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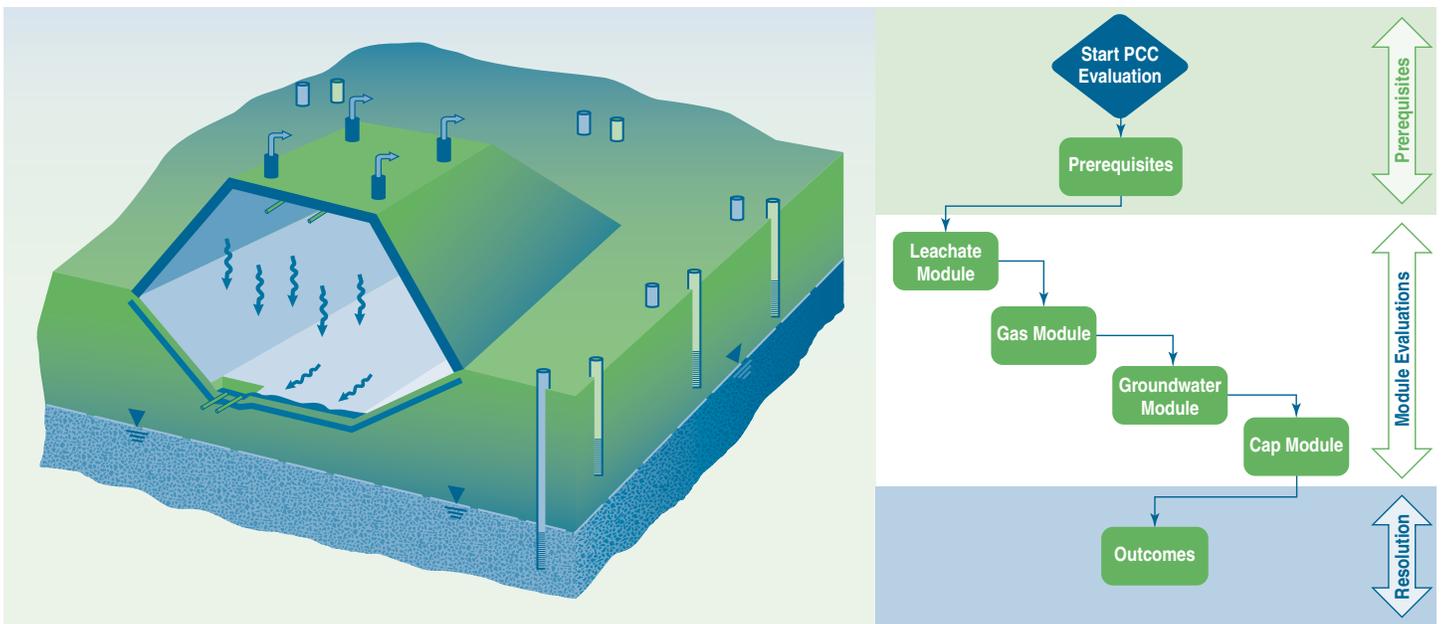


INTERSTATE TECHNOLOGY & REGULATORY COUNCIL



Technical/Regulatory Guideline

Evaluating, Optimizing, or Ending Post-Closure Care at Municipal Solid Waste Landfills Based on Site-Specific Data Evaluations



September 2006

Prepared by
The Interstate Technology & Regulatory Council
Alternative Landfill Technologies Team

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**Prepared by
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The work team also wishes to recognize the efforts of the following states:²

- Colorado Department of Public Health and Environment—Charles Johnson, Team Leader
- California Southwest Regional Control Board—Peter Fuller and Ed Wosika
- Kansas Department of Health and Environment—Paul Graves³
- Montana Department of Environmental Quality—Ricknold Thompson
- New Jersey Department of Environmental Protection, Mark Searfoss
- Oklahoma Department of Environmental Quality—David Smit⁴
- Pennsylvania Department of Environmental Protection—Ramesh Belani
- South Carolina Department of Health and Environmental Control—Van Keisler
- Virginia Department of Environmental Protection, Graham Simmerman

We depend on input from a wide variety of perspectives to give ITRC documents the broadest practical application in the industry. The team members have displayed that mix of perspectives and skills necessary to further our understanding of the municipal solid waste post-closure care requirements and obligations. The team also wishes to recognize the efforts of the researchers investigating these technologies and the consultants and businesses striving to deploy these new technologies. These include Waste Management Incorporated; Alan Environmental LLC; GeoSyntec Consultants; Air Force Center for Environmental Excellence; Department of Defense–Navy; Department of Defense; Lackland Air Force Base; AquaAeTer, Inc.; Aquaterra

¹ The EPA doesn't endorse the approach presented in the document or any other approach that a state agency may elect to use as a method for determining when post-closure care (PCC) should be terminated or potentially extended. States may use the approach described in this guidance or another approach to evaluate the appropriateness of optimizing or terminating PCC.

² States listed were part of a team that prepared three guidance documents on alternative final covers, bioreactor landfills, and optimizing post-closure. Individuals may have been most active in developing one or all of the documents. All were part of the Alternative Landfill Technologies Team.

³ Paul Graves has since move to another department within the State of Kansas.

⁴ David Smit retired from the State of Oklahoma having helped complete approximately 70 percent of the document but has returned as a citizens stakeholder for the remainder of the document preparation.

Environmental Solutions, Inc.; and U.S. Environmental Protection Agency, Region 5. With the states represented above, they contributed the latest research, years of experience, and the case study information contained in this document. Thanks also go to the community stakeholders who participated in the preparation of this document, John Chambliss and David Smit. Special thanks go to speakers who attended team meetings to update the team on latest research and demonstration and other information.

EXECUTIVE SUMMARY

Post-closure care (PCC) at a municipal solid waste (MSW) landfill ensures that a solid waste facility is managed after final closure so that it does not pose a threat to human health and the environment (HH&E). Traditionally, 30 years has been considered the minimum period that PCC must be performed. However, there is no national—and to some extent no consistent state-based—structured process for evaluating, optimizing, or potentially ending PCC. This guidance illustrates a methodology to systematically evaluate the condition of the closed landfill, the waste it contains, the setting and the relevant decisions to manage, reduce, or potentially end PCC activities according to the reduced threat to HH&E.

Through the provisions of 40 CFR Part 258.61(b)(1) and (2), the U.S. Environmental Protection Agency (EPA) allows directors of approved states to either decrease or increase the traditional 30-year PCC period based on threat, as defined in (40 CFR 258.61(b)(1)). EPA does not, however, provide specific guidance for evaluating this landfill condition. This Interstate Technical & Regulatory Council document describes a method for evaluating PCC performance based on criteria established for a defined end-use strategy. It describes a systematic and hierarchical evaluation of (1) leachate, (2) landfill gas, (3) groundwater, and (4) the final cap. It offers a decision process the owner/operator can use to demonstrate that the landfill unit does not pose a threat based upon site-specific data and a defined end use of the property and that regulatory PCC elements can be reduced or ended in accordance with the provisions of Section §258.61(b)(1). Conversely, the same process may be used by regulators to demonstrate the need for continued PCC. Ongoing evaluation for more or less than the traditional 30 years can finally provide the necessary information that the material remaining in the landfill does not pose a potential threat to HH&E.

The Alternative Landfills Technologies Team recognizes that a performance-based evaluation of PCC as described in this guidance is compatible with the existing regulatory structure of PCC. Accordingly, the team supports the concept of reducing or ending PCC based on the outcome of the four module evaluations included in this text. The team further recommends that landfill performance data be used to extend or shorten the term. Some landfills may require additional data collected to perform this evaluation. The team recommends using a 30-year PCC period as a basis for initial financial assurance planning. Support for this approach is based on available technical journal articles (see EREF 2006) that indicate leachate quality and landfill gas production at many closed MSW landfills are expected to significantly reduce in concentration or quantity in less than 30 years.

The Alternative Landfills Technologies Team believes that communities can realize significant benefit from the reuse of former landfill properties, such as brownfields-type redevelopment, by following the processes outlined in this document. Even though the formal regulatory PCC ends, an obligation for continued management is required to maintain the property according to the potential threat at the point of exposure. This is referred to as “custodial care” (CC) of the facility and associated property. CC requires continued care to ensure that it does not pose a threat to HH&E. Institutional controls required by covenant, deed restriction, or other agency mechanisms continue to ensure the property is managed according to its planned end use and CC requirements. States should develop a template, adjustable to their specific state, to track and evaluate the environmental effectiveness of land use controls placed on a landfill site.

While the final draft of the document was in development, the team received state, federal, and peer review comments such as the following:

ITRC's goal of trying to define when a landfill's post-closure care can be ended is certainly a laudable one, and the draft document appears to be addressing the matter in a logical manner which would be consistent with the Department's regulations. There is currently a need for this guidance topic in that many states are beginning to address this matter at landfill sites nationwide, and without some form of standard guidance on this subject, the potential exists to have 50 different approaches being developed. It makes far better sense to establish a standard recommended process for the various states to use rather than to have multiple independent approaches to this matter.

Army concurs as is. Air Force has some editorial comments, and Navy also concurred with some editorial comments that they are vetting with the team. Please consider this e-mail as DoD concurrence with these editorial comments.

This document does not conflict with federal regulations or Illinois regulations.

Closed landfills are no longer isolated from rapidly encroaching development. Even though originally located away from residences or businesses communities, the landfill and material it contains must be managed and the land returned to its proper benefit to the community. Properly managed following closure and PCC, old landfill properties can once again contribute to the economic and social needs of the community. Land reuse should be a planning element (Section 2.1.1) of the waste management industry in support of the surrounding community resource availability and service capacity (ITRC 2006b).

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1.0 INTRODUCTION

One of the challenges facing both state agencies, as lead regulatory entities (in accordance with their statutes, rules, regulations, etc.), and the solid waste industry is determining why, when, and how to evaluate, optimize and potentially end the regulatory post-closure care (PCC) period for a permitted solid waste disposal facility. U.S. Environmental Protection Agency (EPA) guidance (EPA 1998) allows states the use of flexible, performance-based standards for solid waste landfill activities, including satisfying the requirements for PCC and financial assurance (FA), while ensuring protection of human health and the environment (HH&E) (see inset). EPA provides the foundation for use of a performance-based process to determine whether a closed solid waste landfill poses a threat. This Interstate Technology & Regulatory Council (ITRC) guidance document proposes a decision process where the evaluation conducted on a site-specific basis can provide information necessary to defensibly optimize PCC. In addition, this guidance document provides a process to potentially conclude that a closed solid waste landfill does not pose a threat at the point of exposure (POE) and, therefore, allows for the regulatory determination that PCC can be ended. Team discussions and research found that states were not able to clearly define when no further regulatory oversight would be needed; therefore we are introducing the “custodial care” (CC) option to encompass the few remaining control mechanisms necessary, after ending regulatory PCC, to ensure that land use changes do not cause an unacceptable change in the threat to HH&E.

The fundamental basis of threat, as used in this document is human health and the environment.

“If their permitting programs have been approved by EPA, States can allow the use of flexible performance standards established in 40 CFR Part 258 in addition to the self-implementing technical standards for many of the criteria. Approved States can provide owners/operators flexibility in satisfying the location restrictions, operating criteria, and requirements for liner design, groundwater monitoring, corrective action, closure and post-closure care, and financial assurance. This flexibility allows for the consideration of site-specific conditions in designing and operating a MSWLF at the lowest cost possible while ensuring protection of human health and the environment.” (EPA 1998)

introducing the “custodial care” (CC) option to encompass the few remaining control mechanisms necessary, after ending regulatory PCC, to ensure that land use changes do not cause an unacceptable change in the threat to HH&E.

The fundamental basis of threat, as used in this document is human health and the environment.

The decision process presented in this guidance is structured on the foundation established by EPA that an owner or operator may cease managing leachate if it can be demonstrated that the leachate no longer poses a threat to HH&E [40 CFR §258.61(a)(2)]. Section 259.63 of the Code of Federal Regulations (CFR) goes on to state:

(a) Following closure of each MSWLF [municipal solid waste landfill] 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, and consist of at least the following:

- (1) Maintaining the integrity and effectiveness of any final cover, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and runoff from eroding or otherwise damaging the final cover;
- (2) Maintaining and operating the leachate collection system in accordance with the requirements in §258.40, 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 and maintaining the ground-water monitoring system, if applicable; and

(4) Maintaining and operating the gas monitoring system in accordance with the requirements of §258.23.

These solid waste regulations call out the four major landfill elements—the cover (cap), leachate collection system, groundwater monitoring program, and gas monitoring system—that are the focus of PCC. Furthermore, EPA guidance states that assessment of threat may be made at the POEs, rather than in the leachate collection system (i.e., at the source) (EPA 1998, Section 6.6.3). This approach is the basis for assessing threat for the other elements (modules) of PCC, which include landfill gas (LFG) management, groundwater monitoring, and cap maintenance. Therefore, determining the appropriate PCC obligation is predicated on a monitoring and evaluation system associated with determining whether a potential release from a landfill poses, or may still have potential to pose, a threat to HH&E at the POEs. The opportunity to end PCC and initiate CC is predicated on the conclusion, based on results from the modular evaluation process, that the landfill is stable, predictable, and will not present a threat at the POE.

A critical element to ending PCC is the collection and evaluation of data on a site-specific and modular basis to determine whether a threat at the POE exists or can exist in the future. Numerous peer-reviewed technical articles have been published indicating that leachate degrades over time in a predictable manner based on factors such as age of waste, moisture content, and type of wastes disposed of within the landfill. Other publications and EPA models also support that LFG production rates predictably decline on a first-order decay curve depending on similar conditions. Specifically, peak gas production rates typically occur at or near landfill closure (assuming a filtration barrier cap is installed at closure). These publications provide a fundamental foundation that leachate quality and LFG production rates are predictable. Nevertheless, site-specific data (some of which may be over and above minimum requirements of Subtitle D monitoring) is required to assess whether one or more of the elements of PCC pose a threat at the POE.

The concept of a CC program, as presented in this guidance, follows the PCC period, which includes the termination of FA obligations. However, a landfill in CC does not eliminate the owner/operator's requirement to manage the property consistent with its intended land use so that it is protective of HH&E. The CC program is designed to ensure that land use is managed consistently with its intended end use determined during the PCC period and that there are no unacceptable changes in the property according to covenants, deed restriction, or land use controls. In summary, PCC is the evaluation and monitoring of modular data to determine when a landfill does not pose a threat to HH&E at the POE, while CC is the proper and responsible management of the end-use obligations, as determined during PCC, consistent with local and state land use policies and procedures. The transition from PCC to CC is based on the results derived from modular, performance-based evaluation presented in this guidance.

*Regulatory post-closure care is the evaluation and monitoring of modular data to determine when a landfill does not pose a threat to HHE at the POE, while **custodial care** is the proper and responsible management of the end use obligations as determined during regulatory PCC consistent with local and state land use policies and procedures.*

The elements included in PCC for a closed solid waste disposal facility include the following:

- leachate management
- LFG management
- groundwater monitoring
- cap maintenance

Further, EPA points out (1998, Section 6.6.3) that evaluation of threat may be conducted at the POEs rather than at the source (i.e., in the leachate collection system; see box). For the purposes of this guidance, the POE is identified as the closest location at which a receptor could be exposed to the source and receive a dose in a credible pathway from the waste management unit (WMU). Therefore, use of performance-based criteria to determine when PCC can end is supported by EPA guidance, at least for leachate at a solid waste disposal facility (EPA 1998, Section 6.6.3).

EPA provided further guidance on use of a performance-based approach to make such a determination by stating, “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)

However, solid waste practitioners recognize that even when a closed MSWL achieves a condition that does not pose a threat based on the approved care and management strategy, the owner/operator still has an obligation to maintain the property in accordance with an end-use strategy in a manner similar to any other piece of property. This continuing obligation to care for a closed solid waste landfill facility to ensure that it does not pose a threat following completion of formal regulatory PCC requirements is designated in this document as “custodial care.” However, implementing CC cannot begin until the Director of an approved state has approved the owner/operator’s submittal that the closed solid waste facility has met the obligations of the approved closure/post-closure plan, including not posing a threat to HH&E.

A significant challenge to a state’s approval of such a request to end PCC is the issue of long-term property maintenance responsibilities, which is of primary interest to many stakeholders. Ending PCC does not necessarily mean that the owner/operator’s responsibility at the site will end, but that a form of CC begins. CC requires de minimus site management and care activities including meeting end-use obligations, maintaining institutional controls, controlling access, satisfying local ordinances, and fulfilling other applicable regulations (see box).

