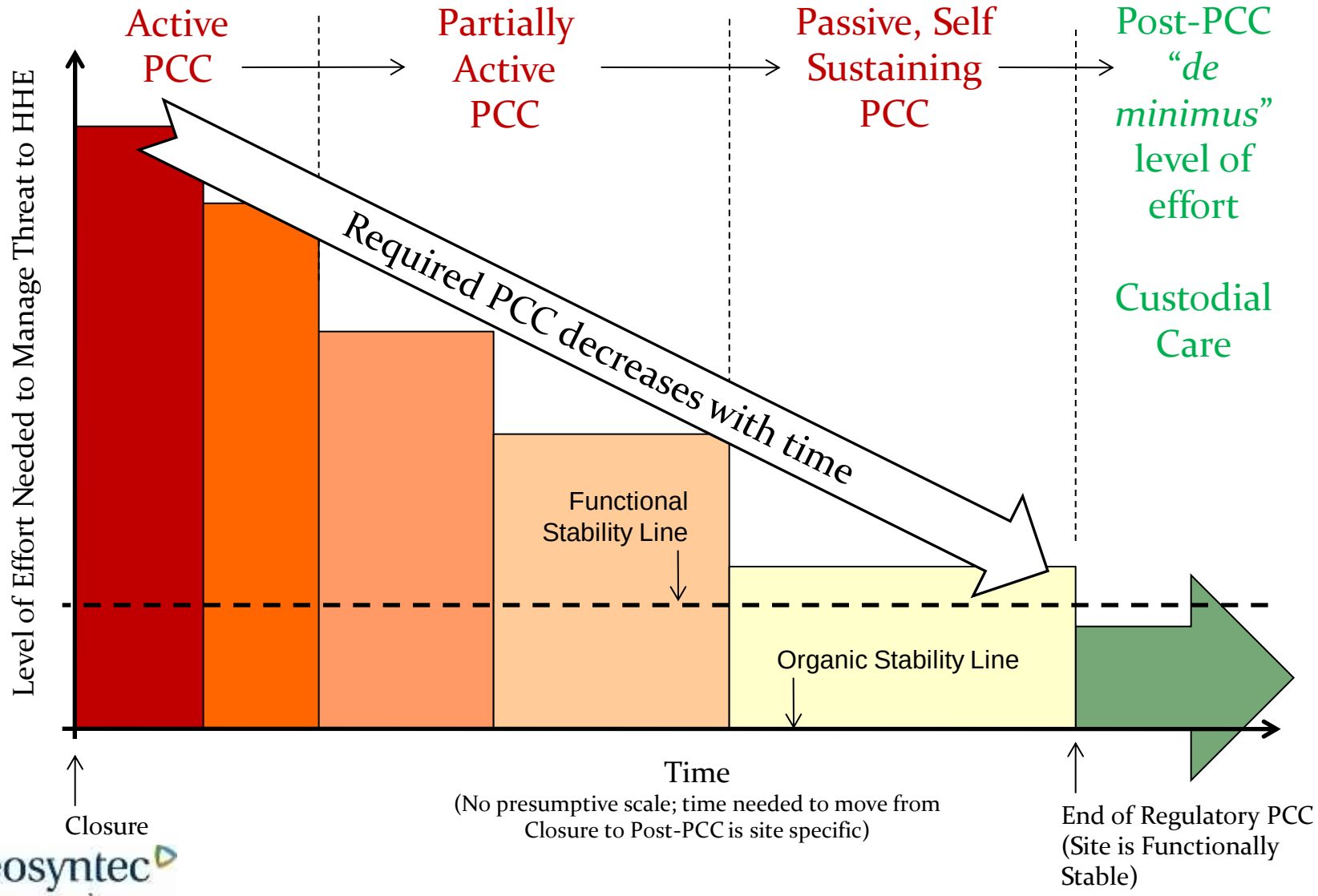
Fundamentals (2):
Dynamic Process of optimizing, active →passive



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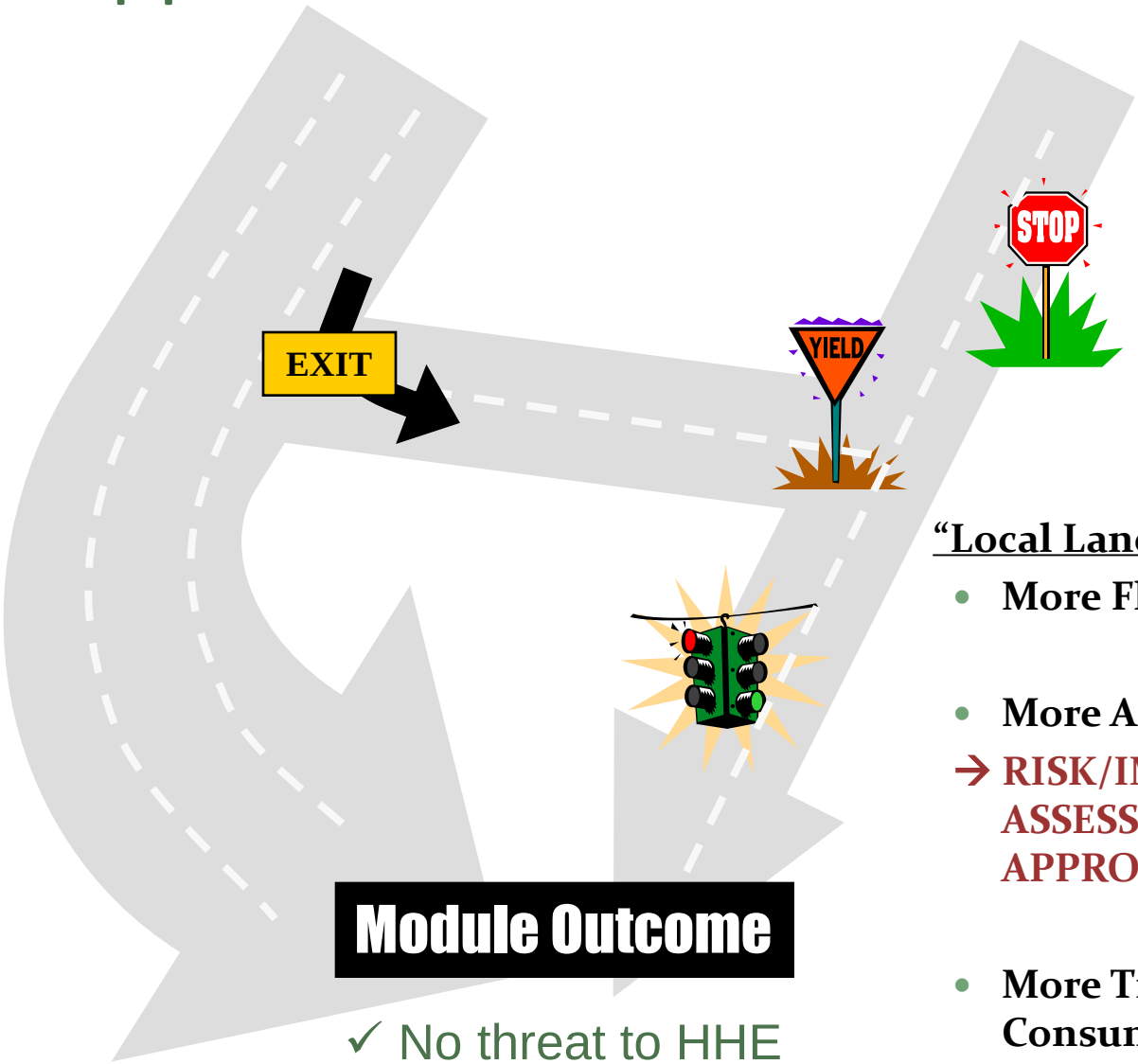
Fundamentals (3)
Step-Down Approach for Evaluations

"Express Lane"

- More Conservative
- More Prescriptive

→ TARGET VALUES APPROACH

- Options to "Exit" to "Local Lane" if needed



"Local Lane"

- More Flexible
- More Analyses

→ RISK/IMPACT ASSESSMENT APPROACH

- More Time Consuming

Module Outcome

✓ No threat to HHE

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Fundamentals (4)
Potential Data Needs for PCC Evaluation

- Landfill design details (liner, cover)
- Site development and operational history
- Hydrogeology and meteorology
- Characteristics of receiving systems
- Leachate
  - Quality
  - Flow
- Landfill gas
  - Quality
  - Collection
- Groundwater quality
- Surface water quality

- Many sites already have a lot of data, but not the data needed to do a performance evaluation
- Having adequate data to do the evaluation requires proper planning and forward thinking

→ IMPORTANCE OF PROACTIVE MONITORING

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LEA Central: Regulation Implementation Guidance

Financial Assurance-Postclosure Maintenance: Step-Down Criteria

Proactive Monitoring

Although each proactive monitoring program will need to be based on site-specific conditions, examples of the data potentially necessary for proactive monitoring include, but are not limited to:

- **Leachate**-Leachate quality indicators such as biochemical oxygen demand (BOD) and chemical oxygen demand (COD) and other general condition indicators; current and historic leachate generation rate; sampling and analytical methods and the frequency and locations of sampling; a list of those Federal Appendix II constituents that used to be detected but are no longer so; a list of those Federal Appendix II constituents that still exceed their respective practical quantitation levels (PQL) in leachate, and, for each constituent, its change in concentration over time; and the concentration change, over time, of nonhazardous constituents that are among the landfill's named Constituents of Concern.
- **Landfill Gas (LFG)**-Current and historic LFG generation rate; methodology to determine the LFG generation rate (i.e., model used), site-specific modeling input parameters; model output; LFG composition (bulk gas constituents, trace non-methane organic constituents (NMOCs), and, for each, a concentration-verses-time plot); sampling and analytical methods and frequency and locations of sampling; internal gas pressure in the landfill (from wellheads, permanent/temporary probes).
- **Ground and Surface Water**-Current/historic ground water and surface water monitoring data and flow direction [using piezometers, compliance wells (including any along the Point of Compliance (POC)) and background wells]; previous/existing impacts attributable to leachate, LFG, or a combination thereof, including the waste constituents involved; and a history and current status of corrective action measures.
- **Final Cover**-Settlement calculations (current and historic) and maps; propagation and persistence of vegetation; current and historic erosion; stability reactions to seismic events; cover component integrity (including both visual inspection and permeability testing and/or leak detection).

In developing a PMP, the operator should demonstrate the appropriateness and reasonableness of the proposed proactive monitoring items as they relate to the specific conditions of the landfill. Agency review of a PMP is addressed in a later section.

Guidance documents have been prepared which address proactive (or performance-based) monitoring with an eye toward indentifying and tracking change, over time, in the threat posed by the waste in the landfill to public health and safety and the environment. These documents include:

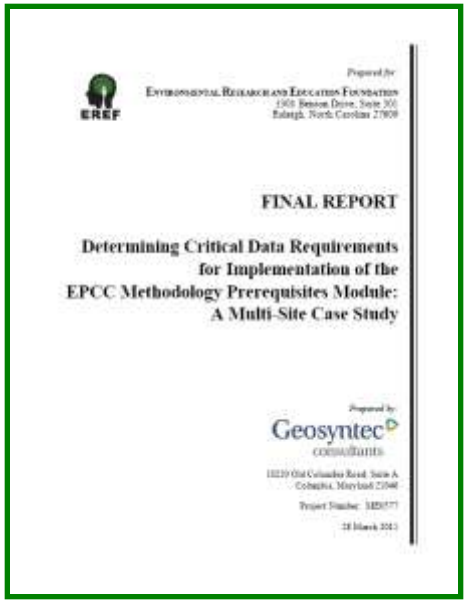
- Interstate Technology Regulatory Council (ITRC), Alternative Landfill Technologies Team, postclosure care approach titled, "**Evaluating, Optimizing, or Ending Post-Closure Care at Municipal Solid Waste Landfills Based on Site-Specific Data Evaluations**," dated September 2006.
- Environmental Research and Education Foundation (EREF) postclosure care approach titled, "**Performance-Based System for Post-Closure Care at MSW Landfills: A Procedure for Providing Long-Term Stewardship under RCRA Subtitle D** (Adobe PDF, 1.9 MB)," prepared by GeoSyntec Consultants, dated September 2006.