Custodial care includes continuing obligations to care for the closed landfill and ensure that it does not pose a threat to human health and the environment following formal regulatory post-closure requirements. Custodial care is considered outside the direct jurisdiction of solid waste regulatory authority. Institutional controls or covenants can accommodate or will include and ensure the protective conditions required in custodial care.

CC will be initiated following a demonstration that the threat associated with a closed solid waste landfill is acceptable for nonregulatory management of the WMU. In Colorado, for example, the components of CC may be developed prior to closure and are included as covenants to the property. These covenants identify conditions that must be maintained; otherwise, the site may be forced to fulfill additional PCC obligations under the jurisdiction of the state solid waste management regulatory authority. A request to change land use may also require the owner to revisit CC obligations and can possibly require additional PCC activities to be performed by the

owner either to confirm or demonstrate the threat associated with the landfill is acceptable considering the proposed change in land use. The Association of State and Territorial Solid Waste Management Officials (ASTSWMO) is considering developing a standard provision that allows states to enforce covenants associated with CC obligations. The ITRC Alternative Landfill Technologies Team (the Team) believes that communities can realize significant benefit from former landfill properties, especially following the processes outlined in this document, which carefully consider future use in the planning process to define safe, productive, and reliable custodial care.

The prescriptive PCC period, initially identified within Subtitle C as 30 years, was based on EPA's judgment that, "...it may take as long as 30 years for material leaching from hazardous wastes to migrate to groundwater..." (See 56 Federal Register [FR] at 51100–51102, dated 9 October 1991, and 46 FR 2819, dated 12 January 1981). The preamble to Subtitle C (46 FR 2820) goes on to state that, other than having a length of 30 years, the PCC period "should be based only on relevant environmental factors."

The 40 CFR Part 258 rule adopted this PCC term as defensible with the intended flexibility that this term can "be reduced or increased based upon relevant environmental factors that determine the threat to HH&E. Federal Subtitle D provides some general PCC guidance and explains that the PCC period should be set at 30 years for financial planning purposes. The 30-year PCC term was based, in part, on EPA's decision that more extended time frames would place an undue economic burden on businesses (EPA 2001). In establishing the RCRA program, EPA explicitly rejected suggestions that all hazardous waste disposal facilities require perpetual care. It opted for a finite, but not "unalterable," 30-year period subject to shortening or lengthening for cause, on a case-by-case basis (45 FR 33, 153, 33, 196–197, May 19, 1980). Relative to permitted solid waste disposal facilities, EPA's CFR Section 258.61 PCC requirements state:

- (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)....
- (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 (EPA 1998, Section 6.6.2).

Approval for such a request resides with the Director of an approved state regulatory agency. EPA further stated that any modification to the PCC term should be based on "relevant environmental factors." (October 1991 preamble to the Subtitle D rule, 56 FR at 51101) However, details of how such a determination is made have not been clearly or consistently established.

This guidance provides a foundation for determining the "relevant environmental factors" that would be included in an evaluation to establish the potential threat that a landfill may pose,

which would allow an owner/operator and regulatory authority to meaningfully establish an appropriate and technically defensible PCC period.

As discussed in Section 2.1.1 of this guidance, the end-use strategy is an integral part in the evaluation of long-term threat and how the PCC elements will be managed and ultimately approved by a state regulatory agency. In any post-closure use, the integrity of the cover and any necessary components of monitoring/management systems must be maintained. This task is generally considered to be more challenging when the site has unrestricted access. Solid waste professionals, the general public, stakeholders, governmental entities, and owners/operators benefit from reuse of land following closure of a solid waste landfill. Golf courses, soccer fields, habitat, shooting ranges, educational resources, and nature preserves are a few excellent examples of community benefit projects that have been successfully constructed and managed on closed landfills.

This guidance is designed to help solid waste professionals consider the broader spectrum of land use when establishing PCC requirements. The performance parameters for evaluating PCC will be based on the determination of potential threats associated with a particular end use. We challenge landfill decision makers—owners, operators, consultants, federal, state, and local government; and the public—to willingly and openly evaluate symbiotic relationships and to seize opportunities for meaningful post-closure use of landfill sites where technically feasible and economically viable.

1.1 What Are Landfills?

The federal regulatory definition of an MSW landfill is as follows:

Municipal solid waste landfill unit means a discrete area of land or an excavation that receives household waste, and that is not a land application unit, surface impoundment, injection well, or waste pile, as those terms are defined under §257.2. A MSWLF unit also may receive other types of RCRA [Resource Conservation and Recovery Act] Subtitle D wastes, such as commercial solid waste, nonhazardous sludge, conditionally exempt small quantity generator waste and industrial solid waste. Such a landfill may be publicly or privately owned. A MSWLF unit may be a new MSWLF unit, an existing MSWLF unit or a lateral expansion.” (40 CFR Part 258.2)

The regulatory definition was augmented in EPA 2002a to include some potential landfill elements that will facilitate protection of HH&E as follows:

Landfills are land-based waste management cells that contain solid wastes. Waste containment systems for landfills consist of liner systems that underlay the wastes placed on them and final cover systems constructed over the wastes.

This simple definition provides a framework that identifies landfills as engineered structures designed, constructed, and monitored to manage threat (protect HH&E) and eliminate (where possible) receptor exposure to waste materials, potentially impacted groundwater, LFG, and leachate.

This text supports the position that a solid waste landfill is a performance-based system that is constructed and/or managed to minimize potential impacts from site-specific leachate, LFG, and/or groundwater. Such a system provides the foundation for a regulatory authority to be able to accurately and defensibly determine potential threat from a landfill to HH&E at the POEs. Accordingly, optimization and/or discontinuation of the PCC program is based upon a defensible, site-specific characterization of gas management requirements, leachate quality and quantity, groundwater quality, cap maintenance, and maintenance of institutional controls.

The Team consider that, when assessing threat to HH&E at the POEs, wastes contained within the landfill structure may represent a potential risk; however, exposure to the wastes can be managed and evaluated on a site-by-site basis to determine whether such a condition represents a threat to HH&E based on the specific state's statute and regulation.

1.2 State of the Post-Closure Care Practice

In some cases the final cover system may be maintained for the long term to ensure that future leachate quality and quantity will not pose a threat. However, the presumed need of maintaining long-term care of the cover system is based on the assumption that leachate quality and quantity will pose a potential and continuous threat unless the cover system is maintained. The assumption that the cover system requires very long-term regulatory care is predicated on the notion that the mere presence of leachate in a landfill means that it has a significant threat

Ongoing evaluation of MSW leachate quality and landfill gas production indicates that leachate quality improves and landfill gas production decreases from the time of closure in a manner that makes the 30-year prescriptive PCC term reasonable for financial planning purposes.

potential. If it can be demonstrated that leachate never posed a threat or that the potential threat is no longer viable (i.e., no exposure pathway to the POE[s], or time of travel (TOT) from landfill to POE combined with consistent decreasing source strength indicates no threat potential), then extended care of the cover system would not be required for the landfill to be protective of HH&E.

Some stakeholders have expressed concern that the landfill management strategy of preventing liquids contact with the waste mass (historically referred to as the “dry tomb” approach) may require management of the cap for a period of time greater than 30 years for some sites. Depending on the defined end use and the type of institutional control (or covenants) that can be included as a condition for termination of PCC, such cap maintenance programs can still be a requirement of the owner/operator but conducted as a part of a CC cap maintenance program. Unless a threat is identified, extension of PCC obligation, even for the cap, does not meet the EPA criteria of “relevant environmental factors” simply because a long-term management strategy of precipitation-controlled containment has been employed by the owner or operator.

The advantages of a “dry tomb” strategy are that it (a) can prevent significant LFG or leachate migration in perpetuity (assuming adequate maintenance), (b) complies with regulations in a straightforward manner and is directly consistent with EPA’s liquids management strategy, (c) has lower capital costs than other strategies, and (d) may be applied to virtually all sites. Disadvantages include (a) that it can be assumed that the final cover system will be maintained and some form of monitoring will be performed for an extended period of time, which means that PCC costs may have to be optimized to maintain the cap for a longer period of time or additional PCC cap monitoring funds may be required and (b) that the waste will likely retain a

relatively high latent threat potential (i.e., if infiltration through the cap increases to regenerate leachate and/or LFG (Bonaparte 1995, cited in EPA 2002a).

For a Subtitle D landfill, an extension of the prescriptive PCC term of 30 years can be imposed if leachate and/or LFG migration is determined to pose a threat to HH&E. EPA guidance points out that such an evaluation should be conducted at relevant POE(s). As stated earlier, the POE is defined as the closest location at which a receptor could be exposed to the source and receive a dose in a credible pathway from the WMU. Each state should apply this definition according to state statute and regulation. The Team does not support defining a credible POE as the leachate collection system or leak detection system that is part of the unit. To end PCC before or after the prescriptive 30-year term, the potential for any exposure to leachate or LFG at the POE must be at levels that would be protective of HH&E.

This guidance describes an approach supporting a performance-based evaluation of the primary landfill elements (i.e., LFG management, leachate collection and recovery, groundwater monitoring, and cap maintenance). The advantage of a performance-based strategy is that it provides the key stakeholders with site-specific documentation of protection of HH&E while employing uniform technical standards usable at all applicable facilities. The main disadvantage is that the period of time required to complete a performance-based evaluation to demonstrate that the landfill elements do not pose a potential threat is not uniformly predictable.

1.3 Need for Guidance on Post-Closure Care

EPA's guidance is not clear on the processes that define when PCC is complete. EPA 1998 details the PCC operation and maintenance requirements for the four systems that prevent or monitor releases from the MSWLF unit:

- cover system
- leachate collection system
- groundwater monitoring system
- gas monitoring system

Owners or operators must comply with these requirements for a period of 30 years following closure. It is clear that guidance is needed so that owners, operators, and regulators can make decisions regarding the optimization, duration, and nature of PCC. EPA adopted the requirement for a 30-year PCC period in the original Subtitle C regulations based on estimated migration potential of liquids from the WMU. A 30-year PCC period is a reasonable benchmark for the program; however, site-specific information may be needed to evaluate the need for PCC at a particular site. Regardless, the intent of the PCC regulation is to provide for care of a closed landfill while the landfill represents the potential for an unacceptable threat.

The need for performance-based PCC to be site-specific is the foundation of the approach in this guidance. The site-specific nature of PCC is defined by variability of characteristics such as geology, climate, proximity to off-site facilities and communities, operational practices, design, and potential land use. In the absence of a clear and comprehensive process for evaluating PCC needs, state and local agencies may conclude incorrectly that the most appropriate course of action for long-term landfill management could be to extend the PCC period. Such a position would ignore site-specific conditions and landfill operational histories and could potentially

result in a loss of resources without providing additional protection to HH&E. A more technically defensible and regulatorily consistent approach for ending the PCC period would reward practices that reduce threat while providing quantifiable PCC activities that measure protection of the environment. This guidance provides a methodology to evaluate the threat that a landfill poses to the HH&E, the need for PCC at the landfill, and when some or all elements of PCC can appropriately be optimized or ended.

Defining the condition at which some or all elements of PCC may no longer be needed has been a topic of discussion at many recent national meetings, including the ASTSWMO meetings in 2001 and 2003 and the RCRA National Meeting of 2003. In its five-year strategic planning document (EPA 2002a), EPA identified long-term landfill care as one of its highest priorities.

Optimizing PCC has significant financial and performance-based implications:

- Adjustments to the financial assurance for longer PCC periods are possible as supported by 40 CFR §258.72; however, changes would be most effective if they are made while the landfill is operating.
- Following landfill closure, revenues cease and the effective management of existing PCC funds is critical to ensure proper protection of the environment into the future.
- Early evaluation of PCC needs will help identify effective operating practices at active landfills. What is learned by better understanding the PCC process—including community input, end-use strategies, stressors, failure modes, threats, and techniques to protect HH&E—could subsequently be used and incorporated in the design, construction, operation, and closure of landfills to reduce the potential for long-term impacts to HH&E from landfills after closure.
- When PCC activities are optimized, owner/operators of closed landfills can concentrate resources on landfill elements that continue to present an unacceptable threat to HH&E. This possibility promotes threat-reduction activities even after landfills are closed (e.g., through waste decomposition actions, alternative cap considerations, gas management practices, etc.).
- Many pre-Subtitle D landfills are approaching or have passed the end of shorter (10-year) PCC periods. State regulators are uncertain about how to evaluate the condition of a landfill to optimize PCC monitoring or approving the end of regulatory PCC.

The waste management community needs a valid performance-based methodology to document the basis for their decisions about closed landfills. Neither the state regulatory agencies nor the industry can afford to manage and oversee closed landfills which do not, nor ever will present a threat.

1.4 Purpose and Use

This guidance focuses on municipal solid waste (MSW) landfills and their associated PCC. However, PCC is relevant to closed sites and facilities managed in accordance with a variety of regulatory programs—RCRA, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), solid waste, brownfields, voluntary cleanup, mined land reclamation, and others. In fact the elements that are evaluated for ending PCC and MSW facilities—leachate management, gas management, cover integrity, and groundwater monitoring—are the same elements used to evaluate the success of PCC in other regulatory programs.

This ITRC guidance describes an approach, detailed in Section 4, which was adapted and modified from the Environmental Research and Education Foundation (EREF) report entitled *Project Summary Report—Performance-Based System for Post-Closure Care at MSW Landfills: A Procedure for Providing Long-Term Stewardship Under RCRA Subtitle D* (EREF 2006). The EREF guidance provides methods to evaluate data collected during the active life of a landfill and/or following its closure to provide the basis for decisions related to enhancing, extending, shortening (i.e., optimizing), or ending PCC at an MSW landfill. The EREF approach referenced herein is an example of one approach to evaluate the data and facilitate PCC decisions. While the EREF approach may not be the only approach for evaluating PCC data, it is certainly a model for data collection and evaluation that integrates the key PCC elements.

1.5 Other Applications

As for MSW landfills, the primary goal of PCC for industrial solid waste and hazardous waste landfills is to provide care until such time that termination of the PCC obligation does not pose a threat to HH&E. Given the diversity of wastes, however, closure requirements for these types of landfills must be tailored for the chemical and biological composition of the waste they contain.

There are currently no specific federal regulations pertaining to PCC for industrial waste landfills. By way of an example, Chapter 11 of EPA's *Guide for Industrial Waste Management* (EPA 2003) explains that performing closure and post-closure care, generally refers industrial waste landfill PCC to the same technical standards as required for MSW landfills. Therefore, insofar as developing PCC standards for industrial landfills is concerned, this reference may provide a strong regulatory basis for using the performance standards clearly designed for MSW landfills at these facilities.

Activities that are typically performed to provide PCC for the RCRA Subtitle C (hazardous waste) landfills consists of four systems similar to elements of PCC required under RCRA, Subtitle D (MSWLF): leachate management, LFG management, cap maintenance, and groundwater monitoring. Regardless of the PCC period, the waste type, or activity; the overall goal of PCC is to protect HH&E.

2.0 ELEMENTS OF POST-CLOSURE CARE

The basis for using a performance-based evaluation to define the end of PCC is referenced in RCRA Subtitle D regulations. The provisions of 40 CFR §258.61(a) requires an MSWLF owner/operator to provide PCC for four systems:

- leachate collection system
- LFG monitoring system
- groundwater monitoring system
- cover system

The owner/operator must verify the performance of the systems through environmental monitoring around the landfill (see Figure 2-1).

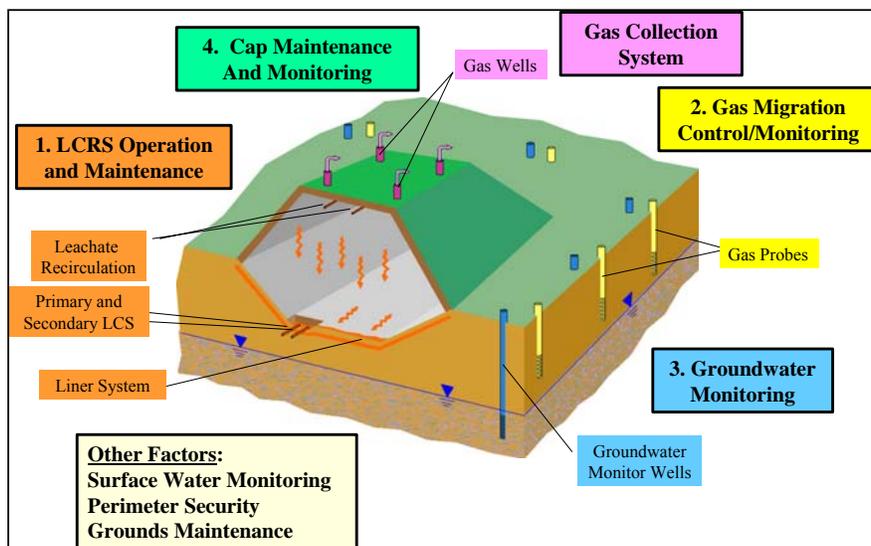


Figure 2-1. Elements of post-closure care required at MSWLFs.