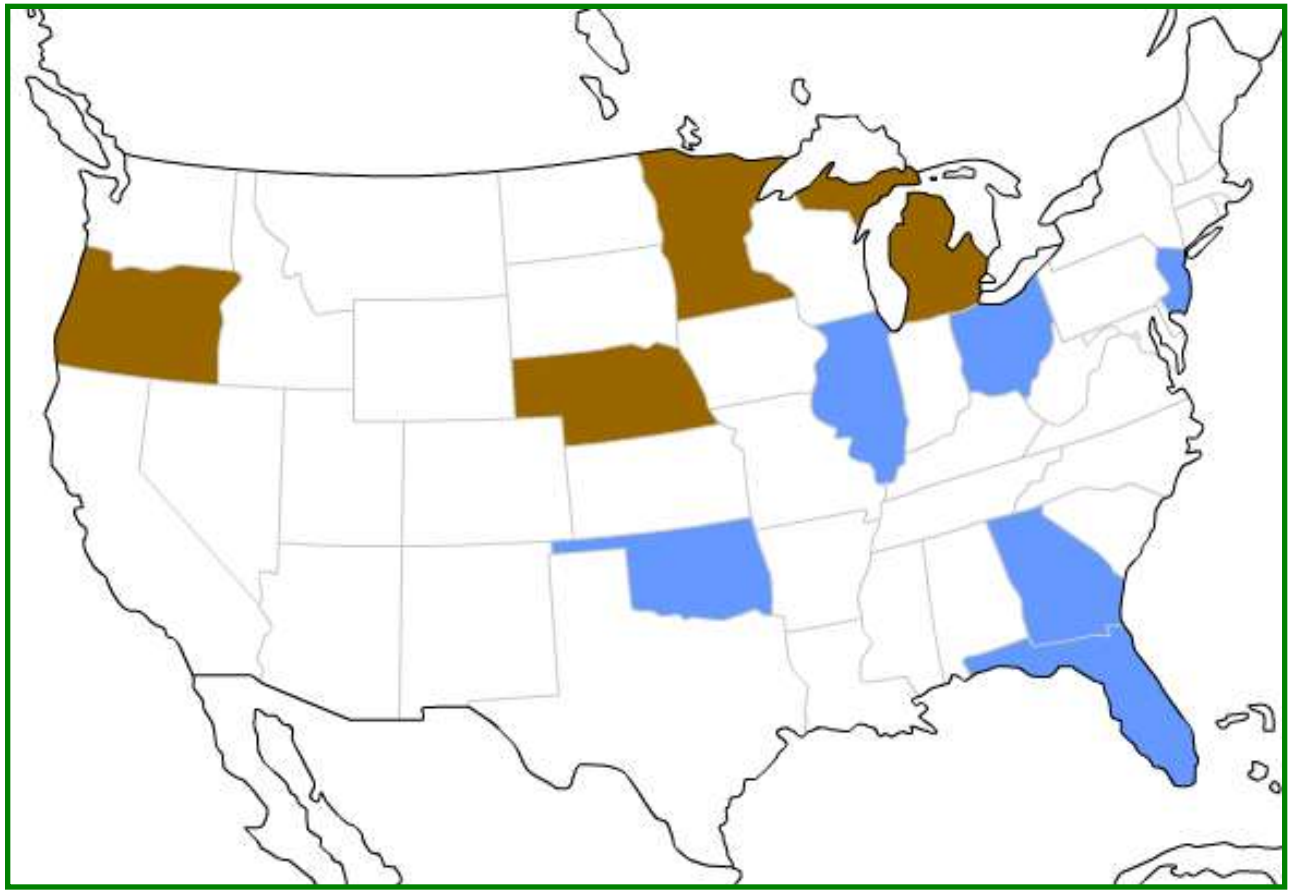
  While the ultimate goal of these documents is to facilitate optimizing postclosure maintenance, the underlying principle of the documents is to develop a PMP to provide a holistic evaluation of the overall condition of the landfill. These documents provide detailed options for monitoring based on various landfill factors. These documents may be used to develop a site-specific proactive monitoring program.

http://www.calrecycle.ca.gov/lea/Regs/Implement/Postclosure/Monitoring.htm

Determining Critical Data Requirements for Implementation of the EPCC Methodology Prerequisites Module: A Multi-Site Case Study

2008-2009, final report March 2011





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2011 study

Several improvements made to simplify use of the 2006 technical manual, incl. enhanced recommendations for proactive monitoring

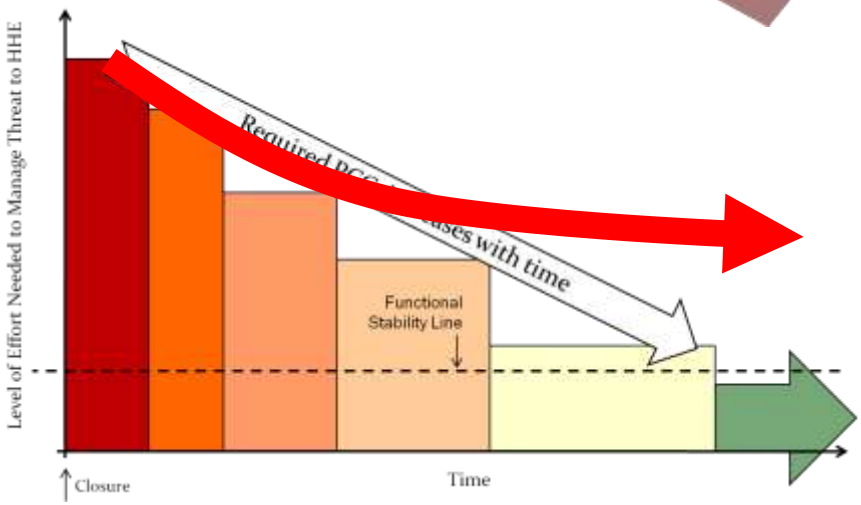
Key Findings:

Few attempts at far-sighted end use planning
Lack of consideration of alternative cover system designs
Few attempts at design stage to think of post-closure activities

Good Availability of GW Data

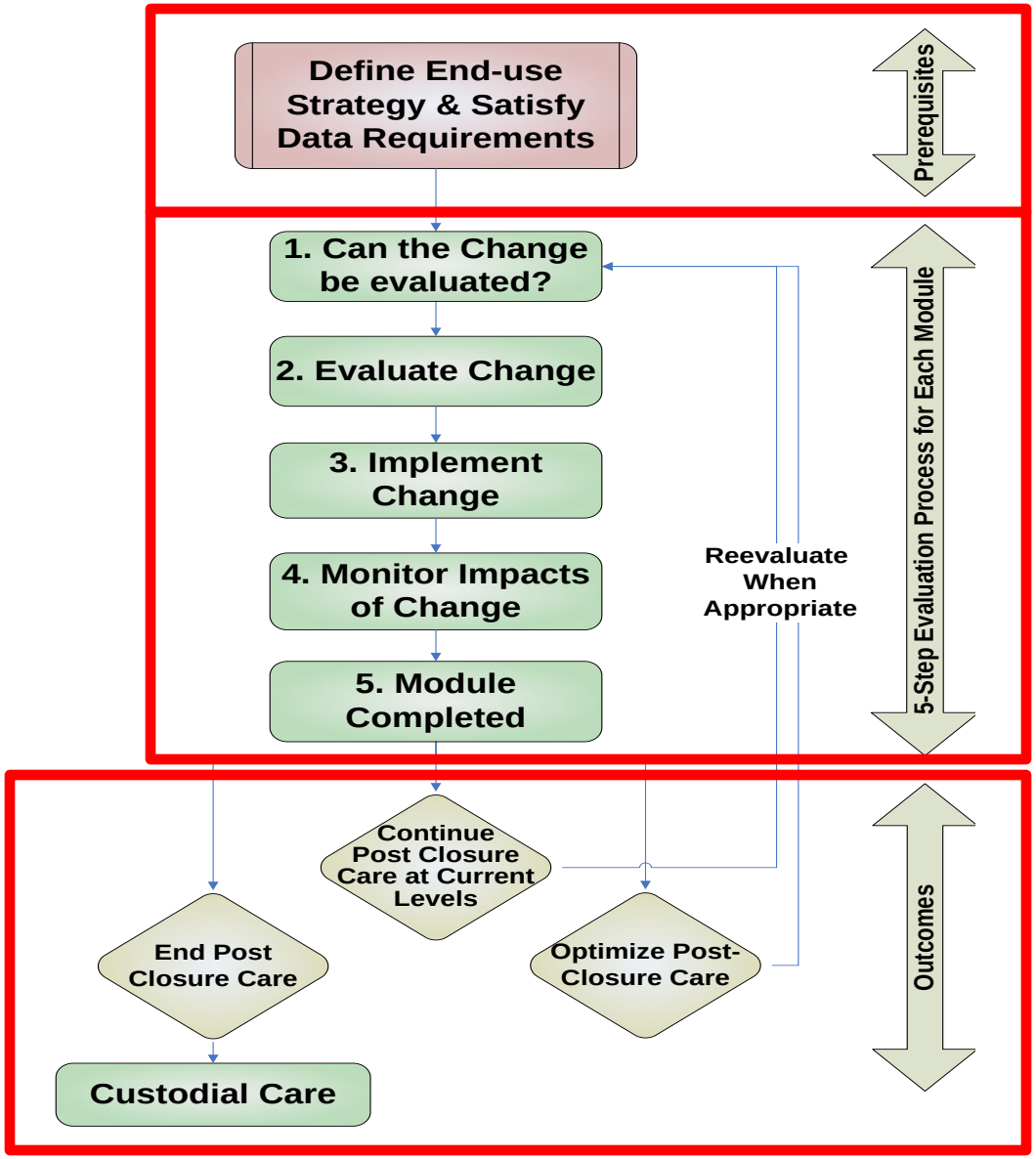
Lack of Comprehensive Leachate + Gas Data

→ Significant limiting factor
→ Reduces flexibility for passive management options
→ Danger of "Flat-lining"



4. Application of the Tools

Module Evaluation Process



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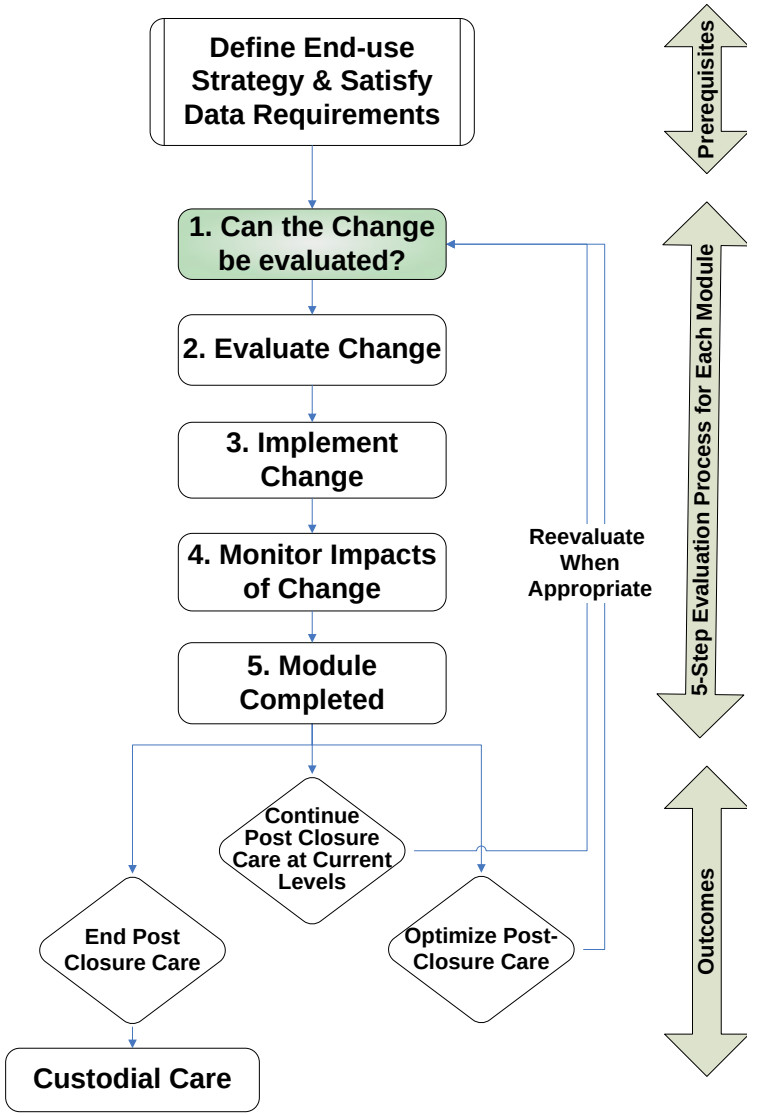
1. Module-specific Requirements

Purpose: Evaluate whether module-specific requirements are met

- Leachate and Gas
  - Downward or steady trend in leachate/gas quality and quantity
  - No impacts
- Groundwater
  - Detection monitoring
- Cap
  - Outcome from all other modules
  - Dependence of other outcomes on the cap are defined



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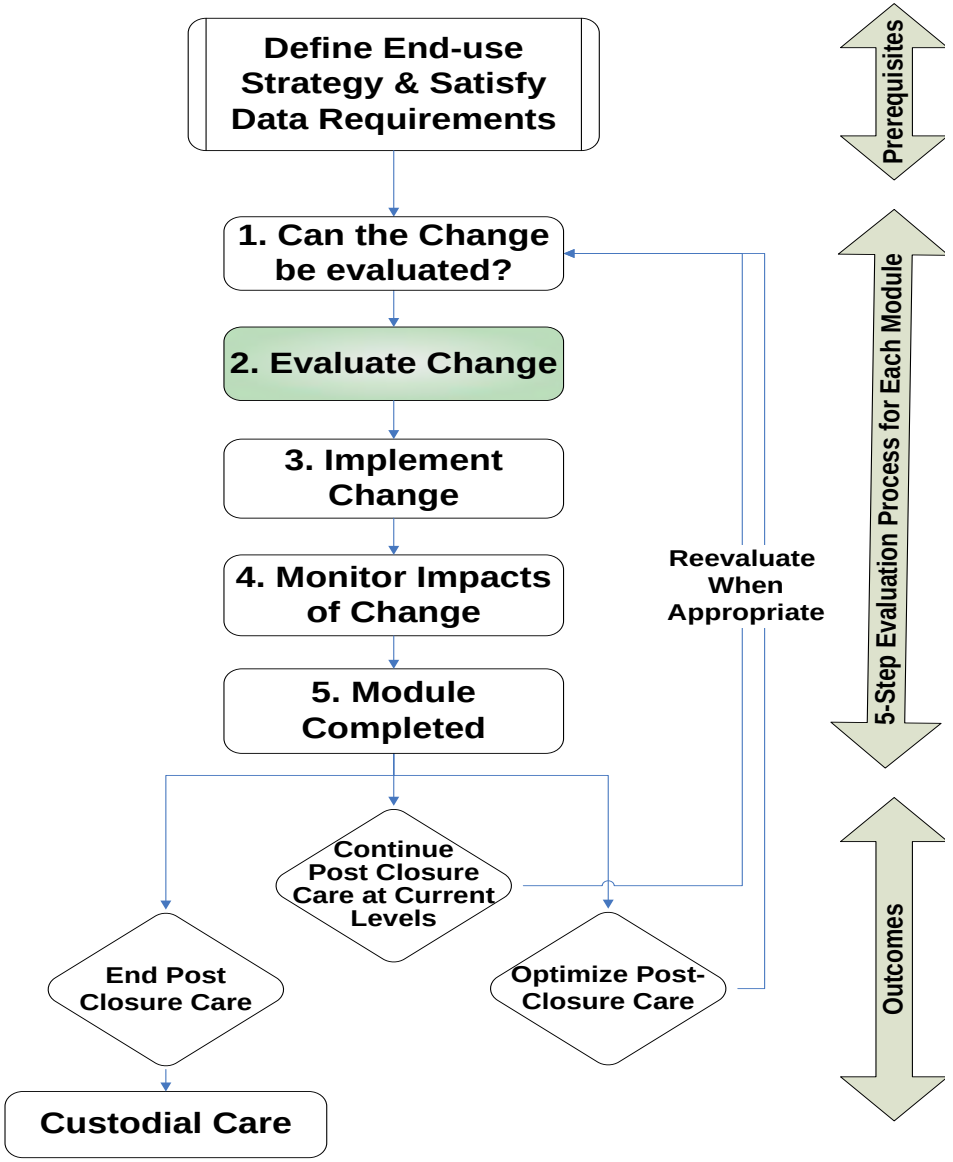
2. Evaluate Change to PCC

Goals are to evaluate:

- Is change appropriate?
- Will change result in unacceptable threat?