Leachate Collection and Recovery System. The purpose of a landfill’s leachate collection and recovery system (LCRS) is to effectively collect and remove leachate from the landfill throughout its active and post-closure life, thereby ensuring that the leachate head on the liner is kept to less than 1 foot unless other criteria have been approved. Routine monitoring and maintenance activities include maintaining and repairing leachate removal and transmission system features (pump stations, meters, valves, manholes, transmission pipes, etc.), inspecting and maintaining leachate collection and storage systems, and sampling and analyzing leachate. Monitoring data such as leachate generation rates; the compositions of the leachate; and proximity to surface water, wetlands, and groundwater will be used to demonstrate that there is no uncontrolled leachate present at the site, that discontinuation of the LCRS is not a threat to HH&E, and that water quality standards in receiving surface water or groundwater are not violated. Furthermore, any previous failures and alleged violations related to the LCRS and any release of leachate into the environment must be addressed prior to discontinuing operation of LCRS.

Landfill Gas Monitoring System. Monitoring LFG is necessary at the property boundary (subsurface methane concentrations cannot exceed 5 percent at the point of compliance at the property boundary or 1.25 percent within on-site structures) and in buildings on site to verify operation and maintenance of the landfill gas extraction system (if such a system exists; note that most large modern landfills are required to operate such a system to comply with the requirements of the New Source Performance Standards under the Clean Air Act), upgrades or repairs to landfill gas management system components, and mitigation of off-site gas migration concerns. An adequate gas monitoring plan/network must be in place for a sufficient period of time to allow the migration of gas to be evaluated. If the PCC includes engineering controls to manage LFG migration, routine monitoring and the proper management of maintenance records are recommended during PCC.

Groundwater Monitoring System. The groundwater monitoring system is designed to allow collection of representative samples of groundwater for evaluating the potential for groundwater

quality impacts at the point of compliance (POC). The POC can be located up to 150 m (about 500 feet) down-gradient of the waste unit or at a property boundary, whichever is closer to the disposal unit. These locations of POC are approved by the regulatory agency and intended to be consistent with state statutes and regulations. This step is to accommodate those states that have no-degradations provisions (e.g., groundwater compliance is assessed immediately below the landfill). POC locations are sampled quarterly, semiannually, and/or annually, depending on the regulatory status of the landfill. Typically, the results from these monitoring events are compared to background conditions or health-based standards to demonstrate compliance or to establish trends that can be used later in the performance evaluation of different landfill elements, including determining an appropriate duration of PCC. In the event that a facility is undergoing corrective actions dealing with groundwater, the facility must demonstrate that the corrective action is complete and no further action is required.

Cover System. In accordance with 40 CFR §258.61(a)(1), PCC includes maintaining the integrity and effectiveness of any final cover system, including making repairs to the cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and runoff from eroding or otherwise damaging the final cover. Under Subtitle C (as an example from another regulatory program), the cover system must have an equivalent hydraulic conductivity less than the lower of (a) 1×10^{-5} cm/s or (b) the hydraulic conductivity of any bottom liner.

The Team understands that alternative interpretations of those requirements are allowed and are presented in ITRC 2003. PCC of the cover system typically involves the following:

- inspection and maintenance of the final cover to verify that it is stable against erosion, instability, and washout
- inspection of storm-water management system features
- mowing and fertilizing/replanting of vegetation on the surface
- institutional controls
- site survey to determine the amount of subsidence, if any, of the waste during the PCC
- repairs required by subsidence of the landfill cover
- remediation of seeps or other conditions causing discharge of leachate and/or landfill gas to the environment

Evaluation of Threat in the PCC Term. As defined in 40 CFR §258.61(a–b), PCC is to be provided for 30 years unless the period is shortened or lengthened by the Director of an approved state. The language used in EPA’s 1998 guidance provides an explicit description, but not a detailed methodology, of the approach that this official is to take in evaluating the need for extending or shortening the duration of PCC of the leachate management system at an MSWLF using a performance-based standard:

At some landfill facilities, leachate concentrations eventually may become low enough so as not to pose a threat to human health or the environment. In an approved State, the Director may allow an owner or operator to cease managing leachate if the owner or operator can demonstrate that the leachate no longer poses a threat to human health or the environment.... The demonstration should address direct exposures of leachate releases to ground water, surface water, or seeps. Indirect effects, such as accumulated leachate

adversely affecting the chemical, physical, and structural containment systems that prevent leachate release, also should be addressed in the demonstration.

EPA provided additional clarification by stating, “Concentrations at the points of exposure, rather than concentrations in the collection system, may be used when assessing threats” (EPA 1998, Section 6.3.3).

The POE is defined as the closest location at the surface at which a receptor could be exposed to the source and receive a dose in a credible pathway from the WMU (a description of what a threat might be and the flexibility or variability of the POE is contained in Subtitle D, 40 CFR 258.61 (a)(2) and EPA 1998. The guidance goes on to detail some of the tools that can be used for the demonstration. Fundamentally, this provision provides precedent and is the basis for applying this performance-based approach. The preamble to Subtitle D discusses how EPA intentionally developed this language to allow for evaluating the duration of PCC based on site-specific conditions (e.g., geology, climate, topography, resources, and demographics) and in terms of ensuring protection of HH&E. Clearly, the citation allows an owner/operator to complete PCC of one system (e.g., leachate management) while continuing to provide PCC of other systems (e.g., groundwater monitoring) and provides for (or even encourages) a phased approach for scaling back and eliminating the other systems (e.g., gas mitigation, groundwater monitoring, and cap maintenance).

The Team feels that nothing in the following methodology in this guidance conflicts with the regulatory requirement or intent of EPA regulations or guidance.

2.1 End Use

Closed landfills were traditionally treated as a parcel of ground that was isolated, secured, and monitored. Certainly this approach was consistent with the literal and limited application of the post-closure regulations. Many of these facilities were located away from potentially impacted residences, business, and commercial operations, but close enough to minimize hauling costs. However, communities continued to grow, and closed landfills found themselves surrounded by homes, businesses, schools, and other of ever-increasing community pressures. The closed landfill, once “out in the country,” found itself to be a prime real estate location that could provide value to the community with a properly managed end-use program.

2.1.1 End-Use Identification

Any closure site end use can be integrated into community service capacity—producing jobs, housing, environmental habitat, mineral resources, agricultural goods, and other societal values at, near, and surrounding a project (ITRC 2006b)—better than our previous practice of isolation or buffers. A strategy for integrating end use into the planning and design process for landfills is depicted in Figure 2-2. The diagram contains a conceptual process for integrating future land use and stakeholder input into a landfill planning and design project. Key to the success of these projects is gaining an understanding of the potential future land uses at, near, or surrounding a landfill. Figure 2-3 shows an agricultural setting often found adjacent to landfills. Integrating stakeholder input regarding their desires for community development and needs is critical. This type of an integrated project can gain support from community stakeholders and allow them to

become advocates for projects that integrate land reuse. This integrated approach can benefit the process of PCC by creating an understanding of the potential future land-use impacts on the landfill and result in a better understanding of stressors on the closed landfill and potential failure modes. Once we understand failure modes, then we can better design the landfill to manage these contingencies or threat at the POE. This process leads to better management of the potential threat at the POE and the resulting impact on PCC needs and management systems. In practice, closing or previously closed landfills may be configured or reconfigured, respectively, to support the anticipated future land use as long as it is protective of HH&E and manages the threat at the POE, all of which will be integrated into the CC program. This method means that the threat at the POE, based on expected future land use at closed landfills, will form the basis for the development and implementation of CC program.

For an end-use strategy to be successful in the long term, it will likely need to be discussed with the local community, regulators as well as other local or regional public and private stakeholders and interested or affected parties. Some available resources in this collaborative effort include municipal and county planning and zoning, mayor’s and governor’s planning boards, homeowners associations, stakeholder meetings, and others. It is important that this process be initiated a number of years ahead of attempting to end PCC.

Not all regulations require outreach to communities or governmental organizations to obtain the necessary permits for construction, operation, and closure. As facilities engage the public and other outside organizations to a greater extent in an attempt to identify preferred future land uses, they may be subject to more scrutiny.



Figure 2-3. Agricultural setting often found adjacent to landfills. (Courtesy Kansas Department of Health and Environment)

However, there is a growing body of success stories associated with facilities that developed and implemented community communications plans to solicit the needs and concerns of their nearest neighbors. These successes are seen in landfills developed into soccer fields, baseball parks, golf courses, ecological diversity and habitat areas, educational centers, and others. Some closed hazardous waste landfills have incorporated closure design aspects to accommodate outdoor historic airplane museums, parking lots, commercial building



Figure 2-2. End-use planning strategy.

property, and industrial work spaces. These success stories describe a benefit for facilities that, in some instances, go beyond the requirements to identify the needs and desires of communities and attempt to integrate those needs into their landfill projects.

There are instances where going beyond the regulations to work cooperatively with the public has made productive partners of the community stakeholders. This cooperative relationship can be more productive than trying to avoid community contact and interaction. The identification of known or potential end uses is key in selecting and designing the best available closure configuration for a landfill. This approach is consistent with the PCC requirements identified in CFR Part 258, Section 258.61(c)(3):

(c) A description of the planned uses of the property during the post-closure period. Post-closure use of the property shall not disturb the integrity of the final cover, liner(s), or any other components of the containment system, or the function of the monitoring systems unless necessary to comply with the requirements in this part 258. The Director of an approved State may approve any other disturbance if the owner or operator demonstrates that disturbance of the final cover, liner or other component of the containment system, including any removal of waste, will not increase the potential threat to human health or the environment.

Identification of end uses can influence the closure design and PCC of a landfill. If the potential end uses are identified early in the landfill life, they can be considered accurately in the initial design, configuration, operation, and closure. This planning process should occur when the landfill is designed and can be reevaluated at the time of closure.

2.1.2 Threat Considerations in End Use Identification

Based on the end-use strategy for a closed landfill, potential exposure scenarios are evaluated to define the stressors, failure modes, and the resulting threat that might be imposed on a receptor. Consideration of the potential stressors and failure modes during PCC should be part of the initial design basis for a landfill. The monitoring program can then be designed to evaluate the resulting threat or confirm that the threat no longer exists. The threat should be based on the exposure tolerance associated with the end-use strategy.

A performance-based approach for evaluating PCC can ensure that these goals are met. A performance-based evaluation can be predicated on managing the threat associated with a closed landfill on either an active or a passive basis. A key premise of the performance-based approach is that the landfill can reach a state of stability in which the remaining contents of the landfill do not pose a threat at the POE. The Team offers the following definition for landfill stability:

A landfill is functionally stable when it does not present a threat to human health and the environment at the point of exposure. Potential threats to human health and the environment must be assessed considering leachate quality and quantity, gas composition and production, cover integrity, and groundwater quality. Potential threats to human health and the environment should be assessed in the context of a proposed end use and a proposed level of post-closure care, which may vary from no care to some level of extended care that is designed to ensure that no factor(s) change that could increase potential threats to human health and the environment.

This guidance describes a performance-based system for assessing PCC needs based on the state of an MSWLF’s functional stability. As long as the long-term condition of a landfill is known and consistent with the intended end use of the site, it is reasonable to allow PCC to be optimized and potentially discontinued after it has been demonstrated that the landfill has ceased to present a threat, regardless of whether any portion of the waste remains in place.

Since this guidance is targeted at MSW facilities, a review of Subtitle D landfill design considerations is provided to emphasize the importance of establishing an appropriate foundation for implementing a performance-based approach to optimizing and potentially ending PCC. Prior to ending PCC, potential landfill threats can be reduced by characterizing the waste materials, identifying threat potential for each of the four landfill elements, and appropriately managing the landfill facility. Hazard characteristics of source material influence the barrier design, performance, and threat evaluation (see Table 2-1). Landfill design and construction are specifically influenced by the characteristics of the waste, waste form and stability. Threat is determined at the point of exposure and not at the source (i.e., within the landfill system) when evaluating the PCC period. The point of exposure must also be consistent with applicable state laws (e.g., some states do not allow degradation of groundwater immediately below the landfill). Table 2-1 is provided only as information to assist in the assessment of the potential fate and transport of compounds contained in MSW if ever released from a landfill. While this document does not provide a tool to quantify the predicted impact of the listed compounds on landfill design and PCC, it does list the characteristics to consider in the design process. Table 2-2 illustrates that, although mechanical and biochemical effects can impact a landfill system, these effects can be effectively managed during operations and PCC through engineered solutions and proactive environmental management.

Table 2-1. Types of solid and hazardous materials

Type	Typically found in nature?	Importance of chemical form to toxicity	Does hazard decay naturally?	Do we know how to destroy hazard?
Municipal solid waste	Some	<ul style="list-style-type: none"> • Can affect the level of exposure to the hazard by altering the ingestion or inhalation uptake of isotopes 	Yes, some natural decay and decomposition	<ul style="list-style-type: none"> • In situ treatment via bioreactor can enhance degradation process
Toxic organic compounds	No	<ul style="list-style-type: none"> • Affects ingestion and inhalation uptake • Determines toxicity level 	Yes, decay generally slow (years, decades) and often dependent on specific chemical environment (e.g., trichloroethylene)	<ul style="list-style-type: none"> • <i>In situ</i> decay may be deliberately enhanced by microbes • Ex situ destruction is generally possible but with associated risks and costs during transportation and destruction
Toxic metals	Yes, although sometimes not in the more hazardous chemical forms	<ul style="list-style-type: none"> • Can affect ingestion or inhalation uptake • Generally affects toxicity 	No, metals do not decay, but the chemical form may naturally change into less toxic forms	<ul style="list-style-type: none"> • Destruction (changing one element into something else) is not practical • In situ alteration of chemical form can sometimes be enhanced by microorganisms • Ex situ destruction is generally possible, but with associated risks and costs during transportation and destruction

Table 2-2. Examples of stressors that may degrade landfill systems

Stressor	Mechanical effects	Biochemical effects
Water (rainfall/snowfall, surface water)	<ul style="list-style-type: none"> Hydrostatic head Erosion (runoff, surface water, movement of materials within barriers, localized depressions pooling water) Ice expansion/contraction 	<ul style="list-style-type: none"> Wet/dry cycles Corrosion Leaching Water influences plant, animal, microbial behavior Water transports contaminants Surface water brings seeds → plant ecology Water brings microbes → microbial ecology
Temperature changes	<ul style="list-style-type: none"> Differential thermal expansion Freeze/thaw Ice expansion/contraction 	<ul style="list-style-type: none"> Influences biochemical reaction rates Climate changes impact biota
Wind	<ul style="list-style-type: none"> Mechanical load Windblown objects Erosion Delaying (lifting layers) 	<ul style="list-style-type: none"> Brings seeds → plant ecology Brings microbes → microbial ecology Adds soil → changes plant growing conditions → changes/hurts/helps vegetation
Mechanical loads (seismic, vibration, subsidence, impacting objects)	<ul style="list-style-type: none"> Punctures Mechanical loads Settling of fines into coarse layers 	<ul style="list-style-type: none"> N/A
Plants	<ul style="list-style-type: none"> Macro open porosity Surface level (run-on) 	<ul style="list-style-type: none"> Uptake contaminated material and bring to surface Impact animal ecology (food supply) Impact microbial ecology (e.g., nutrient profiles) Evapotranspiration
Live animals	<ul style="list-style-type: none"> Macro open porosity Surface level (run-on) Erosion (of excavated material) Excavate contaminated material and bring to surface 	<ul style="list-style-type: none"> Impact plant community/species Impact microbial ecology (e.g., nutrient profiles)
Microbes	<ul style="list-style-type: none"> Plug capillaries 	<ul style="list-style-type: none"> Biocorrosion Bioleaching Change surface tension (e.g., in pores and capillaries) Change PRB biochemistry Soil formation → change plant biota → change animal biota
Radiation (ultraviolet, ionizing)	<ul style="list-style-type: none"> N/A 	<ul style="list-style-type: none"> Material property degradation

2.1.3 End-Use Management

The goal of PCC is to provide monitoring and maintenance following closure of a landfill to ensure that the landfill and its contents do not pose a threat. This is a threat-based goal for PCC management of the landfill and is traditionally accomplished through a combination of quantitative and qualitative tasks (e.g., monitoring and managing the amount of head on a liner system and evaluating the cover integrity using settlement or erosion as indirect means of measure).

When the known or potential end uses of the landfill are identified and understood, how these activities may impact PCC operations can be assessed. The process may be extrapolated as

alternative forms of PCC. Again, identification of potential end uses early in the facility planning stages is the cornerstone to creating a design and facility configuration that better supports the ultimate end uses.

This analysis is extrapolated through the ultimate end use of the site to delineate what stresses will be placed on the landfill during the PCC period. The stressors can then be converted to potential failure modes. The failure modes represent potential threats to surrounding receptors. The receptors could be landfill workers in adjacent landfill cells, people in residential, commercial, or industrial settings in adjacent properties; or wildlife that could be impacted through contaminated air, groundwater, surface water, or soils.

The proposed end use of the closed landfill must consider the potential exposure pathways and evaluate the threat based upon such pathways. If, for example, a landfill will be converted to an industrial park, the PCC process may not need to include aspects of ecosystem management in the evaluation of threat. The paved areas and buildings may provide a barrier protecting against dermal contact with the waste material. Therefore, parking lots and building foundations may serve as the landfill cover system to prevent dermal and ecological contact. However, other controls may be necessary to prevent exposure to LFG. Long-term management strategies (e.g., PCC plans or institutional controls) will need to ensure that future utility workers do not dig into underlying waste.

As the PCC end use of a closed landfill changes, so do the stresses that affect the landfill. Protection of HH&E should be integrated into an evaluation of the stressors, failure modes, and potential threats. A landfill may go from being an industrial park, with workers on site 50 hours a week and protected by paved areas and building foundations, to baseball fields with recreational use 8 hours a week. The threats associated with potential exposure should be adjusted and evaluated with changing use through time to ensure that the closure configuration, monitoring program, protectiveness measures, and institutional controls are appropriate to manage the potential exposures.

2.2 Performance-Based Approach to Post-Closure Care

Several methods have been suggested to address the problems with the current approach of prescribing the duration for PCC under Subtitle D. They are identified below along with their advantages and shortcomings.

- *The Myth of “Walking Away” After Specified Post-Closure Period.* One commonly held concept of the end of PCC is that, after the end of the 30-year PCC period required under Subtitle D, the owner or operator can stop providing any care for the landfill and essentially “walk away” from the site and from any future obligation to care for the site. In reality, local regulations and property-ownership ordinances would likely preclude the owner or operator from “walking away” from a landfill site. Still, there is no guidance in the regulations for how to determine whether a period longer or shorter than 30 years is needed. The Subtitle D regulations do allow the Director of an approved state to lengthen or shorten the PCC period, but there is no guidance for establishing a basis for such a decision. Based on these considerations, the concept of “walking away” at the end of a predefined 30-year PCC period is neither plausible nor desirable.

- *Types of Long-Term Stewardship.* A contrast to the concept of “walking away” after 30 years of PCC is to provide long-term stewardship care. Long-term care involves providing PCC for all elements of the landfill (i.e., the leachate and landfill gas management systems, the landfill cap, and groundwater monitoring system). This task can approach perpetual care, which assumes that the landfill will always have the potential to impact HH&E, the waste will have to be isolated for perpetuity, and the landfill will never be in a stable situation requiring no further PCC. It implies that a constant level of PCC will always be required, regardless of the actual threat posed by the landfill. In addition, no effort will be taken to reduce the threat potential of the landfill because there is no incentive to do so. Due to the finite life of landfill containment systems (e.g., liner materials), it is clear that this is not a protective strategy. Proactive landfill management that reduces the threat potential of the site is more protective of HH&E. The financial exposure from full PCC in perpetuity is considerable and can outweigh the additional expense of data collection and analyses in a performance-based system. The Team understands that perpetual care is an unquantifiable uncertainty with regards to potential future costs. It is difficult for lending institutions to assess as to the amount of funds that need to be lent or allocated to a perpetual care project.
- *Waste Stabilization or Inert End Point.* The Subtitle D Regulations allow a reduction or termination of PCC at MSWLFs once it is demonstrated that a landfill does not present a threat. This condition is generally considered to occur after the waste has “stabilized,” that is, after the waste cannot decompose further into constituents that could harm the environment. Stabilization of heterogeneous waste is difficult to define or measure. There are current efforts to enhance waste degradation via bioreactors. The reader is encouraged to review ITRC 2006a to obtain a better understanding of monitoring criteria to help gauge the effectiveness of bioreactor operations regarding waste stabilization.

A number of technical criteria for defining waste stability have been proposed by various owners/operators, regulators, and researchers, such as Ramin Yazdani from the Yolo County California Landfill (see <http://www.epa.gov/projectxl/yolo/index.htm>) and Dr Tim Townsend from the University of Florida Bioreactor Research Project (<http://www.bioreactor.org/>).

- *Categorization of Landfill Conditions and Types.* The end of PCC could be defined for a landfill based on the condition of the landfill during the PCC period. For example, a shorter PCC period could be prescribed for landfills that were operated as bioreactors, were located in an arid region, or exhibited excellent exclusion of the receipt of unacceptable wastes or facilities with an outstanding compliance history. Conversely, a longer PCC period could be required for landfills that excluded wastes that could accelerate biodegradation, had a poor compliance history, experienced environmental impacts, or had a poor construction quality assurance record. Although such an approach could be fair and accurate, it would be extremely difficult to codify and apply the range of different landfill conditions and types that warrant individual consideration. In addition, it is likely that any approach based on landfill conditions and types would be based on the performance of each category or type of landfill, and so the approach would essentially be similar to a performance-based approach (as described below) with additional (perhaps redundant) considerations for each landfill condition or type. Therefore, this type of approach would likely be needlessly complex and difficult to implement.

- *Performance-Based Approaches.* Performance-based approaches for defining the duration of the post-closure period focus on identifying and quantifying the potential for a landfill to pose a threat. Using a performance-based approach involves defining the sources of potential impacts (e.g., leachate, LFG, solid waste, and potentially impacted groundwater) and evaluating whether or not the waste containment systems and management systems prevent these sources from posing a threat. This type of evaluation involves examining statistical trends in leachate and/or groundwater quality to predict future performance based on past trends. As described in following sections, a performance-based approach can reliably define the duration and effectiveness of PCC.

Performance-based approaches are currently being used at certain sites (see Appendix F for case studies). Also, plausible management strategies exist for long-term care of MSWLFs that protect HH&E through management of only the PCC systems that are needed (e.g., cap maintenance only). Although no examples of performance-based approaches for evaluating and ending PCC have been completed for landfills subject to RCRA Subtitle D requirements, in accordance with every procedure outlined in this ITRC guidance, examples of technical approaches that have been implemented are included for illustrative purposes, indicating that states are using threat- and performance-based methodologies to evaluate PCC needs at closed MSWLFs (see Appendix F).

3.0 REGULATORY OVERVIEW AND FLEXIBILITY

The purpose of this section is to identify regulatory barriers and regulatory flexibilities that may be applied to the PCC of landfills. We attempt to identify and clarify misconceptions about the regulations and, where appropriate, recommend alternative solutions to real regulatory barriers. There is typically flexibility in regulation allowing use of alternative techniques so long as they are as protective of HH&E as the prescriptive regulatory provisions. Discussions in previous sections of this guidance illustrated the flexibility contained in the federal, and many state, solid waste regulations.

40 CFR Title 40, Subchapter I includes the federal solid waste regulations in Part 258. The federal regulations indicate that PCC must be conducted for 30 years. Interestingly, no agency is directly responsible for implementation of these regulations. A third party may sue to enforce the federal rules. Federal PCC will end after 30 years based on the lack of demonstration by an implementing agency to justify lengthening the PCC.

Each state has its own EPA-approved solid waste program. The states are responsible for implementing their own solid waste statutes and regulations. During the first 30 years of PCC, the state programs must be implemented in accordance with the federal rules. After the first 30 years and the termination of the federal PCC provisions, states may implement additional statutory and regulatory flexibility contained within their own statutes and regulations, independently of the federal rules. Of course, such state PCC regulation following the end of the federal PCC period can exist only in a state that has the statutory authority to impose requirements on an MSWLF that is no longer subject to the federal MSWLF regulations.

Arguably, a demonstration made by a state to lengthen PCC or accepted by a state to shorten PCC should satisfy the federal rules if the process was implemented during the first 30 years of PCC. This likelihood is partially a function of the fact that most states adopted regulations very

similar to the federal rules. Therefore, demonstrations to shorten or lengthen PCC should be able to satisfy both the state and federal rules, due to their similarities, and withstand a third-party challenge of the state's final determination.

The following passage from the CFR, which applies to hazardous waste treatment, storage, and disposal facilities, is an example of regulatory flexibility:

Title 40—Protection of Environment

**Part 264—STANDARDS FOR OWNERS AND OPERATORS OF HAZARDOUS
WASTE TREATMENT, STORAGE, AND DISPOSAL FACILITIES**

Subpart G—Closure and Post-Closure

§ 264.117 *Post-closure care and use of property.*

(c) Post-closure use of property on, or in, which hazardous wastes remain after partial or final closure must never be allowed to disturb the integrity of the final cover, liner(s), or any other components of the containment system, or the function of the facility's monitoring systems, unless the Regional Administrator finds that the disturbance:

- (1) Is necessary to the proposed use of the property, and will not increase the potential hazard to human health or the environment; or
- (2) Is necessary to reduce a threat to human health or the environment.

Regulations were written with best available knowledge and experience of the day. Advances in technology and the need to optimize resources encourage innovative decisions using alternative techniques. Fortunately, we have the flexibility built into the system to allow us to make decisions based on new information and improved management techniques; however, this guidance addresses how we should correctly identify and understand the relevant environmental factors that will allow us to properly evaluate PCC performance to defensibly support PCC optimization.

Under the authority of Section 4005(c)(1) of RCRA, EPA requires that states adopt and implement permitting programs that require owner/operators to comply with the provisions of Subtitle D, including PCC provisions. Accordingly, each state having a permit program approved by EPA has the requirement to regulate the PCC process for MSWLFs. The transfer of regulatory authority to the states was enacted with the intent of providing the states flexibility in implementing the Subtitle D regulations. This flexibility has resulted in a variety of state-specific approaches to addressing the duration of PCC at MSWLFs.

The Team surveyed the ITRC states on PCC (see Appendix C for full survey results). Especially important was an understanding of the states' flexibility, by rule, for PCC (Figure 3-1). Roughly 15–20 percent of the responding states claimed to have flexibilities built into the regulations in the major categories of PCC.

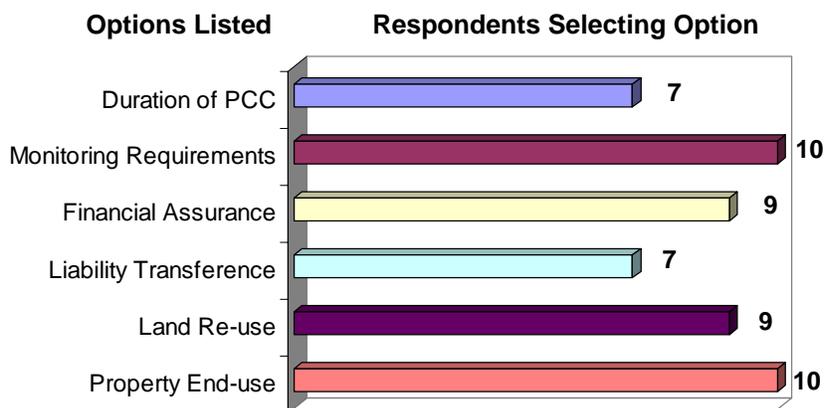


Figure 3-1. Responses to “Do your state regulations governing post-closure care contain flexibility in the following categories?”

Interestingly, few of the surveyed states reported anything other than regulations and statutes guiding them in their decision on PCC (see Figure 3-2). Regulations and statutes, as previously explained, do not provide adequate specificity to accommodate the variability of each site. They normally, and intentionally, provide only broad performance requirements such as “protect human health and the environment,” leaving the definition of protection and the parameters that define that protection to the region or state authorized to implement the federal program or state equivalent. All responding states appear to have some form of information guiding their decision on PCC, but it appears that very few states have a rigorous and structured methodology to evaluate the performance of a closed MSWLF with a goal of optimizing or PCC.

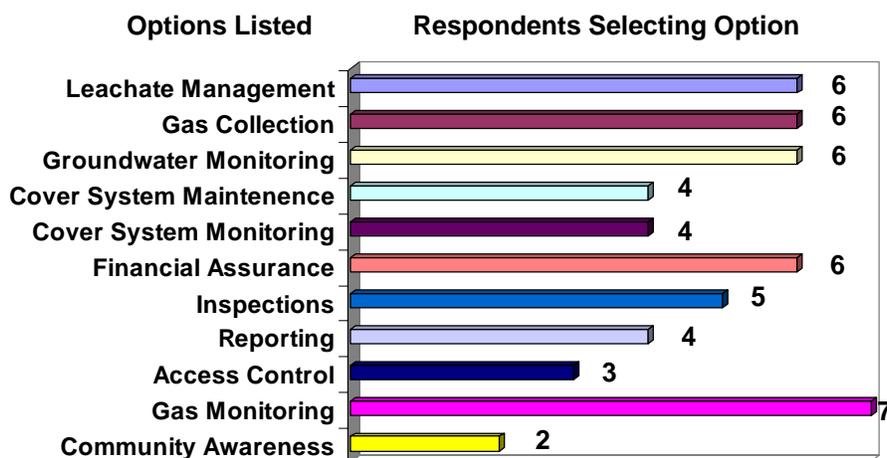


Figure 3-2. Responses to “Which of the following elements of post-closure care can be reduced before the end of the PCC period?”

Federal requirements send a clear message that protection of HH&E is the overriding performance requirement for PCC. Our survey indicated that only half of the states responding considered protection of HH&E to be the sole discriminator in their decision to end PCC. Other parameters that states indicated that they use as a basis for their decision to end PCC include the following:

- “PCC is required for a minimum period of 30 years and until the waste no longer poses a threat to public health and safety and the environment. PCC period is based on potential threat of the waste irregardless of current end use, but [should be based] on potential end use.”
- “The ability of the site to meet regulatory standards outlined in the regulations.”
- “Criteria for ending post-closure care have not been developed yet. [We] will probably follow EPA guidelines, if and when promulgated. The criteria will probably focus on leachate quantity and quality, landfill gas quantity and quality, and groundwater quality.”
- “Completion of the 30-year period and no impacts to groundwater.”
- “15-year minimum for all landfills, with 30-year minimum for MSWLFs (Municipal Solid Waste Landfills), may be reduced if there is not a threat to human health and environment or an adjusted standard from [our] Pollution Control Board.”
- “Time and no monitored change in the environment.”

The respondents were asked whether important parameters of PCC could be reduced during the PCC period. It appears that few states are willing to reduce the parameters of PCC identified in Figure 3-2. However, leachate management, gas monitoring and collection, and groundwater monitoring seem to have slightly more flexibility based on states’ experiences. These factors, along with cap maintenance, should form the basis of any decision to optimize or end PCC, and this project is intended to encourage states to receive and respond to data demonstrating that elements of PCC have achieved their performance goals and can be discontinued.

Approximately 50 percent of the responding states reported that they had specific guidelines for reducing or extending the PCC period. They identified the following as the rationale for changing its duration:

- “[We will] “probably follow Federal guidance if and when they are promulgated. [The parameters] will probably be based on leachate quality, landfill gas generation rates, groundwater monitoring results, condition of cover, and overall assessment of stable conditions [of landfill material].”
- “[We have] no criteria to extend the PCC period since care continues until the waste no longer poses a threat to public health and safety and the environment.”
- “If environmental standards [show they] are out of compliance, PCC period may be extended until remediation is achieved.”
- “Threat to human health and the environment.”
- “Quality of ground water and gas production in addition to other environmental concerns.”
- “Specific criteria [have] not established. The Post-Closure Care period may be increased if ‘necessary to protect public health, safety, and the environment.’”
- “[The post-closure care period will continue as long as there are] continuing groundwater impacts.
- “Protection of human health and the environment.”
- “Monitored releases into the environment, in groundwater, surface water, soil gas, or air emission are used to extend or decrease the post-closure care period.”
- “[Our state] statutes and regulations do not allow the post-closure care period to be shortened.”