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2. Evaluate Change

Leachate Management

- Define change
- Step-up evaluation of change
  - Step 1: Compare source leachate concentrations to standards
  - Step 2: Evaluate diluted leachate concentrations at the point of compliance
  - Step 3: Assess threat at point of exposure
- Modify/Optimize leachate management system(s)
- Modify PCC plan accordingly to reflect new leachate management strategy

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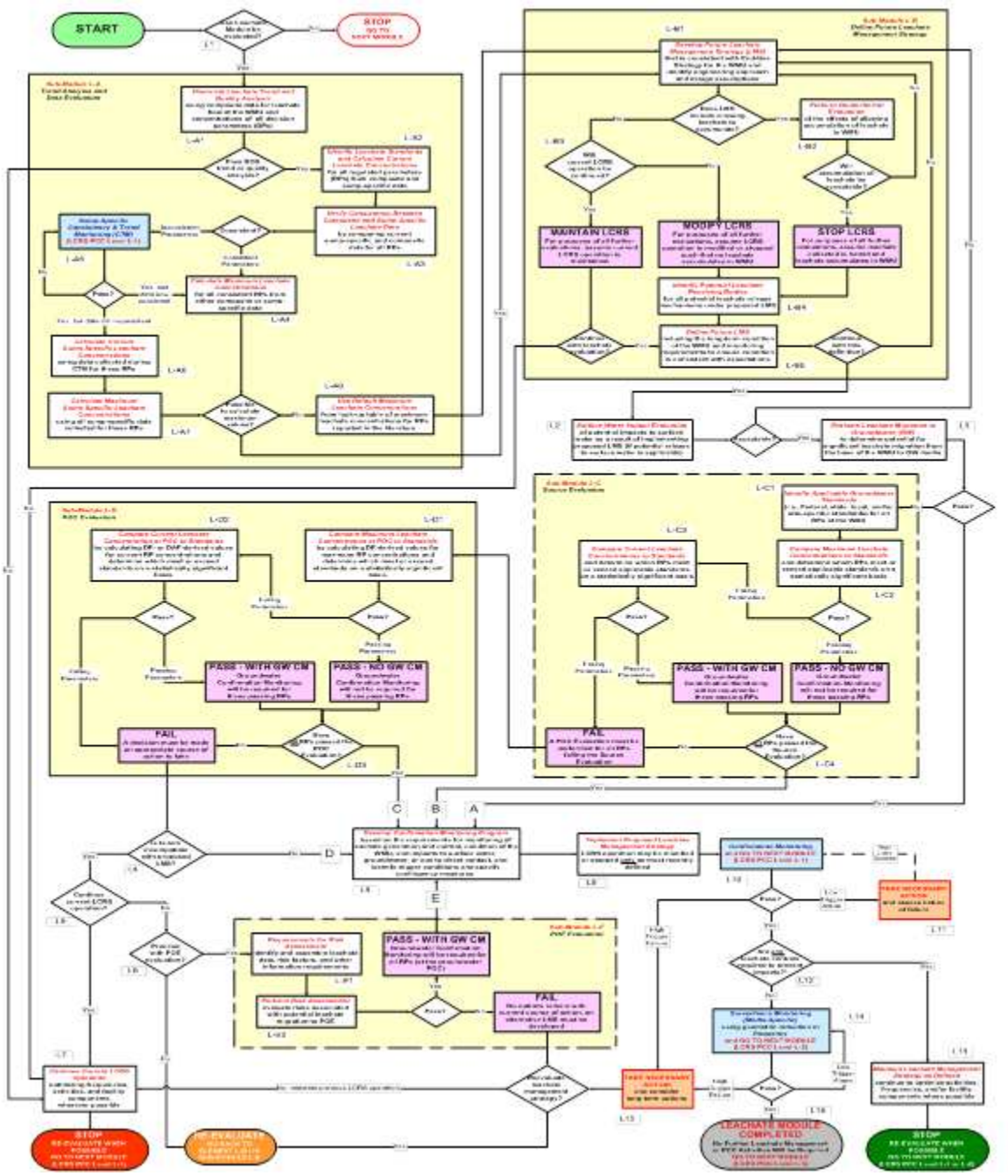
Leachate Module Flow Logic

Technical Manual provides a high level of detail, and instructions to help decision-making at every step



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2. Evaluate Change

Gas Management

- Define change
- Step-up evaluation of change
  - Step 1: Preliminary screening evaluation, compliance with other regulations (e.g., NSPS, GHG Rule)
  - Step 2: Engineering evaluation approach
  - Step 3: Assess threat at point of exposure
- Optimize gas management system
- Modify PCC plan to reflect new gas management strategy

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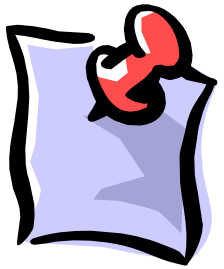
2. Evaluate Change

Groundwater Monitoring

- Requires outcomes from Leachate and Gas Module to be established
- Evaluate potential for future groundwater impacts
  - Consider leachate and landfill gas impacts
  - Confirm that time to potential impact has passed based on time of travel from landfill to POC
- Identify opportunities to optimize groundwater monitoring program
  - Reduce parameters, frequencies?
- Modify PCC plan as appropriate

NOTE:
Modified approach required for landfills with no leachate collection system



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2. Evaluate Change

Cap Module

- Define Post Closure Care requirements
  - Regulatory requirements
  - Requirements established by outcomes of other modules
  - Performance requirements
    - Geomechanical stability, completion of settlement
- Evaluate compliance with PCC requirements
- Identify opportunities to optimize cap maintenance and monitoring
- Modify PCC Plan as appropriate

NOTE:
Active care → Passive care transition is much easier with an all-soil cap

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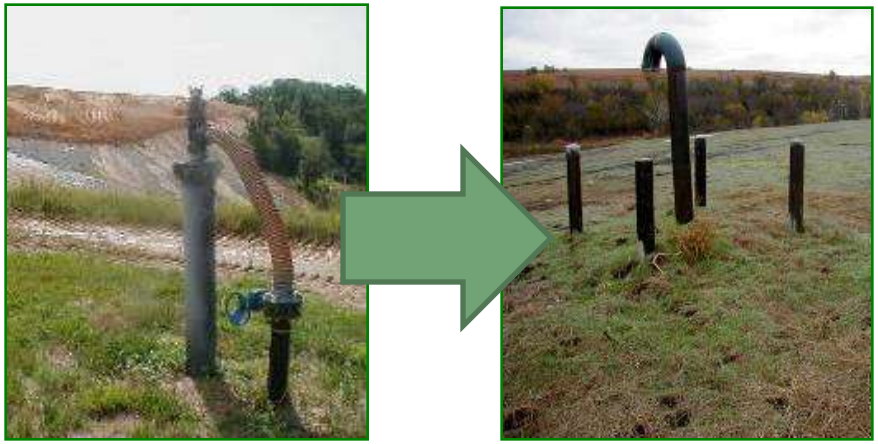
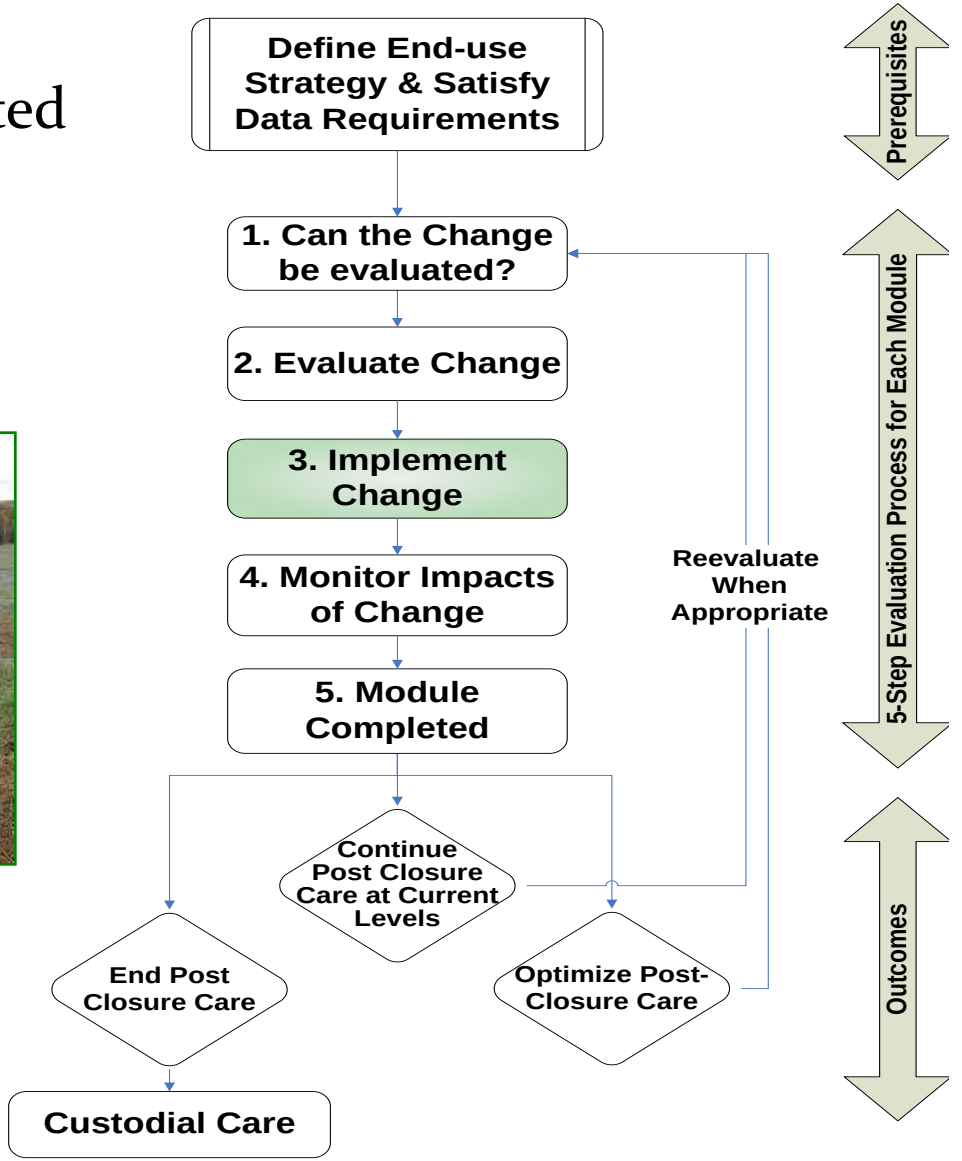
3. Implement Change

- Implements the changes evaluated in Step 2 based on "no adverse impacts are expected" outcome





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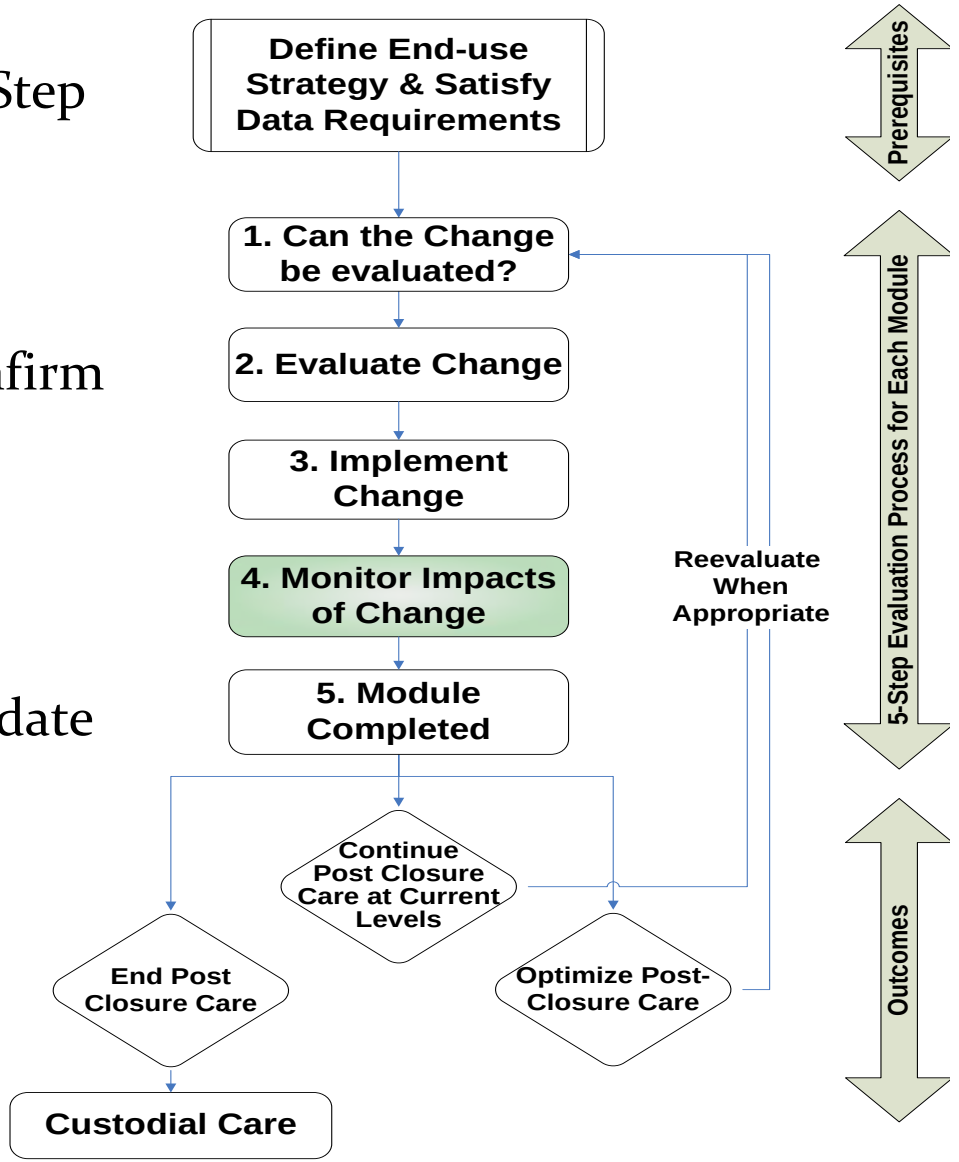
4. Monitor Change in PCC

- Monitor the change made during Step 3 and confirm that it works as predicted
- Confirmation Monitoring
  - Monitoring **during** PCC to confirm that a change resulted in the predicted outcome
- Surveillance Monitoring
  - Monitoring **after** PCC for an extended period to further validate the decision to end PCC for a module



Confirmation Monitoring – Outcome Not As Planned

Two Possible Outcomes:

1. Out of Compliance:
   - Evaluate Cause; or
   - Return to PCC at Original Levels
2. In Compliance, but behavior is not wholly as predicted:
   - Evaluate need for responsive action
   - Responsive action could include:
     - Re-evaluate result, further monitor trends, if appropriate; or
     - Return to previous, more stringent levels of PCC
   - After reevaluation, new Confirmation Monitoring must start

   <u>Example:</u>
     - Turning off an active gas system → passive vents
     - Landfill gas is detected above predictions but below regulatory thresholds
     - Increase frequency or duration of Confirmation Monitoring, or
     - Turn active gas system back on, or
     - Reevaluate, design new "change" (e.g., partially active)

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Confirmation Monitoring – Outcome As Planned

Two Possible Outcomes:

1. If NOT ending PCC, then continue PCC as modified during Step 3
2. If ending PCC, then proceed to Surveillance Monitoring
   - Provides longer-term monitoring at a geometrically reduced level to document that the decision to end PCC was appropriate:
   - Requirements for SM:
     - No operation or maintenance
     - It has been demonstrated that the landfill is 'self-sustaining' and can meet Custodial Care criteria
     - No controls exist other than those that will continue to be in place throughout Custodial Care

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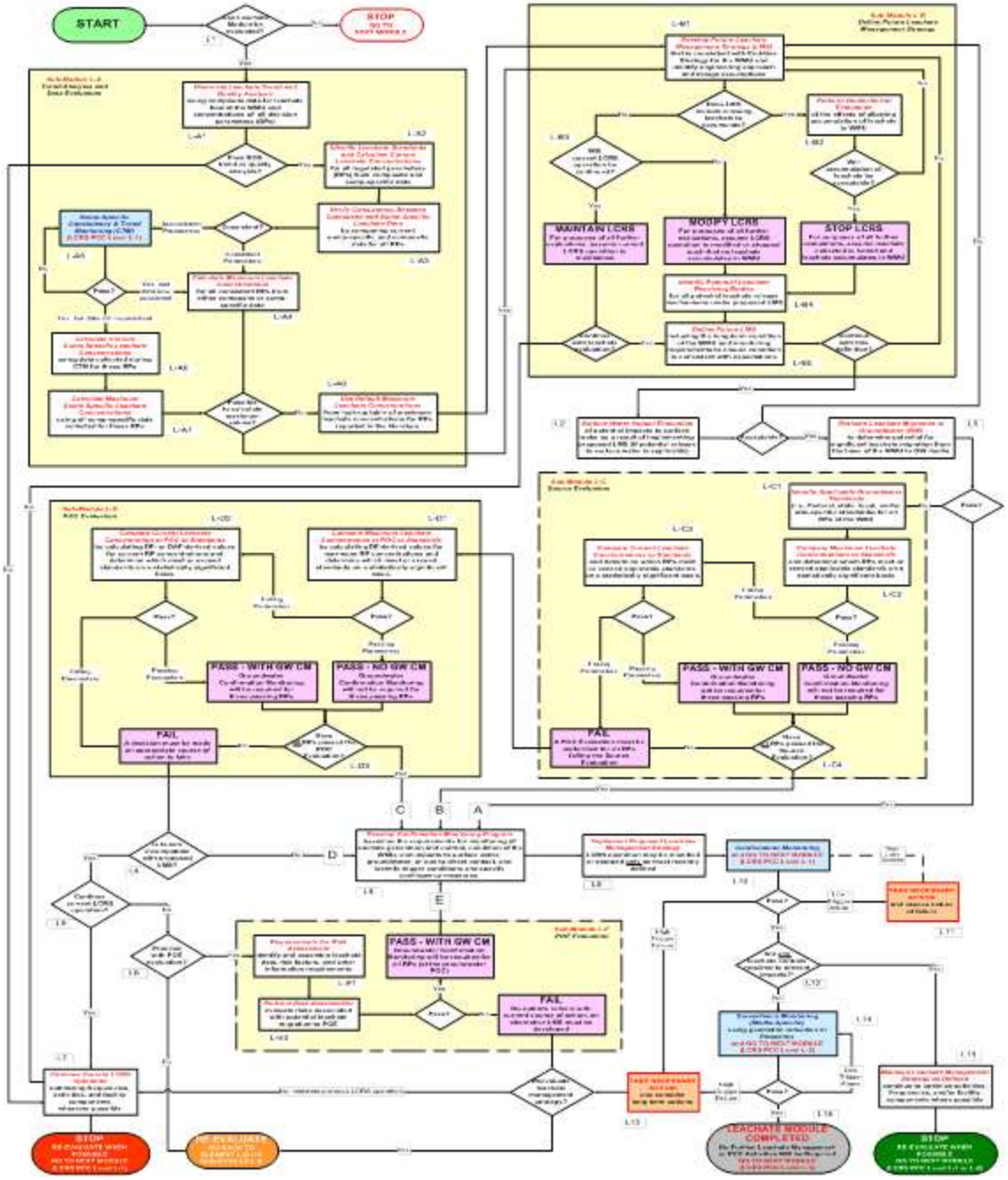
Leachate Module Flow Logic

Seems like a lot of keep track of… but remember, there's lots of help on the decision process for CM and SM



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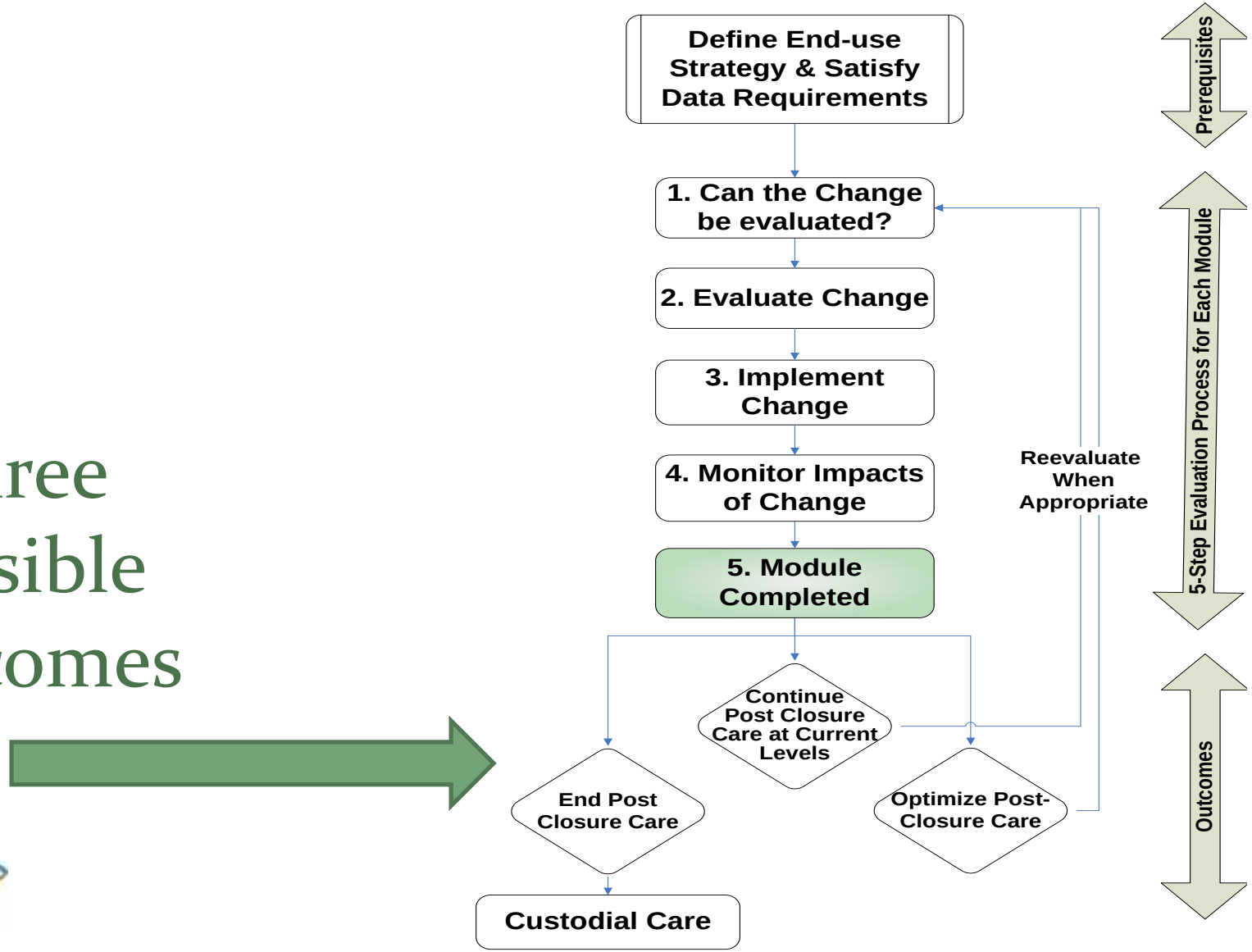
5. Module Completion

Three Possible Outcomes



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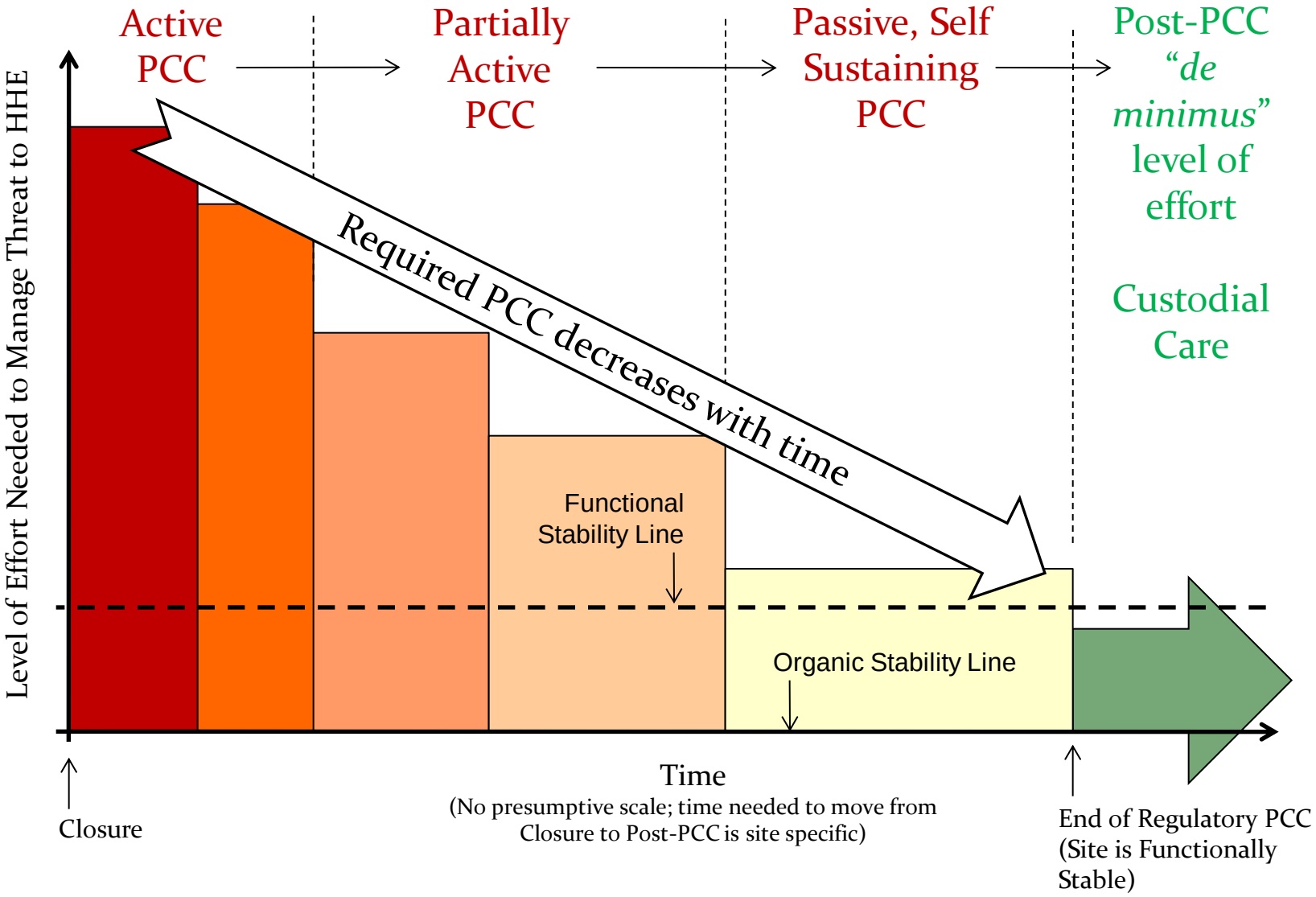
Remember Fundamentals:
Dynamic Process of optimizing, active →passive