- “Demonstration by [a] responsible party that the waste no longer poses a threat to public health and safety and the environment.”
- “No pollution and no gas for two to three years continuously.”
- “We have not shortened post-closure care on any facilities that I am aware of. Since a 30-year post-closure period is specified in State statutes, legislative action would be necessary to shorten post-closure care.”
- “Overwhelming evidence of no groundwater impact.”
- “Demonstration that the site is not a threat to human health or the environment.”

It appears there is flexibility in many states; however, some states have identified the 30-year conventional PCC period in statute, which would require a legislative change or approval to accommodate anything less or more than the 30-year PCC period. If the regulations specify a PCC duration, then an exception or exemption from the rule can be made by the agency director for anything less or more than 30 years.

For those states that claim flexibility in their decision to end PCC, it appears that protecting HH&E is the overarching concern, followed by groundwater quality and gas and leachate management. They agree these are the parameters most likely to demonstrate the performance of PCC.

All states have adopted the federal Subtitle D regulations for MSW. Twenty-two states retain precisely the same performance expectation and flexibility as EPA. Fourteen states require at least a 30-year PCC period; six of these note within their rules that they allow the 30-year PCC period to be adjusted. Eight states specifically include within their rules that at least one of the four critical systems of a landfill—leachate management, gas management, groundwater monitoring, and cap maintenance—is required to demonstrate a change in the PCC period. Table D-1 (Appendix D) contains the information supporting these conclusions plus citations for each state. The survey was prepared by the Environmental Research and Education Foundation in support of EREF 2006.

Table D-1 also shows that the duration of PCC varies somewhat from state to state, with some states directly adopting the fixed, 30-year federal PCC requirement and others requiring an owner or operator to petition for cessation of PCC activities. Based on this review of state regulations in effect in June 2003, states typically require the owner or operator to demonstrate that all aspects of the facility’s PCC plan have been completed. Some regulations also require a demonstration that the facility does not pose a threat to HH&E or that there will not be a future release to the environment. The regulations do not provide detailed procedures for demonstrating that PCC requirements have been achieved.

Additionally, there are other regulations that apply to PCC of MSWLFs. The regulations in 40 CFR §258.3 require that owners and operators of MSWLFs comply with all other applicable federal laws, regulations, and requirements. Therefore, prior to developing or implementing a PCC plan, an owner/operator must identify any additional applicable requirements and understand the relationship between those regulations and Subtitle D. There are several other federal laws and regulations that may be applicable to MSWLFs during the PCC period; these regulations are summarized in Table D-2 (Appendix D). In general, these additional requirements identify the specific activities and/or media that are controlled during the PCC

period and provide specific threshold criteria (e.g., nominal concentrations, emission rates) that must be attained to demonstrate compliance.

Table D-3 (Appendix D) provides a summary of the associated EREF approach to which the regulation is most applicable. As shown in the table, these additional regulations include those associated with the Clean Air Act, Clean Water Act, and the Safe Drinking Water Act. EREF makes clear that Clean Air Act, Clean Water Act, and Safe Drinking Water Act requirements are separate and independent and that obligations under those statutes are not waived simply because RCRA PCC ends.

4.0 PERFORMANCE-BASED EVALUATION OF POST-CLOSURE CARE

There is no single widely accepted approach for conducting performance-based evaluations of PCC; however, a detailed approach that has been developed for MSWLFs is described in EREF 2006. The following is based largely on this approach; however, the mix of ITRC Alternative Landfill Team members, including representations of state and federal agencies, industry, consultants, and community stakeholders, has contributed additional perspectives to the method.

4.1 Purpose

The objective of this approach, illustrated in Figure 4-1, is to perform an evaluation of the level of PCC at a closed landfill based on the performance and outcome of four evaluation systems:

- leachate management
- LFG management
- groundwater monitoring
- cap monitoring and maintenance

Each of these four components is evaluated independently and in a specified sequence, with each evaluation referred to as a “module.” The four PCC modules are preceded two evaluations in a prerequisites module: an end-use strategy must be identified, and data requirements and module-specific prerequisites must be satisfied.

Each evaluation of the four PCC modules involves the following:

- whether a change in PCC (e.g., stop or reduce leachate management, reduce LFG migration monitoring frequency) is appropriate
- monitoring to confirm that any appropriate and approved change did not produce an unexpected outcome

Specifically, each PCC module evaluation is performed in five steps, as described below and illustrated in Figure 4-2.

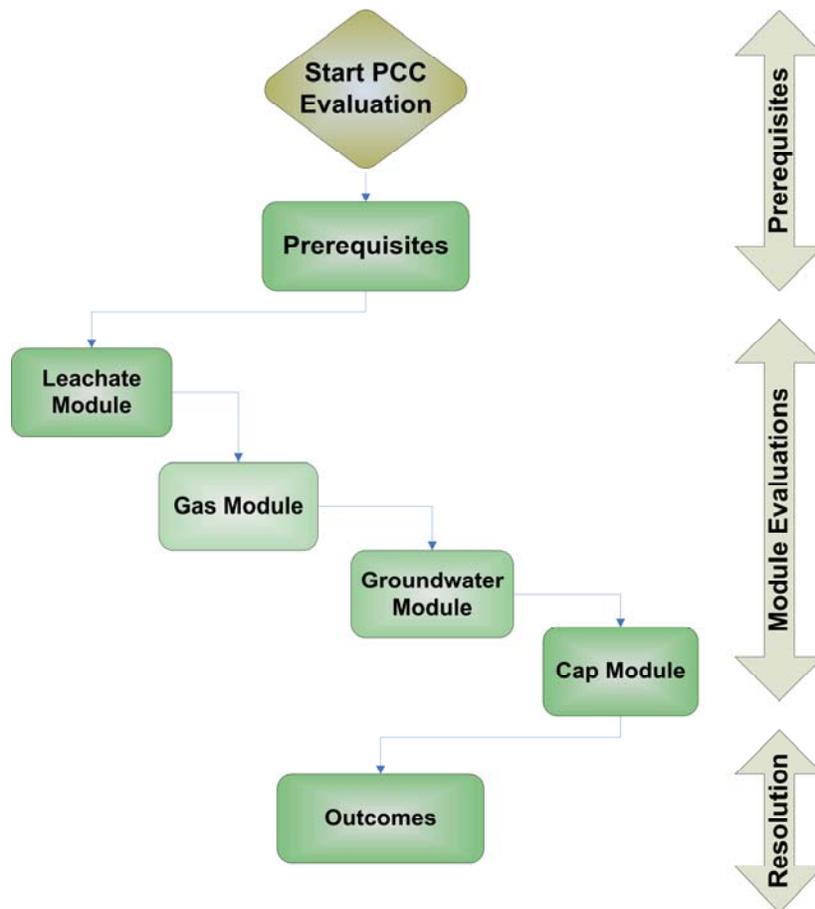


Figure 4-1. Components of a post-closure care performance evaluation.

Step 1: Satisfy Prerequisites. This step confirms that sufficient data exist to perform the PCC evaluations, that an end use has been defined for the landfill or WMU, and that all module-specific prerequisites have been satisfied.

Step 2: Evaluate Change. This step evaluates whether a proposed change to PCC activities is appropriate. Where necessary, data are analyzed to verify the validity of any assumed trends in leachate or LFG generation or quality.

Step 3: Implement Change. This step implements a change for which, in Step 2, it was concluded that no adverse impacts would be expected.

Performance Monitoring as Described in the EREF Document

- ***Confirmation monitoring*** is performed during the PCC period to confirm that a change in the PCC system and/or activities during PCC resulted in the outcome that was predicted.
- ***Surveillance monitoring*** is performed after successful completion of confirmation monitoring and only when the outcome of a module evaluation has concluded (and subsequent confirmation monitoring has demonstrated) that scheduled maintenance of module-specific PCC control systems should no longer be required. Surveillance monitoring can essentially be considered to be a period of “insurance” monitoring performed prior to complete cessation of regulated PCC activities related to those particular PCC systems and prior to transitioning into CC activities.

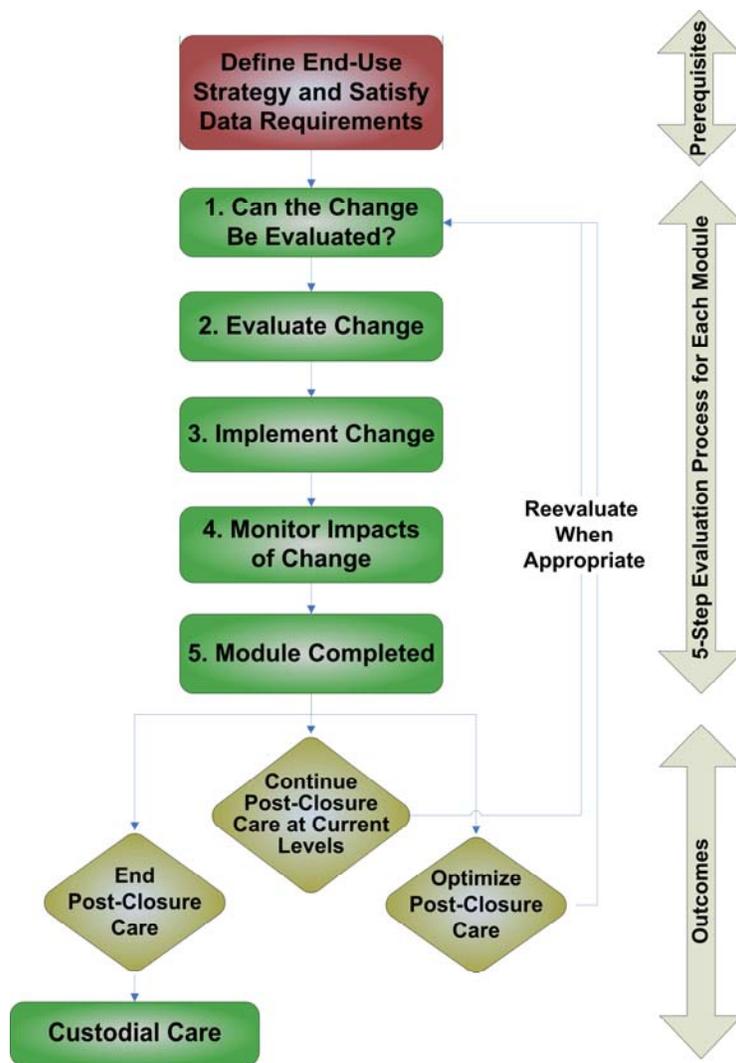


Figure 4-2. Overview of the post-closure care performance evaluation process.

Step 4: Monitor Change. This step monitors the change to confirm that its implementation in Step 3 had the anticipated outcome.

Step 5: Module Completed. This step occurs only after monitoring is completed for a component of PCC. Completion of this step means that the appropriate level of future PCC required for that component has been defined and that level of PCC must be provided until a future evaluation confirms that a different level of PCC is appropriate or a de minimus amount of care is appropriate. As previously stated, this de minimus amount of care may be provided during CC.

The prerequisites module involves two activities, confirming the end use of the MSWLF and satisfying data requirements and prerequisites for the subsequent PCC modules, as described below.

Define End-Use Strategy. The end-use strategy defines the long-term condition of the landfill (e.g., environmental protection systems, waste containment systems, property uses at and near

the site). See ITRC 2006b for guidance on establishing the site service capacity for land reuse strategies. This directs the owner/operator to determine the “permanent” physical setting and use of the site in the indefinite future (i.e., long after a typical 30-year PCC period). This is the first step of the evaluation process because the level and need for PCC is determined by the proximity of the closed site to receptors, and the end-use setting defines the proximity of the site to potential receptors.

Note that, if end use conditions change (e.g., if the landfill is converted from a restricted, fenced site to an open-access facility such as a park) after the PCC evaluation is performed, then some or all modules will need to be reevaluated to determine whether the changed end-use condition would produce a different outcome to the modular evaluation.

Satisfy Data Requirements and Module Prerequisites. Data requirements and prerequisites are module specific. In general, most of the following sets of data and information, which should be readily available for facilities that are in compliance with applicable regulations, are useful to perform a site-specific performance-based evaluation of threat:

- Closure and PCC plans
- Plans of the site configuration, including base grades and settlement data, liner system, cover system, cell geometry and size, construction history, layout of gas migration and groundwater monitoring features, institutional controls, surface water and receiving environment, geological and geotechnical conditions, storm water management features, and, if applicable, previous and existing impacts and remedies
- Description of site operations, including history of the waste types accepted and total volume of waste in place, operational practices, waste management practices, and (if possible) waste composition and characterization
- Leachate management data, including LCRS design, leachate flow data, and leachate analytical data
- LFG-related data, including LFG management/collection system design, flow and quality data (e.g., methane and/or nonmethane organic compounds analytical results), generation and emissions modeling, and LFG migration monitoring system design and migration monitoring data
- Groundwater-related data, including a sampling plan and schedule, groundwater background and compliance monitoring data, and groundwater flow rate and fate
- Meteorological data (e.g., typical annual precipitation including snow melt)
- State regulatory framework
- End-use plans

4.2 Leachate Management

The leachate module involves evaluating whether the leachate management system can be modified, optimized, or eliminated while protecting HH&E. The individual steps of the module evaluation are summarized below.

Step 1: Can Change Be Evaluated? This step generally requires that all data required for the evaluation be collected prior to embarking on an evaluation to change existing PCC features and activities related to leachate management (see Figure 4-3).



Figure 4-3. Leachate riser. (Courtesy Kansas Department of Health and Environment)

Step 2: Evaluate Change. To evaluate the proposed change, an analysis of the trend of the data must be performed, the future leachate management strategy must be defined, and an evaluation must be performed of the potential for the landfill to threaten HH&E under the future strategy. The purpose of the trend analysis is to establish whether a steady or downward trend is observed to predict that the characteristics of leachate production at the WMU will improve with time or, at the very least, not get worse (i.e., that the future threat to the environment can be predicted with statistical confidence to be equal to or less than current conditions). Then, any

modification to the long-term strategy for leachate management requires an evaluation of future quality and quantity of leachate, long-term geotechnical stability of the WMU, and impacts of hypothetical leachate releases on receiving bodies. The leachate management strategy defined in this module must be integrated into the remainder of the leachate module as well as the other modules in this approach. Next, the future leachate management strategy is evaluated to assess whether it is protective of HH&E.

The evaluation approach involves the following tiered evaluation process. Tier 1 evaluation involves comparing leachate quality to direct discharge standards. If leachate at the source passes applicable regulatory standards, by definition there could be no threat at the location of regulatory determination, the POE. If a passing outcome is not achieved under a Tier 1 evaluation, then a Tier 2 evaluation compares groundwater quality at the POC location to groundwater protection standards. Again, leachate passing the regulatory standard at a POC more stringent than the POE by definition will ensure no threat at the POC. If a passing outcome is not achieved under a Tier 2 evaluation, then Tier 3 evaluates the threat at the POE. Passing the evaluation at any of these levels enables implementation of the new leachate management strategy (e.g., PCC optimization) along with confirmation monitoring (CM). Note that the tiers are provided to save the costs associated with characterizing threat at the regulatory POE when simpler characterization at the point of source or compliance ensures absence of threat.

Step 3: Implement Change. Following satisfactory completion of the required evaluation steps for all parameters, operation of the LCRS may be modified in accordance with the leachate management strategy used in the evaluations, pending regulatory approval.

Step 4: Monitor Impacts of Change. After the new leachate management strategy is implemented, the ongoing objective of the leachate module is to demonstrate that the new strategy is appropriate, thus allowing it to be formally accepted or, if it is shown to be inappropriate, ensuring that necessary action is taken. This demonstration process involves both CM and surveillance monitoring (SM) programs. CM involves demonstrating that data on which the evaluation was performed are complete and document the existence of the trends that the evaluation was based on. SM provides long-term monitoring at a reduced level to document that

the decision to optimize or end PCC was appropriate. Exceedence of CM or SM levels requires the owner/operator to reevaluate the decision to optimize or end PCC of the leachate management system and to provide a greater level of PCC until such decision is confirmed.

Step 5: Module Completed. All outputs from the leachate module are directed to go to the next module and assigned one of three LCRS PCC levels. These levels relate to the PCC status of the leachate module at the stage of the evaluation process at which the leachate module was exited. The LCRS PCC levels assigned in the leachate module are as follows:

- **Continue PCC at Current Levels:** Active LCRS operation and/or some active level of leachate management are still required. Accordingly, regular PCC monitoring and maintenance activities must continue.
- **Continue PCC at Optimized Levels:** This status implies an optimized level of leachate management related to PCC. Generally, the LCRS has been modified or eliminated, but some optimized level of LCRS operation or other institutional or engineering controls are still required for leachate management. Any site in CM or SM is also automatically assigned this level, because such monitoring implies reduced or optimized PCC. If a WMU has any institutional, engineered, or natural controls for leachate management that require any monitoring or maintenance, then it cannot progress beyond this level.
- **End PCC:** The LCRS has been completely stopped, no leachate controls requiring monitoring or maintenance exist, and SM has been completed and demonstrated that the site is “impact neutral” or benign with respect to leachate releases. No leachate-related PCC requirements apply any longer, and the leachate module is completed.

It may be necessary to maintain institutional or engineered controls on other components of the WMU if the status of the leachate module is predicated on proper maintenance of that component. For example, if limiting leachate generation is required to ensure that the outcome of the module continues as defined and the means of controlling leachate generation is tight-capping of the WMU with a geomembrane cover system, then cap maintenance must be performed to ensure that the tight cap performs as planned in the leachate module evaluation.

4.3 Landfill Gas Management

Methane migration is monitored under Subtitle D of the MSWLF regulations to determine whether off-site migration of methane is occurring at levels that may be potentially explosive. Quarterly routine monitoring is performed at monitoring points around the perimeter of the landfill.

The landfill gas module involves evaluating whether the LFG management system (Figure 4-4) can be modified, optimized, or eliminated while still protecting HH&E. Where LFG control systems exist at a site, a key aspect of the evaluation is determining the need to continue operation of these



Figure 4-4. Landfill gas treatment plant.
(Courtesy Kansas Department of Health and Environment)

systems to mitigate LFG migration potential. The process of evaluating whether discontinuation of operation of an active gas collection system can be completed is typically done in two stages. First, it may be possible to request a reduction in the frequency of monitoring during the PCC period if there is sufficient history of compliance at these perimeter wells, provided any systems in place to extract or vent gas remain static (Figure 4-5). Second, following interim termination of operations of the active gas collection and control system (GCCS), evaluation of gas monitoring data from a period of at least two years without operation of an active system should be conducted to determine that such a decision did not have an adverse impact on subsurface gas migration. Although the landfill gas module focuses on the requirements for monitoring migration of explosive gases, it also makes clear the need to comply with any applicable Clean Air Act or other air requirements (e.g., 40 CFR Part 60, Subpart C) outside of the Subtitle D regulatory PCC requirements. The individual steps of the landfill gas module evaluation are summarized below.



Figure 4-5. Landfill gas vent. (Courtesy Kansas Department of Health and Environment)

Step 1: Can Change Be Evaluated? This step generally requires that all data required for the evaluation be collected prior to beginning the evaluation to change existing PCC features and activities related to LFG management.

Step 2: Evaluate Change. To evaluate the proposed change, an analysis of the trend in LFG generation and quality data must be performed, the future LFG management strategy must be defined, and an evaluation must be performed of the potential for the LFG to impact HH&E under the future strategy. The purpose of the trend analysis is to establish whether a steady or downward trend is observed to predict that the characteristics of gas production in the WMU will improve with time or, at the very least, not get worse (i.e., the production rate is on a downward trend). Then, any modifications to the long-term strategy for LFG management require an evaluation of future quality and quantity of LFG, potential impacts to cover quality or integrity, and impacts of hypothetical LFG migration from the WMU on receptors. Any modification to the LFG management strategy resulting from this evaluation may be integrated into the preceding leachate module as well as subsequent groundwater and cap modules. Then, the future LFG management strategy is evaluated to assess whether it is protective of HH&E.

The approach involves a tiered evaluation. Tier 1 is a qualitative screening evaluation (e.g., exceeded explosive gas standard at a POC). If the qualitative screen is exceeded, a more detailed Tier 2 engineering or threat evaluation may be performed. Passing the evaluation at either of these levels enables implementation of the new LFG management strategy along with a CM program.

Step 3: Implement Change. Following satisfactory completion of the evaluations, operation of the LFG management system may be modified in accordance with the strategy used in the evaluations, pending regulatory approval. If a WMU has any regulatory (e.g., new source

performance standards [NSPS], permit conditions, etc.), engineered, or natural controls for LFG management that require any monitoring or maintenance to maintain explosive gas migration control, then it cannot progress beyond this level without additional evaluation or consent from an appropriate regulatory agency.

Step 4: Monitor Impacts of Change. After implementing the new LFG management strategy, the ongoing objective of the landfill gas module is to demonstrate either that the new strategy is appropriate or that additional action is taken if the modification is shown to be inappropriate. CM and SM provide the means to demonstrate effective implementation of the change. CM involves demonstrating that data on which the evaluation was performed are complete and substantiate the trends that the evaluation was based on. SM involves providing long-term monitoring, potentially at a reduced level, to document that the decision to optimize or end operation of the active LFG management system was appropriate. Exceedence of a threat- or permit-based level may require the owner/operator to reevaluate the decision to optimize or end the LFG management system.

Step 5: Module Completed. Following completion of the landfill gas module evaluation, assign one of three outcomes to the evaluation:

- **Continue PCC at Current Levels:** Active LFG management system operation and/or some active level of LFG management is still required. As such, regular PCC monitoring and maintenance activities must continue to control gas migration.
- **Continue PCC at Optimized Levels:** This status implies an optimized level of LFG management related PCC. Generally, the LFG management system has been modified or eliminated, but some reduced level of LFG management operation or other institutional or engineering controls are still required for LFG. If a WMU has any institutional, engineered, or natural controls for LFG management that require any monitoring or maintenance to maintain explosive gas migration control, then it cannot progress beyond this level without additional evaluation or consent from appropriate regulatory agency.
- **End PCC:** The LFG management system has been completely stopped, no LFG controls requiring monitoring or maintenance exist, and SM has been completed and demonstrated that the site is not a threat with respect to LFG migration.

Note that it may be necessary to maintain institutional or engineered controls on other components of the WMU if the status of the landfill gas module is predicated on proper maintenance of that component. For example, if the outcome of the landfill gas module depends on limiting LFG generation and limiting LFG generation depends on limiting infiltration through the cap, then cap maintenance (within PCC or outside in CC) must be performed to ensure that the tight cap performs as planned in the landfill gas module evaluation. Also note that NSPS obligations are independent of the RCRA analysis relative to control of explosive gas migration and may extend beyond the Subtitle D PCC period.

4.4 Groundwater Monitoring

The purpose of groundwater monitoring during PCC is to determine whether a release of leachate or gas to the “uppermost aquifer” from the landfill unit (see EPA 1998, Section 5.6.3) has occurred. In a performance-based approach, confirmatory groundwater monitoring is implemented to determine whether discontinuation of the LCRS or GCCS has adversely impacted the environment and therefore is an integral part of the leachate and gas modules CM

program. This guidance document considers that impact from that LFG to groundwater is possible and should be considered as part of a performance-based evaluation of threat. The groundwater module involves evaluating how long groundwater must be monitored to provide protection of HH&E in the future as a result of implementing new leachate and/or LFG management strategies. The foundation of the evaluation involves a conservative estimate of the time-of-travel in groundwater as an indication of the total length of time that PCC groundwater monitoring is necessary. If groundwater is appropriately monitored for a period of time sufficient to detect a release and no such release is detected, then it can be defensibly estimated that no environmental impact has occurred. The steps needed to perform the groundwater module evaluations are described below.

Step 1: Can Change Be Evaluated? You cannot complete the groundwater module if (a) the facility is in assessment monitoring, unless the owner has prior approval from a state regulatory agency, (b) the facility is in regulatory corrective action, or (c) the data required for the evaluation have not been collected (see Figure 4-6).



Figure 4-6. Groundwater monitoring well.
(Courtesy Kansas Department of Health and Environment)

Step 2: Evaluate Change. The “change” that is evaluated in the groundwater module is the optimization or termination of the groundwater monitoring program. For a WMU that has an LCRS, this module uses the results of the leachate module (i.e., the characterization of source liquids over time) to define whether leachate represents a current or future threat to continued protection of HH&E at the POC and/or POE. Thereafter, the groundwater module identifies those constituents that would be most indicative of a release and useful as indicator parameters. For a WMU that does not have an LCRS, this module assumes that the WMU does not have an engineered liner to be breached and that groundwater monitoring will therefore be active from the time of unit closure until sufficient time has passed for a potential release to reach the POC. Since an unlined unit without an LCRS does not have an expected preferential release point (i.e., sump) the TOT should be measured, at a minimum, from the midpoint of the unit to the POC (see EREF 2006). Consideration of migration pathways from the landfill unit to the saturated zone should be discussed with local regulatory agencies regarding the total time that groundwater monitoring will be required at the facility. Based on the outcome of either of these evaluations, a determination is made of the need to continue monitoring groundwater for potential leachate impacts. The assumption, intrinsic to a performance-based evaluation, is that the source is appropriately characterized and that appropriate leachate indicators have been identified for use in the groundwater module. No additional groundwater monitoring is needed in cases where any of the following can be demonstrated:

- The conditions for a successful No Migration Demonstration as described in 40 CFR §258.50(b) can be met (EPA 1999).
- The minimum TOT for the leading edge of a leachate plume to migrate from the WMU to the POC along the shortest potential flow path is excessive (such that groundwater flow is essentially stagnant and the TOT from the WMU to a potential POE is not considered feasible).

- There is no potential for leachate to impact groundwater at the POC even under “worst-case” conditions for a leachate release (i.e., assuming maximum default concentrations for all regulated parameters in leachate, upper-bound estimates of leachate generation, and a conservative dilution-factor approach).
- The conservative groundwater TOT calculation indicates that, with an appropriate factor of safety, a past leachate release from the WMU would have already been detected and the current conditions do not represent a threat to HH&E.

Where the evaluations show that groundwater monitoring should be continued, the module again identifies those constituents that would be most indicative of a release and useful as indicator parameters. Once the actual or assumed leachate source has been characterized (and the potential for groundwater to be impacted as a result of LFG migration has been accounted for), the groundwater module takes a step-by-step approach to evaluating, establishing, and/or optimizing the detection monitoring program (ASTM Standard D7045-04) and any other future groundwater monitoring requirements.

Step 3: Implement Change. Following satisfactory completion of the evaluations, the groundwater monitoring program may be modified in accordance with the strategy used in the evaluations, pending regulatory approval.

Step 4: Monitor Impacts of Change. Following termination of operation of the LCRS and GCCS (if operational at the facility), a period of CM is conducted to verify that the change performs as expected. CM involves demonstrating that data on which the groundwater module evaluation was performed are complete and demonstrate the existence of the trends that the evaluation was based on. The terminal end of the groundwater module involves implementation of SM. This suggested monitoring period is not mandatory to complete a performance-based evaluation but is recommended to provide extended monitoring at a reduced level to document that the decision to end groundwater monitoring was appropriate. Exceedence of CM or SM levels requires the owner/operator to reevaluate the decision to terminate PCC of the groundwater monitoring system and to provide a greater level of monitoring until such decision is confirmed.

Step 5: Module Completed. The outcome of the groundwater module follows the same three-level pattern for tracking purposes as that for other modules:

- **Continue PCC at Current Levels:** This level indicates that groundwater monitoring under a detection monitoring program is still required at the WMU (i.e., it is still not apparent whether the WMU leachate or gas source has the potential to impact groundwater quality). If a WMU has any engineered or natural controls for leachate and/or LFG management that require active operation, monitoring, and/or maintenance, then PCC must be continued at current (i.e., PCC plan) levels. The owner/operator may focus on continued optimization of remaining monitoring activities.
- **Continue PCC at Optimized Levels:** Any WMU that has fully terminated detection monitoring of groundwater quality is automatically assigned this level because, for such WMUs, regulated groundwater monitoring has been completed. For these WMUs, all groundwater-related PCC activities may be eliminated in the future following successful completion of CM and SM in the absence of any triggers.
- **End PCC:** WMUs that have completed CM and SM without any triggers may terminate PCC of groundwater.

Note that, as with the other modules, it may be necessary to maintain institutional or engineered controls on other components of the WMU if protection of groundwater quality depends on the outcome of another module. For example, if the outcome of the groundwater module depends on limiting leachate generation by minimizing infiltration through the cap, then cap maintenance (in or out of PCC) must be performed to ensure that the tight cap performs as assumed in the groundwater module evaluation.

Before any request for optimization of groundwater monitoring requirements is submitted for review by the governing regulatory body of a closed waste facility, a comprehensive historical groundwater quality database is needed. In the absence of a detailed process to determine how such an optimization would occur, ASTM Standard D7045-04 provides guidance based on federal and state guidance. This guidance document requires a historical summary of leachate data that represents source concentrations within the landfill unit and compares the source concentrations to a statistically or nonstatistically generated background value for regulated constituents. Therefore, the optimized detection monitoring or CM parameters would include only those parameters that are represented in the source liquids and can be differentiated from background.

As a facility develops a history of compliance with groundwater quality standards, it would seem reasonable that monitoring frequency and number of parameters could be reduced in a stepwise fashion. Facilities that monitor groundwater on a quarterly basis could be allowed to reduce the frequency to semiannual (or semiannual to annual) if modification of the frequency is not expected to compromise the effectiveness of the monitoring program. With continued compliance with groundwater standards, it may be reasonable to further reduce the frequency to annual. This approach sets up a type of SM to ensure that the PCC systems continue to function as designed. Any facility with a history of groundwater problems or currently in the process of groundwater assessment and/or remediation is not a strong candidate for reduction of groundwater monitoring requirements.

In the case of this document and the modular approach to evaluating PCC requirements, facilities would need to demonstrate that each module is performing satisfactorily before a reduction in requirements could be approved. A history of the final cover performing to design and regulatory standards would be beneficial before reduction of groundwater monitoring requirements would likely be approved. Likewise, leachate quantity and quality would need to be at levels indicating that no significant threat to groundwater would be posed by a release. In a lesser manner, air quality may also need to meet acceptable levels for methane and nonmethane organic compounds. If all of these modules are in acceptable ranges, then the regulating authority could consider a reduction of the frequency.

4.5 Cap Management and Maintenance

The purpose of a cap under Subtitle D regulations is to minimize infiltration through the cap and eliminate exposure of the waste mass to the receptors (protect HH&E). It is reasonable that different WMUs have different closure and capping requirements (see ITRC 2003). These differences result from the potential threat the landfill poses to HH&E, community needs, and site- and facility-specific considerations (e.g., nature of the waste streams disposed). This variation is reflected in current capping practices. A variety of alternative cap types currently

exist at closed WMUs around the United States: exposed geomembrane covers, state-specific designs, caps designs featuring capillary break systems, “store and release” covers, phyto-caps, bioactive cover systems, simple soil covers, etc. In addition, alternative covers and capping scenarios may be considered to facilitate post-landfilling operations (see ITRC 2003). The consideration of alternative covers and the timing of cover placement to support post-landfilling operations is consistent with the regulatory flexibility identified above 40 CFR 258.60 (f) and (g) (see box), provided their performance is protective of HH&E. In summary, the central questions to answer with regard to cap performance are as follows:

- Does containment of leachate, LFG, and/or waste need to be continued, and, if yes, for how long?
- If the condition of the cap were to change, or if there were no cap, would the quantity and/or quality of leachate, LFG, and/or waste change in a way that would adversely affect protection of HH&E and thus require containment?
- Knowing the site-specific performance requirements, what needs to be done for the cap to continue to fulfill its required function?
- At what stage and under what conditions can it safely be assumed that PCC for the cap will be ended and long-term care of the WMU will be transferred to a post-regulatory program such as CC?