Outcome: Continue Post Closure Care at Current Levels

- One or more modules still require PCC
- Evaluations should be performed again in future

Continue Post Closure Care at Current Levels

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Outcome: Optimize Post Closure Care

- Intensity or scope can be reduced
- Justification depends on human health and the environment considerations
- Requires changes to PCC operation and/or maintenance plans

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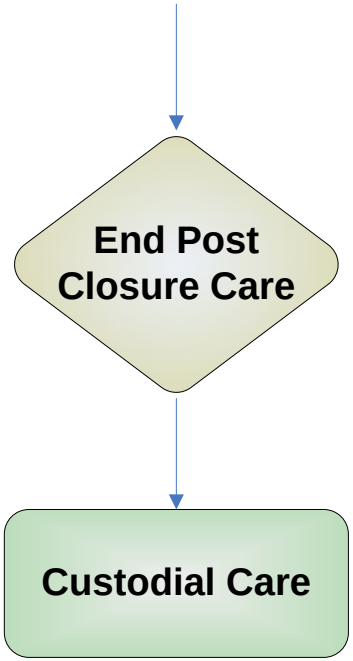
Outcome: End Post Closure Care

- All confirmation monitoring and surveillance monitoring and maintenance are concluded
- Regulatory Post Closure Care is completed
- Establish de minimus levels of care required for Custodial Care (administrative property restriction)



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Leachate Module

Indicators of Functional Stability

Requirement for ending PCC

- Downward trend in macro indicators of leachate quality
- All sumps are represented by a composite dataset
- Worst-case 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/semi-passive leachate management in place
  - Confirmed to be working as designed
  - Can leachate management be wrapped into a cover inspection and maintenance program?
  - Could a landscaper take care of it?

Landfill Gas Module

Indicators of Functional Stability

Requirement for ending PCC

- Statistical downward trend in methane collection rate
- Eliminating active gas control has not resulted in impacts due to migration, emissions, or odors
  - Generally predicated by some level of cap maintenance
  - Gas management is compatible with beneficial reuse of the property
- Long-term passive/semi-passive gas management in place
  - Confirmed to be working as designed
  - Can gas management be wrapped into a cover inspection and maintenance program?
  - Could a landscaper take care of it?

Groundwater Module

Indicators of Functional Stability

Requirement for ending PCC

- Evaluate potential for future groundwater impacts
  - Functionally stable outcome from Leachate Module
  - Functionally stable outcome from Gas Module

- Main question – has monitoring been conducted for long enough to have detected an impact if it were to occur?
  - Evaluate based on time-of-travel from landfill to POC

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Cap Module

Indicators of Functional Stability

Requirement for ending PCC

- Regulatory requirements for Cap are met
  - Containment
- Performance requirements for Cap are met
  - Geomechanical stability
  - Significant settlement has been completed
- Requirements established by outcomes of other modules
  - Functional stability has been demonstrated in other modules
  - Cap meet needs for other modules

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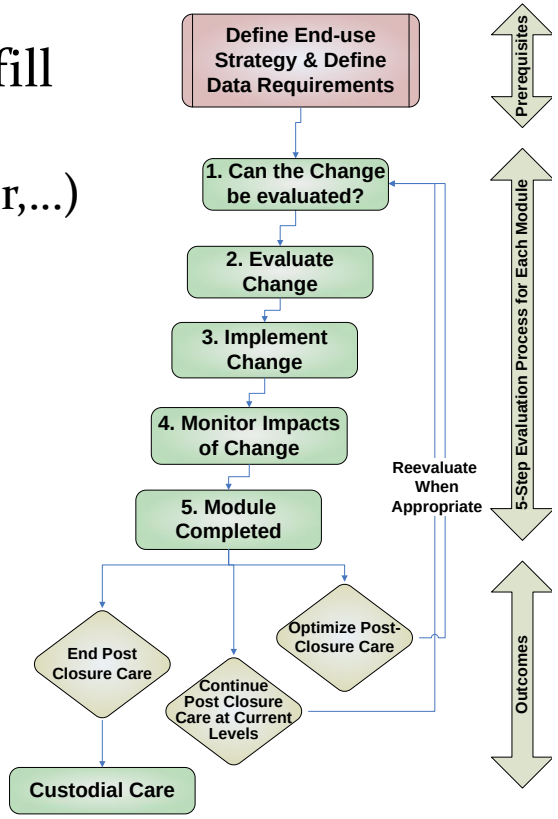
Custodial Care

- Continuing obligations to care for the closed landfill so that it does not pose a threat
  - Maintain some site controls (cap, fences, stormwater,…)
  - Could a landscaper take care of the property?
- Outside of the direct jurisdiction of solid waste regulatory authority
- Institutional controls or covenants to ensure the protective conditions
  - Deed restriction
  - Covenants
  - Alternate land use control mechanisms



Custodial Care

Notes on Custodial Care (1)

- Recurring questions :
  - Why does Custodial Care have to be outside the solid waste regulations?
  - Why can't we accept the concept, but keep the site within the regulations, albeit at a very low level of supervision and oversight?
- In developing the approach for performance-based PCC, it was always envisioned that Custodial Care had to be outside the regulations because of the need to end FA
- Response question to consider:
  - Can a regulated site be released from its PCC permit, and thus from FA?

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Notes on Custodial Care (2)

- What is important:
  - Site can be released from FA in its current form
  - Site PCC permit can be surrendered in exchange for a Custodial Care permit – which means regulators need to be able to write such a permit
  - Regulated status of site should not be a barrier to beneficial reuse, because this is what provides the opportunity for the site to generate revenue to pay for remaining care activities and cap maintenance
  - Regulated status should not significantly impede the value of the property

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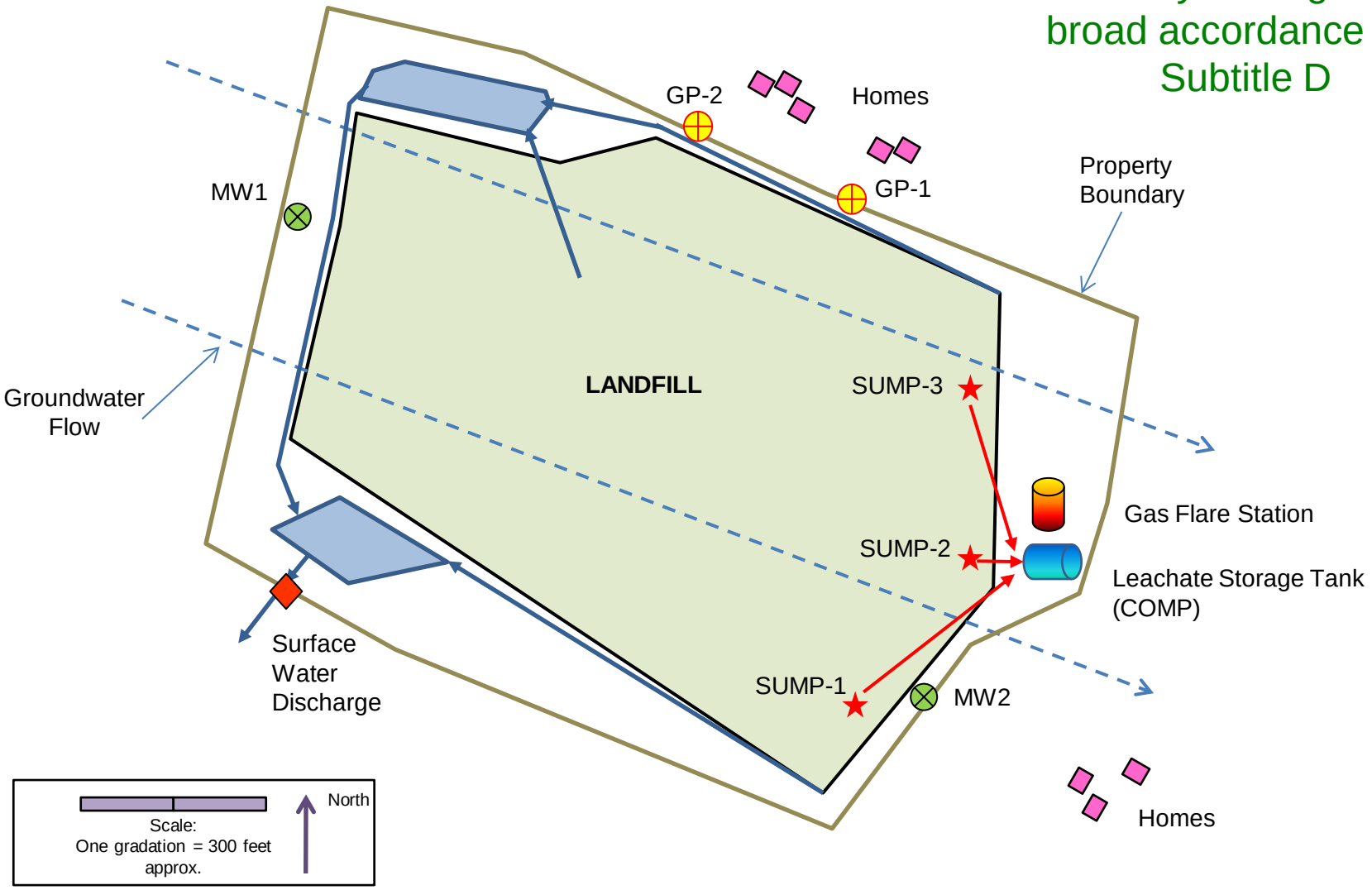
5. Example: Site Evaluation

Layout of Site and PCC Systems of Interest

70-ac site closed ~18 years ago in broad accordance with Subtitle D



Site Evaluation

Leachate Module

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Leachate Management Strategy

- Assumptions:
  - End use = natural green space with restricted public access
  - Maintenance of the existing cap and stormwater management system will continue to limit infiltration
  - To avoid excessive leachate build-up within the landfill over time ("bathtub" effect), leachate will continue to be pumped and disposed offsite to POTW

- Questions (Goals):
  - Can reduced levels of LCRS pumping be recommended because favorable leachate chemistry supports scaling back operation to focus on limiting leachate backing up into the waste rather than strict head-on-liner control?
  - Can more passive leachate management approaches be considered to eliminate offsite POTW disposal?