40 CFR Part 258.60

(f) The owner or operator must begin closure activities of each MSWLF unit no later than 30 days after the date on which the MSWLF unit receives the known final receipt of wastes or, if the MSWLF unit has remaining capacity and there is a reasonable likelihood that the MSWLF unit will receive additional wastes, no later than one year after the most recent receipt of wastes. Extensions beyond the one-year deadline for beginning closure may be granted by the Director of an approved State if the owner or operator demonstrates that the MSWLF unit has the capacity to receive additional wastes and the owner or operator has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the unclosed MSWLF unit.

(g) The owner or operator of all MSWLF units must complete closure activities of each MSWLF unit in accordance with the closure plan within 180 days following the beginning of closure as specified in paragraph (f) of this section. Extensions of the closure period may be granted by the Director of an approved State if the owner or operator demonstrates that closure will, of necessity, take longer than 180 days and he has taken and will continue to take all steps to prevent threats to human health and the environment from the unclosed MSWLF unit.

<http://www.epa.gov/epaoswer/non-hw/tribal/pdftxt/40cfr258.pdf>

The cap module addresses these questions in the following steps:

- Evaluating whether the existing cap provides the level of integrity needed to fulfill the post-closure requirements (CC) of the WMU
- Guiding modification of the cap as needed for it to fulfill all of its applicable post-closure requirements (including CC)
- Developing a cap monitoring and maintenance plan (CMMP) that will demonstrate that the level of cap integrity needed for the cap to meet all applicable post-closure obligations (including CC) is provided for as long as required for continued protection of HH&E.

The cap module is the final PCC element to be evaluated in a performance-based program. The cap system (see Figure 4-7) exists to contain and isolate the waste, prevent its direct contact with potential receptors, and provide a level of control over leachate and/or LFG generation and/or release. To end PCC of the cap, the cap must have attained a geotechnical stability (i.e., general slope stability and surface settlement) and vegetative stability (i.e., sustainable vegetation and resistance to erosion that would expose the waste or threaten vegetation) such that no additional care is needed to ensure such stability.



Figure 4-7. Final cover erosion control system.
(Courtesy Kansas Department of Health and Environment)

A key purpose of the cap module is to evaluate whether the cap has achieved this degree of stability and, therefore, warrants release from further regulatory PCC. The evaluations of the cap module involve determining whether the landfill has complied with the PCC performance requirements of the cap (which are mostly a function of the outcomes of the leachate, gas, and groundwater modules) and whether the existing cap (or any modification to the existing cap) would be expected to continue to satisfy these performance objectives after PCC of the cap is ended. The module also involves evaluating whether the CMMP can be modified, optimized, or eliminated while still meeting the cap performance requirements. The individual steps of the cap module evaluation are summarized below.

Step 1: Can Change Be Evaluated? This step requires that all of the other modules be evaluated and that all data required for the evaluation be collected before beginning any evaluation to change existing PCC features and activities related to the cap system.

Step 2: Evaluate Change. This evaluation involves assessments of the expected performance of the cap (e.g., rate of cap settlement, cap stability, maintenance history, and the dependence of other module outcomes on the performance of the cap) under the proposed level of care and end-use program. Accordingly, the module involves an evaluation of whether or not cap as it is or after the proposed changes (e.g., modification of the cover, optimization of the maintenance costs) will fulfill all of the following:

- post-closure regulatory requirements
- post-closure requirements of the cap established by the outcomes of previous modules
- cap-specific functional requirements that must be met to provide the needed level of performance

The outcome of the cap module evaluation will satisfy one of the following three broad categories:

- If the evaluation indicates that the cap is insufficient to maintain the outcomes of the other modules (i.e., the cap does not meet its post-closure performance requirements), then it must be modified accordingly and the cap module and/or other modules reevaluated as necessary.
- If the evaluation indicates that the cap is sufficient to maintain the outcomes of the other modules but that significant scheduled monitoring and maintenance activities are necessary (e.g., while maintenance of hydraulic control is required), then PCC under a regulatory program may be continued.
- If the evaluation indicates that the cap is sufficient to maintain the outcomes of the other modules and cap integrity is stable, then the PCC standard for cap integrity and effectiveness is achieved and, under these conditions, PCC under a regulated program may be ended.

Step 3: Implement Change. Following satisfactory completion of Step 2 for all parameters, the proposed change to the cap or CMMP may be made with regulatory approval.

Step 4: Monitor Impacts of Change. After implementing the new cap management strategy, monitoring is performed to either demonstrate that the new strategy is appropriate, thus allowing it to be formally accepted, or ensure that necessary action is taken if it is shown to be inappropriate. This demonstration process involves both CM and SM programs. A change in conditions, as defined on a site-specific basis in the CMMP, requires the owner/operator to reevaluate the decision to terminate or optimize PCC of the cap and to provide a greater level of PCC until such decision is confirmed.

Step 5: Module Completed. The outcome of the cap module is defined as follows:

- **Continue PCC at Current Levels:** PCC of the cap is still required. Accordingly, regular PCC monitoring and maintenance activities must continue at PCC levels.
- **Continue PCC at Optimized Levels:** This status implies that no care is needed for the cap and only monitoring is needed. For this situation, CM and SM are needed to verify the reduced level of care needed for the cap-related PCC. Any site in CM or SM is also automatically assigned this level because such monitoring implies reduced PCC. This level represents the final component of regulated PCC at a WMU before transfer of care to a post-regulatory CC program.
- **End cap monitoring and maintenance:** All cap monitoring and maintenance has been eliminated, SM in the cap module has been completed, regulated PCC at the WMU has ended, and CC begins.

When evaluating the success of PCC systems, the integrity of structures and in particular the cap system seems to have the most impact on other systems. Even if other post-closure modules are functioning well and producing data showing no problems, if the cap system fails or develops significant cracks or other structural issues, problems in the groundwater, air, or leachate monitoring systems may start to show up. It is unlikely that requirements for routine monitoring and maintenance of the cap system will ever be completely eliminated, given the overall importance of the final cover on the performance of the closed facility. However, as with the other systems, the frequency and intensity of monitoring and maintenance may be reduced in a geometrical manner (i.e., the frequency or number of monitoring points can change together or independently). For example, a landfill may be able to sample groundwater monitoring wells at a reduced frequency, eventually going from quarterly to semiannual to annual. Another example might be initially analyzing the groundwater for a full or robust list of constituents and later for

an indicator list of constituents. These changes may be done independently of one another or in combination with one another in a progressive fashion.

4.6 Outcome of Evaluations for Ending Post-Closure Care

For a landfill management strategy to be effective in both the immediate and long term, it must be based on meeting the requirements for PCC and end use. A number of potential strategies for long-term landfill management exist, each with associated advantages and disadvantages and differing implications for long-term landfill maintenance and monitoring. Before any potential strategies can be evaluated and compared, site and climatic conditions, performance criteria, the regulatory framework, and an agreed-upon definition as to what constitutes the desired PCC end point for the landfill in question must be established. Thereafter, conceptual designs reflecting each candidate strategy should be developed, preliminary cost-benefit life-cycle analyses performed, data requirements identified, and the extent of design redundancies (i.e., overdesign to compensate for uncertainty) considered. Finally, monitoring and maintenance frequencies should be identified and appropriate funding mechanisms secured.

There are multiple strategies that can be employed at a closed landfill in terms of long-term landfill management. After evaluations in all modules have been completed, the outcome of the evaluation can be determined. It is important to stress that if a facility has ongoing corrective action programs in place, they may not consider termination of the PCC period. In all other situations, however, there are three possible outcomes:

- **Continue PCC:** If one or more of the modules still require significant levels of PCC within the regulatory framework to protect HH&E, the outcome of the evaluation will direct continuation of PCC under the approved PCC plan. Some PCC activities may be optimized according to outcome of the module evaluations.
- **Optimize PCC:** In many cases, the evaluation may reveal that the intensity or scope of some PCC activities can be reduced while still providing the necessary level of protection of HH&E. In these cases, the relevant PCC activities may be optimized. Optimization may involve, for example, eliminating nondetected constituents from further monitoring, reducing maintenance frequencies, or changing the design of a system (e.g., from an active to a passive LFG management system).
- **End Regulated PCC:** If the outcomes of all four modules indicate that no further PCC is needed for any module and the criteria are met, then all PCC activities for the landfill in all modules have been completed. In this case, PCC under the jurisdiction of the state agency would be ended, although a de minimus level of care will invariably still be required for the cap and site. Examples of de minimus site management and care activities therefore include meeting end-use obligations, maintaining institutional controls and their associated requirements, controlling access, satisfying local ordinances, and fulfilling other non-MSW applicable regulations.

4.7 Custodial Care

As defined in the previous section, the end of PCC is defined as the end of the regulatory oversight of a waste management unit. However, in many cases, evaluation of the cap module

will show that some care of the cap will likely continue to be required after completion of regulated PCC to continue satisfying local land-use requirements, comply with deed restrictions, contain the waste, protect HH&E, and maintain the outcomes of the other three PCC modules. This phase of de minimus care provided after completion of regulated PCC in the cap module (i.e., completion of SM in all modules) is termed “custodial care. A CC program involves property management activities that are typical of any property, such as paying property taxes, controlling access, complying with local zoning ordinances, and complying with the property-use restrictions identified in the deed to the property. In many ways, the level of CC required in these circumstances is similar to the care required at sites exiting post-remediation care under EPA Brownfields programs (EPA 2002b) and is the final phase of monitoring and maintenance at a MSW landfill.

4.7.1 Prerequisites to Custodial Care

To exit the regulatory oversight required in PCC and commence CC, all of the following criteria must apply:

- There must be a history of good performance and low maintenance associated with the cap during the PCC period. This historically good performance would be demonstrated through compliance with the cap post-closure requirements during SM in the cap module.
- The only activity required to contain the waste and to comply with the outcomes of other modules is maintaining the integrity of the top layer of the cap.
- Only occasional nonintrusive care activities (e.g., repair of minor erosion rills, mowing, reseeding of grassed surfaces, maintenance of a parking lot or other capping element if employed) are needed to maintain the integrity of the cap.

The reason that no other criteria are needed to enter CC is that other applicable criteria were previously addressed in the evaluations of the four PCC modules. After SM in all four of the PCC modules has been completed, it has been satisfactorily demonstrated that, in the absence of regulated PCC, the MSWLF does not pose a threat to HH&E under its defined end-use conditions. Therefore, only those few activities described above are required to care for the property and demonstrate continued containment and continuity of the cap. It is reasonable that these de minimus activities could be safely conducted outside of a state PCC program and under the requirements of other regulatory programs that also apply to non-MSWLF facilities (e.g., controlling erosion, off-site sedimentation, or site access).

Based on the above considerations, completion of PCC should occur at the end of an appropriate SM period in the cap module. By definition, completion of regulated PCC period at a WMU also implies that FA for PCC at the unit is no longer required.

4.7.2 Post-Regulatory Program Obligations

The end-use obligations and strategy for the closed landfill govern the outcome of each system evaluation module and the final condition of the closed landfill and, as such, must be considered from the outset of the module evaluation process. Once an end-use strategy has been defined, it must be carried forward consistently in future evaluations of the modules. When a component of PCC has been completed with respect to the regulatory framework (i.e., evaluations have demonstrated that PCC can safely be modified or eliminated), any predetermined end-use obligations for the site must continue to be met. Evaluating an end-use strategy must consider the

strategy's potential affects on the applicability of long-term landfill management at the site and thus on the range of outcomes that will be available from each module. In addition, deciding on a strategy is a site-specific process that needs to consider, among other things, the following:

- local laws, rules, and ordinances and as they relate to the facility, deed restrictions, and the likely pattern and nature of future development around the site (for more information, see <http://www.epa.gov/brownfields> and the ITRC Brownfields Team [http://www.itrcweb.org/gd_Brnflds.asp]).
- a number of long-term technical, geotechnical, environmental, ecological (see the ITRC Ecological Land Reuse ITRC Team [http://www.itrcweb.org/gd_EE.asp]), and public health issues, e.g. storm-water management, surface-water quality issues, legacy management
- other nontechnical issues and liabilities, regulatory limitations, and/or community concerns

The effect of deed restrictions could work in favor of or against the owner/operator during end-use strategizing as follows: existing deed restrictions may limit the breadth of end-use opportunities available at the site, but new deed restrictions or administrative mechanisms may be imposed as part of an end-use strategy to ensure that any conditions pertinent to the success of a performance-based approach to modifying PCC are not permitted to be changed in the future. For an end-use strategy to be successful in the long term, it will likely need to be considered in conjunction with the local community and regulator as well as other local or regional public and private stakeholders and interested or affected parties. It is important that this process is embarked upon a number of years ahead of attempting to end PCC.

As an example of a state that applies and enforces covenant restrictions on a property containing an MSWLF, Kansas may require a restrictive covenant or easement or both at permitted disposal areas where wastes will remain in place after closure. The restrictive covenants are required to be submitted to the department before the final permit is issued, which must demonstrate that the restrictive covenant has been filed with the State Register of Deeds. These restrictions must cover all areas that have been used or will be used for waste disposal, must specify that property use after closure preserve the integrity of the waste containment systems and all environmental monitoring stations, and require subsequent owners or tenants to consult with the Kansas Department of Health and Environment during planning of any improvements to the site for approval. See Kansas Administrative Regulations 28-29-20 for more detailed information about restrictive provisions required at waste disposal facilities.

Texas also has land-use restrictions for use of land over any type of closed municipal solid waste facility. MSWLFs that are no longer in PCC; closed landfills that were developed before permitting requirements; and closed, unauthorized landfills are regulated under the rules for persons owning, leasing, or developing property or structures overlying a closed MSWLF (30 Texas Administrative Code, Chapter 330, Subchapter T).

The Colorado Department of Public Health and Environment must approve requests by any party to restrict the future use of a property using an enforceable agreement called an "environmental covenant." These covenants, which are recorded with the deed and run with the land, provide a mechanism to ensure that institutional controls that are applied to a site are documented, followed, and monitored. The covenants are recorded in the land records so that they will show up in a title search whenever the property changes hands. In determining whether to grant a request for a covenant, the department consults with the affected local government to determine

whether zoning or other local laws would prohibit the uses proposed under the environmental covenant. If they would, the department must condition any approval of the covenant on the applicant obtaining a change to, or exemption from, the local law. The Colorado law directs the Department of Public Health and Environment to coordinate with the local government whenever the department creates, modifies, or terminates an environmental covenant within the local government's jurisdiction. The department must provide the local government with a copy of the documents creating, modifying, or terminating the covenant.

Colorado statute requires that the department create and maintain a registry of all environmental covenants. The official registry in a database format includes information on site name, location, contaminants of concern, covenant requirements, verification of covenant effectiveness, and other information deemed to be pertinent. To effectively implement the restrictive use of these covenants, local governments must notify the department when they receive an application affecting land use or development of land that is subject to an environmental covenant. The department then reviews the proposed application to determine whether it is consistent with the restrictions of the covenant and notifies the local government of its conclusions. In the event of actual or threatened violations of a covenant, the department may issue administrative orders requiring compliance, file suit for injunctive relief, or both.

In summary FA is not required during CC. Covenants, deed restrictions, or other land-use control mechanisms may assure that the land is used only accordingly and that appropriate custodial care is provided. For the purpose of CC, covenants, deed restriction, or other land-use control mechanisms are only as effective as the government's ability and resources to enforce them. These mechanisms may be tied to the land and ultimately are the owner's responsibility. State environmental agencies should have a legal mechanism for notification when a land-use control has been violated. This allows the state agency an opportunity to investigate any environmental or health consequences of a land-use control violation.

The Team recommends that states develop a template they can use and adapt to track and evaluate the environmental effectiveness of land-use controls placed on a landfill site. This might be best accomplished through a national organization that represents the states.

5.0 ALTERNATIVE LANDFILL MANAGEMENT STRATEGIES TO OPTIMIZE OR END POST-CLOSURE CARE ACTIVITIES

5.1 Proactive Strategies for Landfill Management

This section describes a few alternative landfill management strategies to optimize or end PCC. These strategies focus on (a) enhancing the rate and extent of waste degradation through bioreactor operations, leachate recirculation, and/or in situ aeration; (b) potentially reducing the threat from incoming waste during the active operational phase or the PCC period; or (c) removing the threat potential of the landfill altogether by means of waste removal closure (clean closure).