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Availability of Leachate Analytical Data

- 234 Regulated Analytes
  - 230 GW analytes (Site List, Federal Part 258 Appendix I & II)
  - 9 SW analytes (Site List, Federal Part 445 Subpart B)
    - Only 4 are not also GW parameters

- Leachate Data (Leachate Storage Tank)
  - Multiple data collected over 25+ years for 134 analytes (57%)
  - Single value collected for other 100 analytes as part of this study

→ Some limitations, but data availability is generally good

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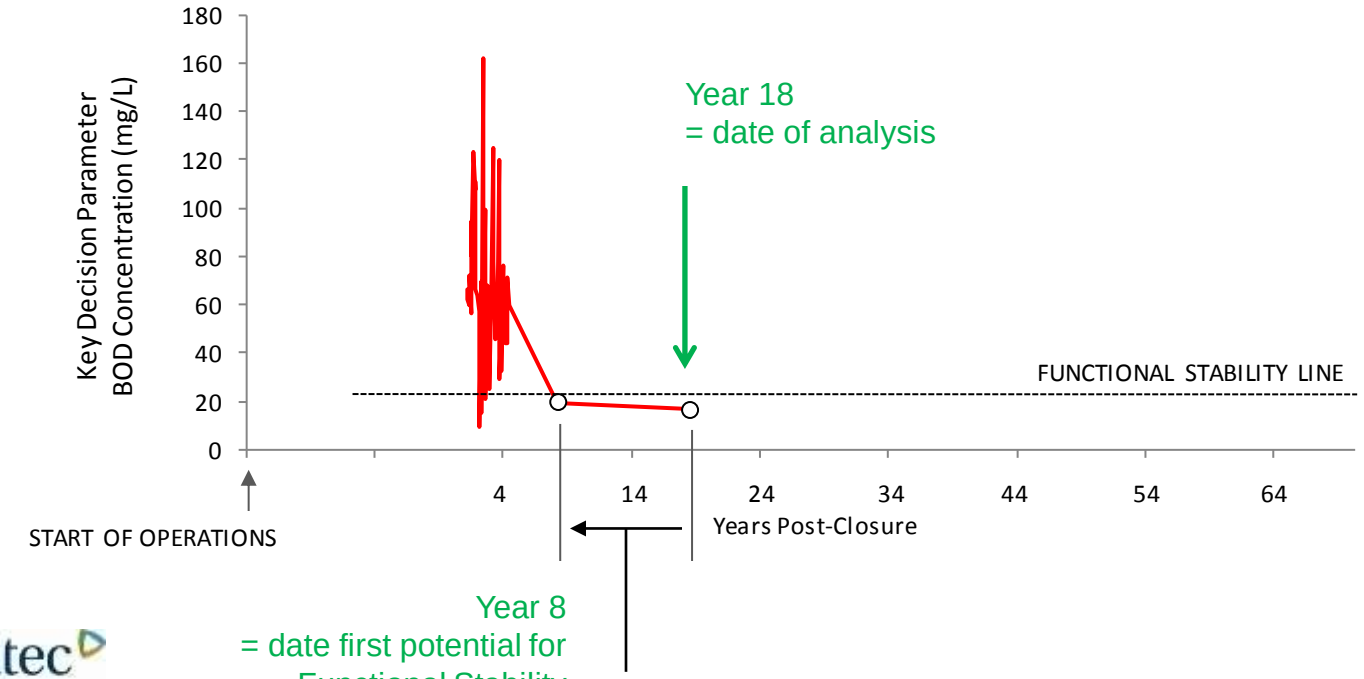
Data Analysis (1)

- Trend in Leachate Decision Parameter (BOD Concentration)
  - BOD data available for PCC Years 1 thru 18
  - Statistically significant decreasing trend evident since PCC Year 8
    - Empirical evidence that leachate quality will continue to improve with time
    - Necessary condition for demonstrating Functional Stability, but not a condition in itself → Analysis of Regulated Analytes



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Data Analysis (2)

- Comparison to Groundwater Standards
  - 134/230 (60%) analytes pass full statistical evaluation
    - Demonstrated not to pose a threat to GW quality
  - Remaining 40% pass single-value comparison
    - Suggests likely to pass full evaluation once additional composite sampling has been completed (<2 years)

- Comparison to Surface Water Standards
  - Only potential path for leachate to SW is indirect migration in GW
  - 6/9 (66%) SW analytes pass full statistical evaluation
    - Demonstrated not to pose a threat to SW quality
  - Remaining 3 analytes are all reported as ND
    - Suggests likely to pass evaluation once additional composite sampling has been completed

Site Evaluation

Groundwater Module

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Approach for Groundwater Module

- ✓ Calculate time of travel (TOT) for a potential leachate release to migrate from an appropriate landfill release location (e.g., deepest sump) to the downgradient POC
- ✓ Define total required duration of GW monitoring
  - ✓ GW monitoring must be continued until potential past releases impacting GW would have been detected
- ✓ "Site not ready" – Optimize GW monitoring activities
  - ✓ Reduce list
  - ✓ Performance-based frequency
- ✓ "Site ready" – Transition to Confirmation Monitoring
  - ✓ Indicator parameter only (generally chloride)
  - ✓ Performance-based frequency and duration

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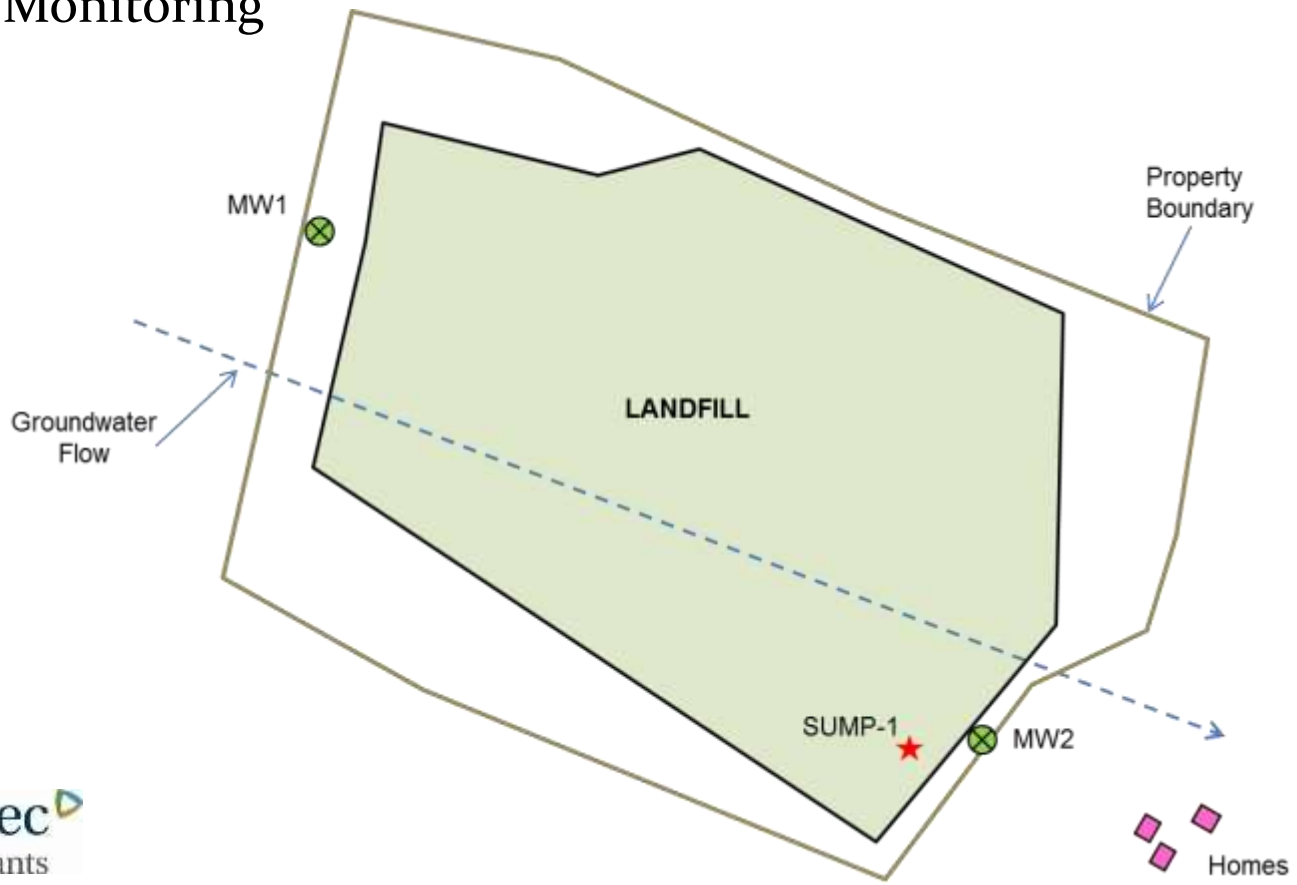
Groundwater Outcome – Summary (1)

- Groundwater level and quality data have been collected throughout the 18-year PCC period
  - Good hydrogeologic characterization of the site
  - Selection of downgradient well MW2 as POC for Confirmation Monitoring



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Groundwater Outcome – Summary (2)

- If observed trends in leachate are verified by year 20 of PCC, CM should be initiated at this well and monitoring at all other wells ended

- CM should then be conducted:
  - Indicator parameter = chloride
  - Performance-based duration = 36 years (based on TOT)
  - Performance-based frequency = 5 years
    - Sampling more frequently is redundant and does not improve protection of HHE

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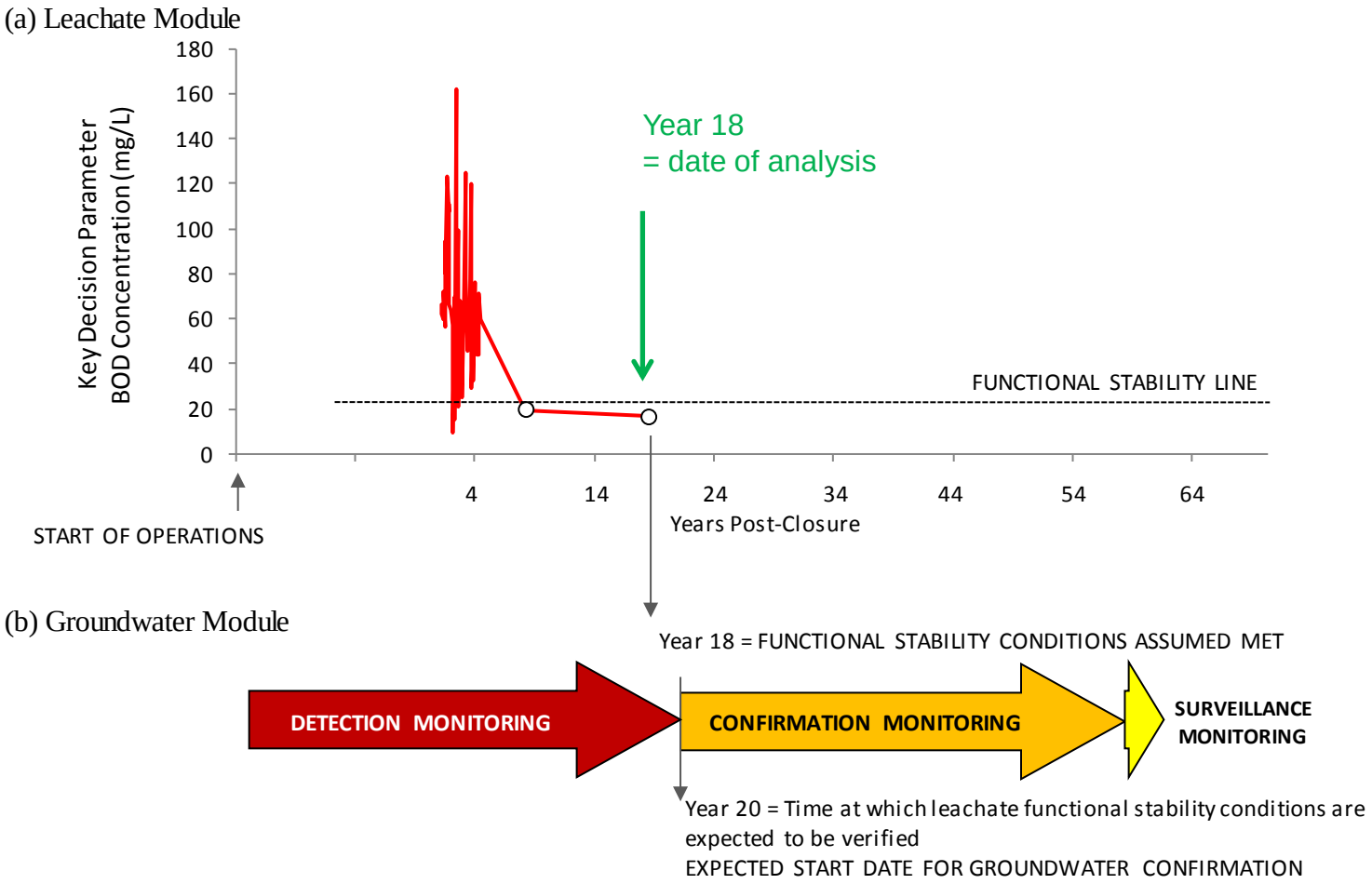
Groundwater Outcome – Summary (3)



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Site Evaluation

Gas Module

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Gas Management Strategy

- Assumptions:
  - End use = natural green space with restricted public access
  - Maintenance of the existing cap and stormwater management system will continue to limit infiltration and fugitive gas emissions

- Questions (Goals):
  - Can elimination of the GCCS be recommended, or more passive approaches to LFG management?
  - Can LFG monitoring be scaled back?

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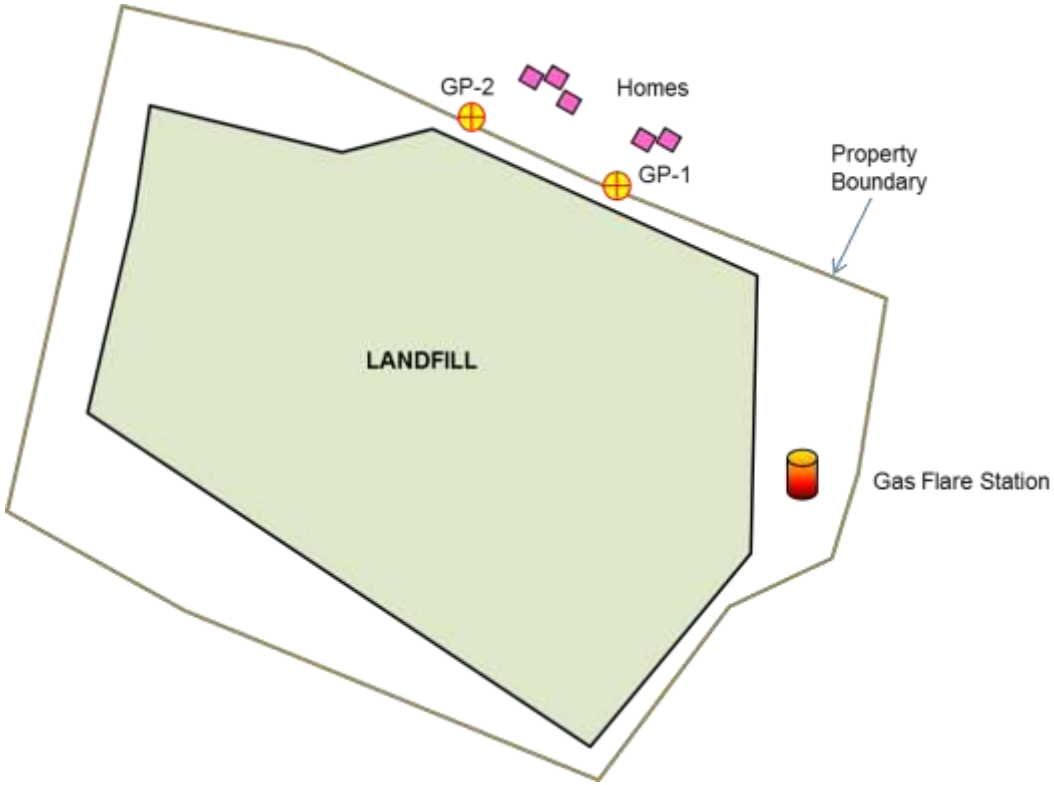
Data Analysis

- Reasonable estimates of the mass/volume of waste in place were available for gas modeling to compare to measured gas collection rates
- Because of the close proximity of homes to the POE, performing detailed analysis or risk assessment was not recommended



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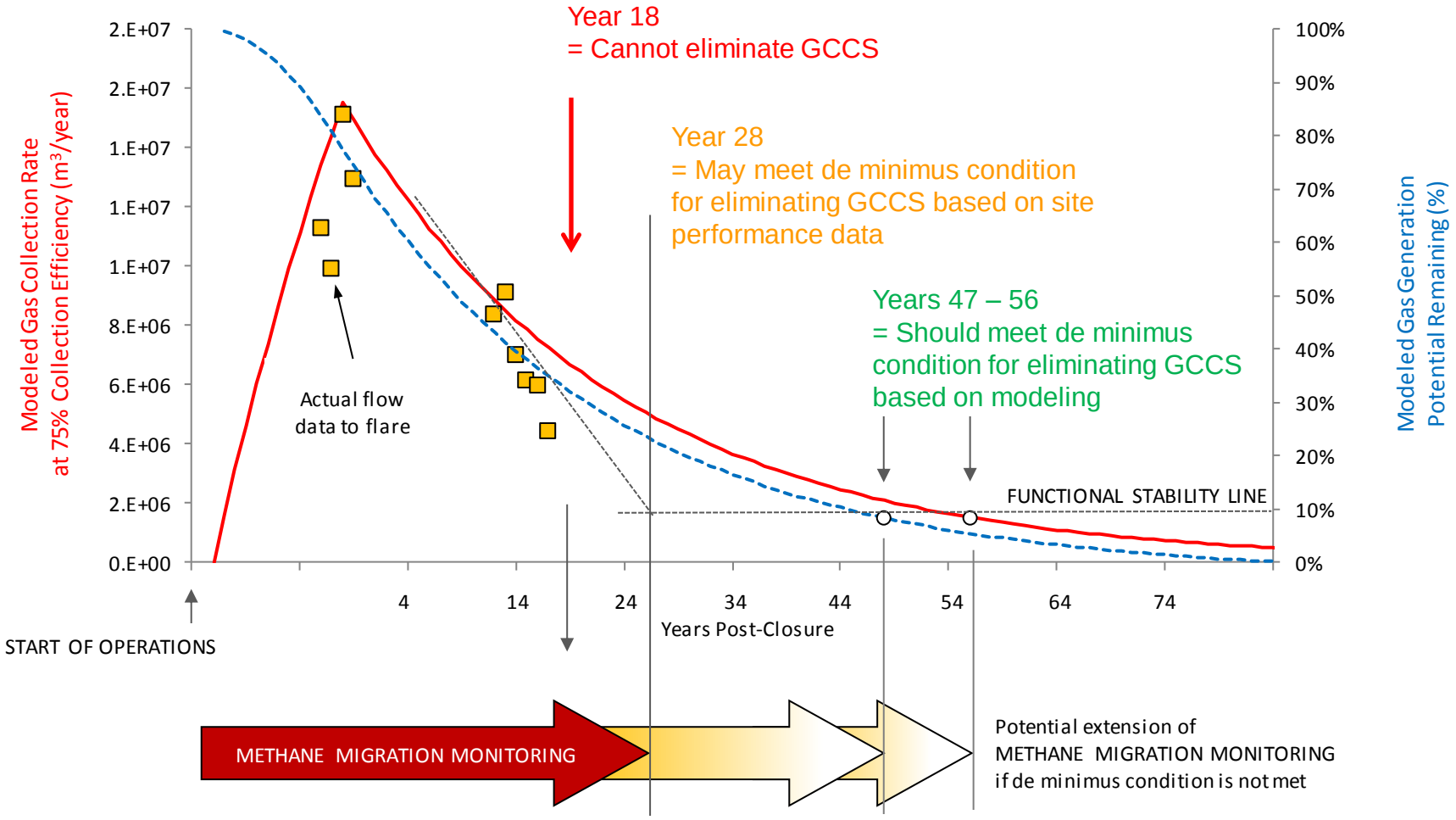
Gas Outcome – Summary



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Site Evaluation

Cap Module

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Evaluation of Cap (1)

- Data to support the cap evaluation include documentation of final cap design, construction, monitoring, and maintenance/repair since closure
- Post-closure inspections and monitoring conducted over the last 18 years confirm that the final cap has the necessary durability to provide the required isolation of the waste

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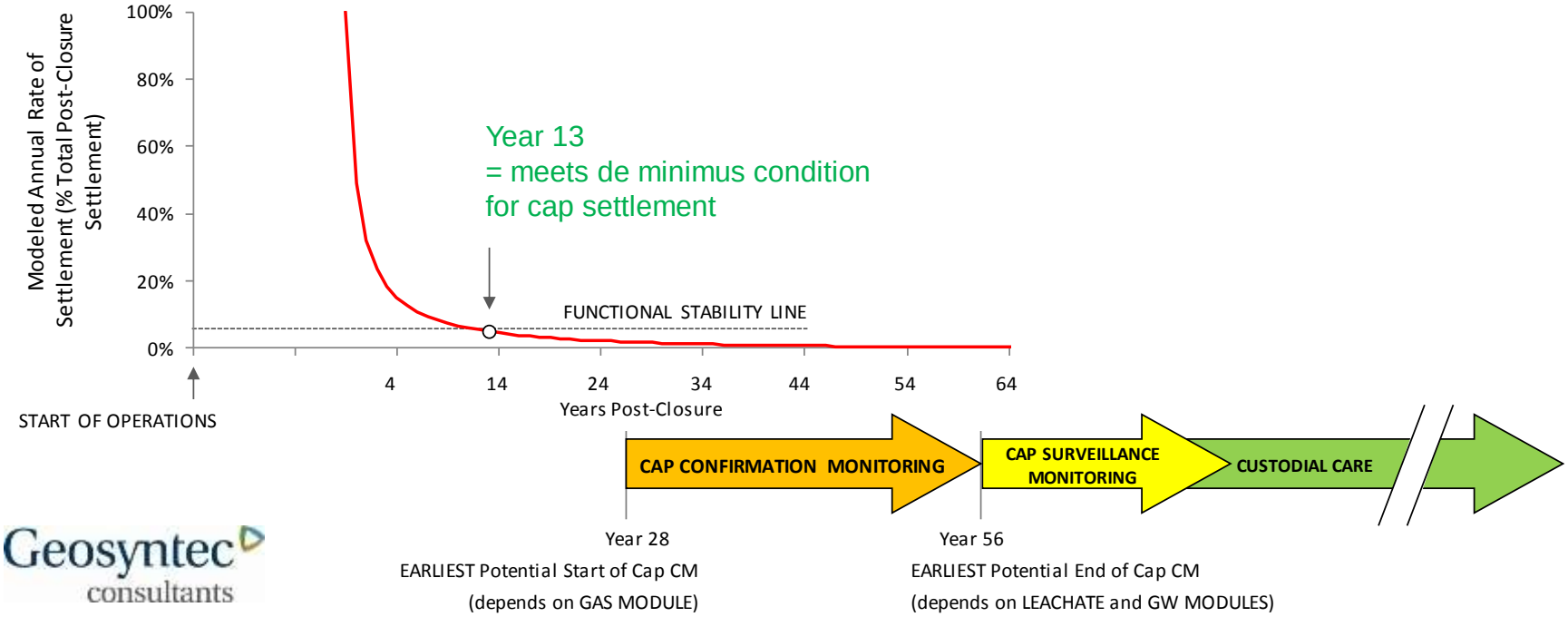
Evaluation of Cap (2)

- Evaluation of expected annual settlement showed that the annual post-closure settlement rate should have reached a de minimus 5% rate indicative of Functional Stability by PCC Year 13
- It is emphasized that the leachate and gas modules (and by reference the groundwater module) require the continued presence and functioning of the cap in its current configuration to support their outcomes



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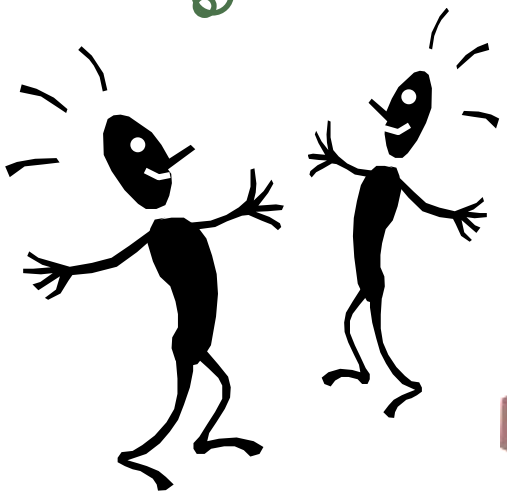
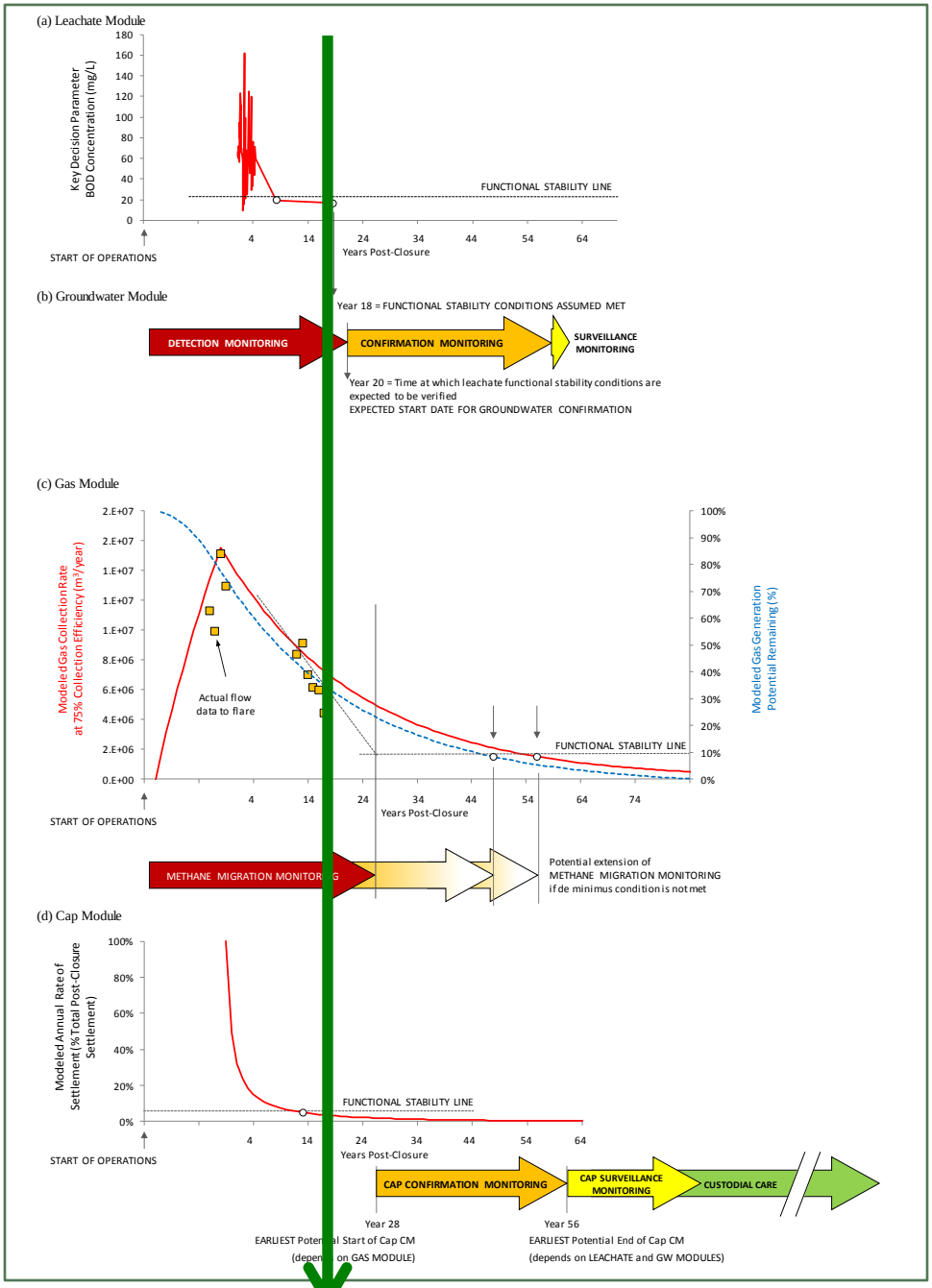
Outcome

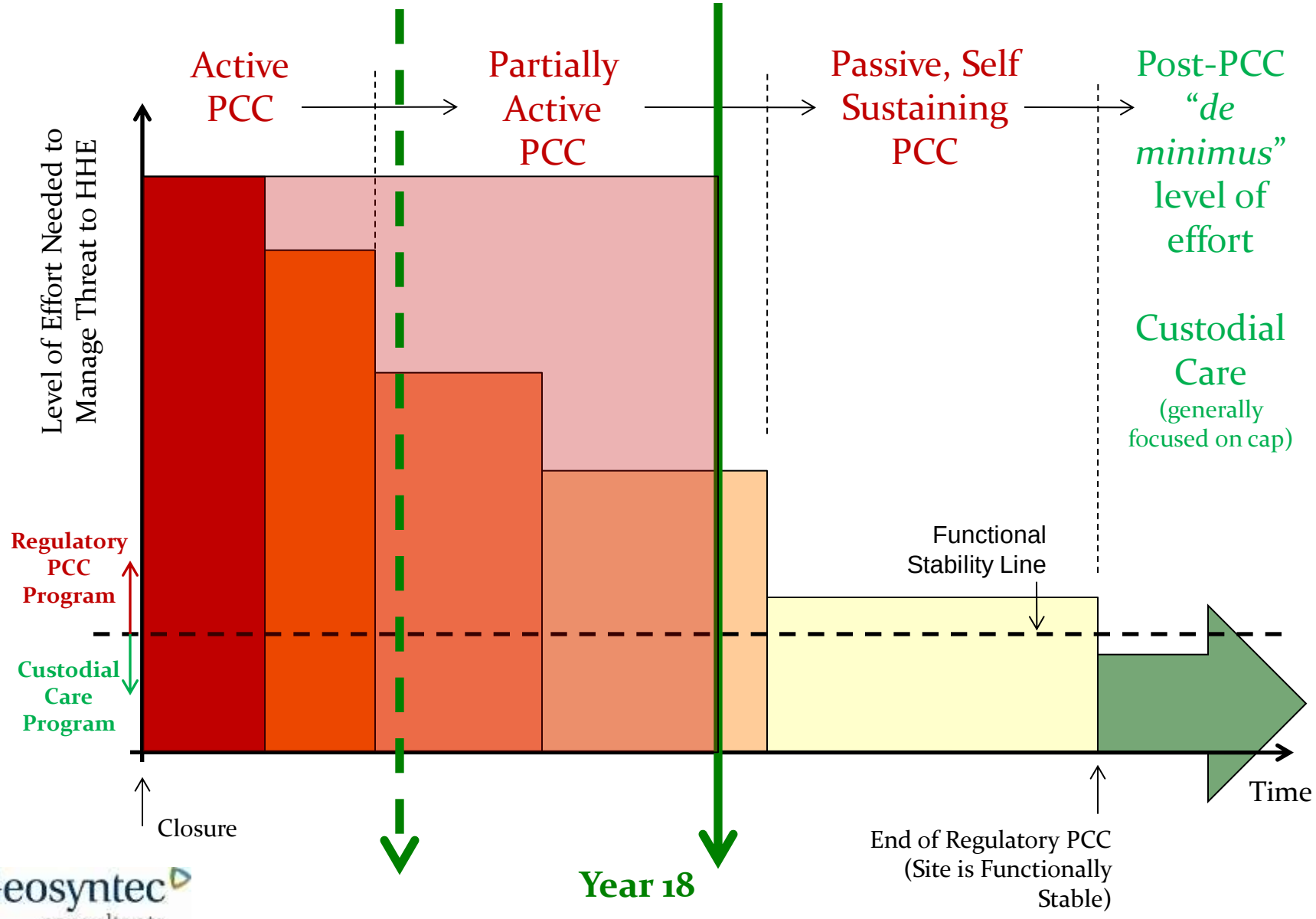
Outcome

"That's where we are on the curve!"





Here's Where We are on the other Curve…



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6. Cost Considerations

Example Economic Analysis

- Evaluation of 50-ac landfill:
  - "Business as Usual" (BAU) Scenario
  - EPCC Scenario, with five evaluations in Years 5-35
- PCC costs divided into 6 broad categories:
  1. site access control maintenance
  2. landfill cover maintenance (mowing, localized repair/reseeding, runoff controls)
  3. maintenance of leachate and LFG management systems
  4. leachate monitoring and disposal/treatment
  5. maintenance and replacement of groundwater monitoring wells and gas probes
  6. Compliance monitoring (groundwater, surface water, and gas migration) along with analysis and reporting

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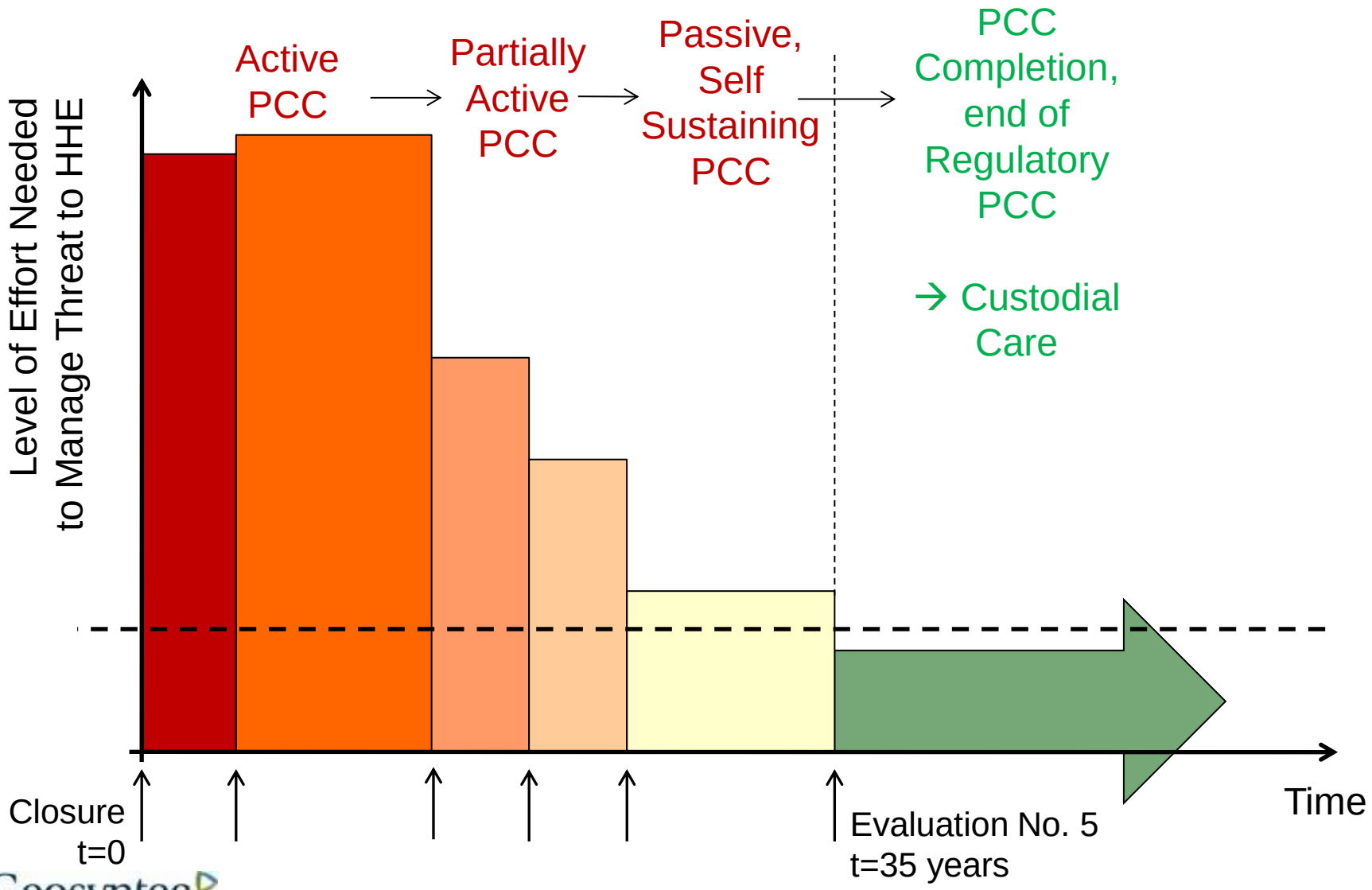
Evaluations Under EPCC Scenario



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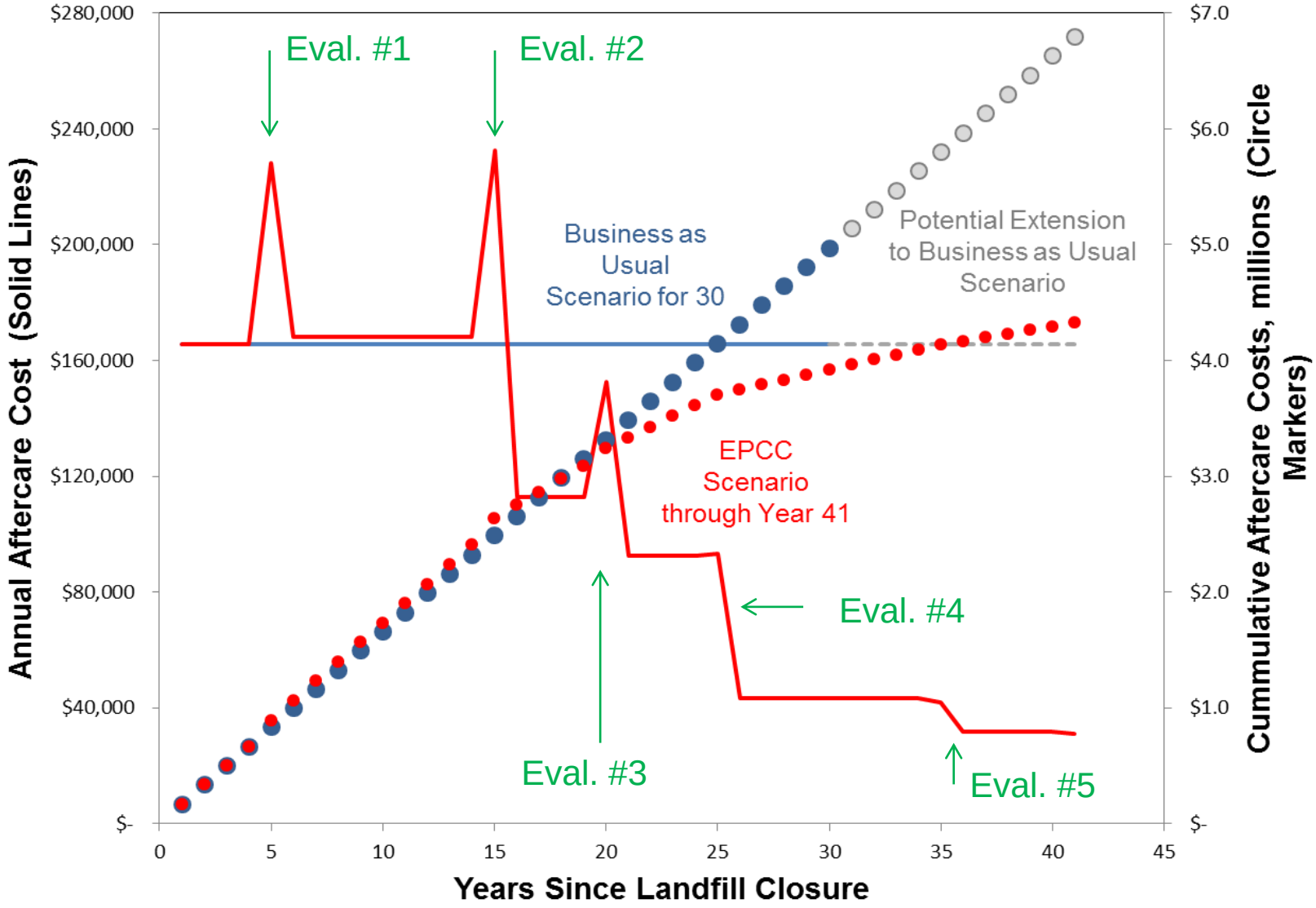
Cost Comparison between BAU and EPCC



Outcome

- Performance-based EPCC Scenario offers significant cost savings and long-term cost certainty over current Business as Usual approach

Coming Soon:

"Step-Down Performance-Based Approach to Landfill Post-Closure Care Completion and Reuse"
Accepted, SWANA Landfill Symposium
27-28 February 2013
Atlanta, GA

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7. Closing Summary

Advantages of Performance-Based PCC

- Quantifies Ability of Design to Protect the Environment
  - Doesn't depend on quantifying in-situ waste "stabilization", which can be problematic
  - Procedure based on optimization and step-down reduction in care
  - Focuses effort and resources on critical systems and activities
- Identifies how a Site has Reduced or Eliminated Potential Threats to the Environment
  - Provides purpose to, and enhances control over, PCC duration and costs
  - Encourages landfill design and operation to focus on reducing post-closure risk and impacts
- Rooted in Existing Technical Guidance and Regulations
  - Structured approach helps build consistency
  - Provides an opportunity to reach concurrence between the regulator and owner/operator

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Functional Stability and Custodial Care

- The ITRC/EPCC Methodology provides:
  - A process to assess whether a site has achieved "Functional Stability"
  - Structured approach to objectively evaluate the progress of PCC
- Provides a realistic end point for PCC
  - Proposed mechanism for transition from regulated PCC to post-regulatory "Custodial Care"
  - Tied to specific end use
- Two-step monitoring is recommended before ending PCC for a functionally stable landfill
  - Additional monitoring (i.e., confirmation and surveillance) provides "insurance" for decisions that were based on analysis

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Last words…

- ✓ Proactive Data Collection

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8. References

Guidance Documents

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1. ***"Evaluating, Optimizing, or Ending Post-Closure Care at Municipal Solid Waste Landfills Based on Site-Specific Data Evaluations"***
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Thank You

Questions?

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