- Enhanced waste degradation (e.g., bioreactor) landfill. The long-term threat reduction potential of MSW treated using enhanced waste degradation (or bioreactor) technologies has been discussed in great detail in peer-reviewed journal articles and ITRC guidance (ITRC 2006a). Accelerating the degradation process reduces the expected gas production period of

the landfill, thus eliminating subsurface LFG migration as a threat in the future. Additionally, accelerated waste degradation improves leachate quality in a shorter period of time, also reducing the long-term threat of impact to groundwater and surface water in the future. An ancillary benefit of this technology is that using waste liquids with elevated biological oxygen demand and chemical oxygen demand eliminates this load to wastewater treatment plants, thus improving treatment efficiencies and reducing long-term threat from potential discharges to the environment. The operational advantages of this strategy are similar to those for a standard landfill except that the capital and operations costs are likely to be higher (although these may be more than offset by the reduction in leachate disposal costs, recaptured airspace, increased gas generation rates as a revenue source, and/or revenue from accepting nonhazardous liquid wastes, if permitted) and gaining regulatory approval may be more burdensome. If a waste is functionally stable, it could have a lower latent potential to impact receiving systems, and thus PCC maintenance costs are expected to be reduced and allow earlier transition to CC relative to traditional waste-disposal practices. The main disadvantages are also similar to those for standard landfills except that with a documented reduction in long-term threat potential, the PCC period is likely to be significantly shorter (Bonaparte 1995, cited in EPA 2002a; Stegmann 2001; Haskell and Cochrane 2001).

- Landfill Using Screening and Waste Diversion Potentially Resulting in Reduced Threat. This strategy is applicable only to future landfills or landfills planning an expansion. Under this strategy, MSW must receive some level of mechanical biological pretreatment, such as mechanical separation or shredding, composting, anaerobic digestion, or incineration, such that the landfilled residue has a reduced threat potential and/or enhanced ability to undergo anaerobic degradation under landfill conditions (Stegmann 2001, Stentsoe and Houe 2001). However, Team experience with waste exclusion programs does not, in all instances, reduce the threat potential from a landfill.
- Waste Removal Closure of Landfill (Mining). Waste removal and removal of any remaining residual, thereby eliminating any remaining threat, may be implemented with or without prior supplemental moisture addition to the waste. Advantages of this approach include the elimination of the contaminant source and thus concerns about the long-term performance of LCRS and waste containment systems and the potential for waste to be mined and used as a resource. However, the disadvantages are considerable and include the facts that waste removal closure may not be cost-effective, environmental impacts of waste removal closure operations must be addressed, and waste residuals must be managed (Bonaparte 1995, cited in EPA 2002a). There may currently be disadvantages, but the future could present more efficient and effective means of removing and reusing waste previously placed in a landfill.

5.2 Active Strategies for Landfill Management

A wide range of active strategies may be employed to reduce the overall extent of PCC activities required at a landfill but not the total duration of care required by an owner/operator such as the CC phase of facility maintenance. By focusing PCC activities only on perpetual maintenance of the systems and/or structures that require such attention, overall PCC costs at a landfill may be significantly reduced (Bonaparte 1995; Rowe 1998, cited in EPA 2002b). One example of an active strategy is an inward gradient landfill. An inward gradient landfill may be developed with or without supplemental moisture addition or other means of enhancing waste degradation. The inward gradient design must not allow leachate diffusion through the liner system. Advantages

include the fact that an inward gradient provides active rather than passive control of contaminant advection and diffusion and that flexibility to convert to an alternative strategy at a later time is inherent in the approach. Disadvantages include that this strategy is not compatible with typical landfill management strategies to reduce or control liquid infiltration to the waste; large liquid volumes must likely be collected in the LCRS; and an inward gradient will not exist in the unsaturated zone above the water table unless an engineered hydraulic control system (e.g., double liner system) is constructed. An inward gradient landfill may be initially operated until such time that sufficient waste degradation has occurred to allow the PCC period to be limited or alternatively until clean closure is carried out. In general these active strategies may be to degrade or stabilize the waste so that they no longer present a threat and thereby reduce the term of PCC.

5.3 Passive Strategies for Landfill Management

As with other strategies, the goal of passive long-term management strategies should be to reduce the threat such that landfills require little or no PCC activity. For example, when discussing options for passive landfill management, Stegmann (2001) recommends that active landfills be operated as bioreactors, future or expanded landfills should accept only pretreated waste with little emission potential left, and closed landfills should employ in situ aeration and leachate recirculation to further reduce the emission potential. It is important that future possibilities regarding the use of passive strategies be incorporated into landfill operation and management strategies from the initial design phase (i.e., even before active filling commences). For example, one recommended approach is that consideration should be given during landfill siting to the mechanisms by which this landfill will eventually passively discharge leachate after LCRS pumps have been shut down (Stentsoe and Houe 2001).

Following successful culmination of proactive or active strategies, site-specific, climatic, and regulatory conditions should be considered during the design of a passive landfill management strategy. Thereafter, a wide range of strategies is available to achieve a sustainable, very low-maintenance, passive PCC strategy. These will not be discussed in detail but include the following:

- Final Cover Systems. The use of alternative final cover systems such as evapotranspirative caps (ITRC 2003) or “store and release” covers (Blight et al. 2003) may be employed to control leachate production.
- Leachate Management. Landfills can be built with natural leachate drainage (Stentsoe and Houe 2001). Leachate may be treated on-site with low-maintenance ecological systems such as wetlands (Robinson 1999, Stegmann 2001) before the clean effluent is discharged or allowed to infiltrate groundwater in a controlled manner.
- Landfill Gas Management. Any remaining LFG generated can be treated with bioactive cover systems, such as compost covers, or biovent systems.

It is important to realize that passive strategies can be applied only to specific aspects of long-term landfill management and thus used in conjunction with other strategies. In this way, while the long-term management strategy for a site as a whole may principally be active, some components may be wholly or partially passive. For example, leachate may be routed via gravity drainage through a constructed treatment wetlands system and discharged while active LFG extraction and cover system maintenance is still ongoing at a site.

6.0 POST-CLOSURE CARE MONITORING AT MSWLF SITES

The demonstration that no unacceptable environmental impacts occur after modification of any PCC activities or features at a WMU is achieved through a process of confirmation monitoring, as shown in Figure 6-1. Following successful completion of a CM program, a second PCC monitoring period would be surveillance monitoring. A program of SM can commence only for PCC components that pose no long-term threat to HH&E and, therefore, warrant no future monitoring or maintenance of any kind. During this period, monitoring would be performed according to a geometrically reducing schedule, the initial duration and frequency of which would be linked to the time previously needed under CM. In this way, SM can essentially be considered as a period of “insurance” monitoring performed prior to complete cessation of PCC components.

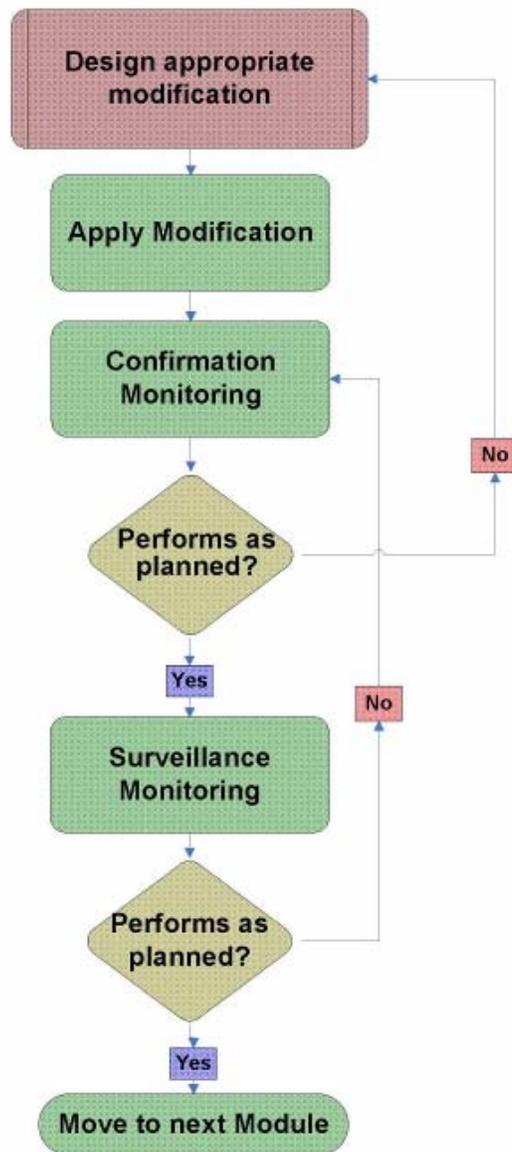


Figure 6-1. Optimizing post-closure care.

6.1 Methodology and Techniques

CM is particularly rigorous in the leachate module because impacts related to leachate may take time to manifest themselves. Before it can be completed, CM is required to demonstrate the following:

- The post-modification condition of the landfill is as expected from the evaluation(s).
- Any alternative or additional institutional, engineered, and/or natural controls constructed or used are performing as defined.
- No unacceptable impacts have resulted from the modification.

As long as engineered controls that require significant operational oversight are needed to protect HH&E (i.e., any care activity other than those defined under CC), the user cannot move past CM. Post-CM PCC monitoring and maintenance, albeit at a reduced level and frequency, will continue to be required unless all three of the following conditions can be met for the PCC module in question:

- All activities and requirements prescribed by the applicable regulatory authority as a part of the post-closure permit have been fulfilled and can be certified complete.
- No engineered control systems exist for which any significant monitoring or maintenance activities are required to protect HH&E (aside from de minimus care that can be provided under a CC program).
- A successful analysis of potential future threats to HH&E has been completed, and CM was conducted for long enough to demonstrate that cessation of PCC activities is acceptable.

If these conditions can be met, then performance of an “insurance” period of SM on a geometrically reducing time scale can commence. In other cases, SM cannot begin, and the module must be exited and the post-CM defined PCC activities performed as defined.

Trigger failure and alarm situations are incorporated into both the CM and SM programs. Generally, a failure signifies a high-level trigger (such as would result in noncompliance with permit conditions), whereas an alarm represents a low-level trigger (which generally indicates that, while the landfill is still in compliance, its behavior is not wholly as predicted). Should a failure situation be encountered, a facility is likely to be required to take responsive action and/or return to previous, more stringent levels of PCC. For example, detection of landfill gas at 3 percent of the lower explosive limit in a perimeter probe after turning off a gas collection system might be considered a low-level alarm. An alarm might require only CM to be continued for an additional period or SM moved back up a level in the geometrically reducing schedule while the nature of the situation causing the alarm is investigated (see EREF 2006, Vol. II, Appendix E).

6.2 Statistical Procedures for Evaluating Data Required for Terminating Post-Closure Care Modules

In 1980 EPA promulgated RCRA regulations for hazardous waste landfills. This was the first environmental regulation that required the use of statistical analyses for evaluating groundwater monitoring data. In subsequent years, statistical methods have played a major role in environmental monitoring programs. With the development of a modern statistical approach to environmental regulatory statistics (e.g., Gilbert 1987; Davis and McNichols 1987; Gibbons

1987a, 1987b, 1994, and 1996; Davis 1994), there has been a major evolution in the way in which environmental impact decisions are made. Based on this initial work and due to unacceptably high false positive rates from using the original RCRA statistics, regulations were modified under RCRA in 1988. This change was an improvement in evaluating groundwater data and focused largely on groundwater detection statistics, which focused on providing early detection of a potential release. Similar groundwater monitoring statistics were promulgated under RCRA Subtitle D regulations for solid waste landfills. As these new methods have become incorporated into state and federal regulation and guidance (e.g., EPA 1988 and 1992), the need for improved statistical approaches to related problems of assessment and corrective action monitoring as well as long-term PCC monitoring has grown.

Unfortunately, far less statistical work and guidance have come out in this area. Corresponding environmental impact decisions are often still based on the comparison of individual measurements to fixed standards or at best simple normal confidence bounds, and the decision to continue monitoring a closed facility is based on a single measured concentration exceeding an environmental standard. Furthermore, statistical work and guidance developed for evaluating trends and other data distribution characteristics in other media, such as leachate and gas quality and quantity, are not typically performed. These types of evaluations would be useful in evaluating when management of these systems can be reduced or terminated during or after the regulatory PCC period.

This practice is of concern for two reasons:

- First, because decisions should be based on comparison of the true concentration to the standard and not simply the measured concentration. Of course, without infinite sampling the true concentration can never really be known; however, statistical analysis provides a means of estimating the true concentration distribution from a series of measured concentrations.
- Second, because it treats all environmental problems as being equal. For example, exceeding an environmental standard in one of five samples is a very different problem than exceeding an environmental standard in one out of 500 samples.

Again, the statistical approach to addressing this problem should incorporate the uncertainty in the true concentration distribution rather than simply assuming, often erroneously, that the measurements are made without error and each result represents truth. Here, the variability in the system is based in large part on the practice of the laboratory and the preparation and analysis of the individual samples. In almost all cases, analytical measurements are accepted as true concentrations without regard to their uncertainty. Confidence bounds on measured concentrations are rarely, if ever, reported, despite the availability of historical data that could routinely be used for this purpose.

The purpose of these recommended statistical procedures is to describe the statistical theory that underlies evaluation of the monitoring data of groundwater and leachate critical to the post-closure process for the purpose of predicting long-term environmental behavior. The goal is to present an approach that can be applied readily and that accommodates the variability that is common in landfill and surrounding environmental media monitoring data. Appendix E of this document addresses how analytical measurements (extracted from Gibbons and Bull 2006) can be used in evaluating the PCC monitoring program, including the determination of trend, comparisons to average and extreme values of the distribution to regulatory standards, minimum

number of data points, frequency of collection, etc. In addition, there is a discussion regarding the handling of censored data (i.e., data below the laboratory limit of quantification), testing distributional assumptions, and testing for outliers to ensure that the probability of detecting a real exceedence is large, while the probability of falsely concluding that there is an impact is small. Since many of the statistical methods recommended in this document relate to determination of trends and calculations of appropriate statistical maximum concentrations in source liquids (e.g., leachate), some of the methods recommended herein are fairly new in terms of application. As the science of environmental statistics progresses over the coming years, other methods that are not discussed herein may be applicable. However, the methods described can be applied to provide statistically defensible calculations.

6.3 Planning, Recordkeeping, and Reporting

Careful planning, recordkeeping, and reporting of all evaluations and subsequent monitoring programs required for every module will be an important component of applying the EREF project approach (EREF 2006).

- Planning. To assist with this process, all data requirements and prerequisites that must be addressed before embarking on a module evaluation are provided in the stand-alone prerequisites module. This module must be consulted before attempting any evaluations to ensure that it will be possible to complete a module. In some cases, it will be necessary to begin collecting data well before attempting an evaluation. In addition, careful consideration of the end use of the site must be made and regulators consulted to encourage their acceptance of a proposed long-term PCC strategy.
- Recordkeeping. Good recordkeeping will be vital to ensure continuity. In addition, where any PCC activities remain in place, revisitation of the entire process is recommended periodically (e.g., 10 years); subsequent reevaluation processes will be expedited where good records of previous evaluations exist. It is strongly recommended that all documentation supporting, and the final determination to end, PCC be maintained as part of the administrative record and incorporated into any institutional control governing the future use of the property.
- Reporting. Specific reporting requirements are state and site specific. Each state agency should have specific procedural approaches and/or requirements for submitting an application to modify PCC activities and features at a WMU under its jurisdiction.

7.0 STAKEHOLDER CONSIDERATIONS

Stakeholders should be involved in the evaluation, selection, and the modifications of any PCC program that involves a change in the end use of the closed landfill. Experience has shown projects benefit from stakeholder input. While these outreach efforts may exceed the specific regulatory requirements, they create a more cooperative partnering between the facility and the community. Stakeholder involvement could benefit the public interest with direct input into the development and implementation of a public involvement plan, public meetings, and public facility technology working sessions. However, such participation does not subjugate the owner or operator as the responsible party required to design and implement a responsible PCC plan that considers potential threat to relevant POEs.

Stakeholders could include local, state, and federal government officials; representatives of affected tribes; facility owners and operators; nearby residents; and environmental groups. This outreach should, at a minimum, address the local, state, and federal statutes, regulations, guidance, and policy provisions for community input. In addition, efforts beyond those specifically mandated may be warranted at individual sites on a case-by-case basis. Such involvement can lead to better, more defensible solutions and expedite site reuse and the ultimate management of PCC threats. One of the objectives of the owners and operators should be to integrate tribes and stakeholders into all of their processes. Stakeholder discussions should clearly define the specific cleanup goals and criteria.

Since changing land uses and evaluating the potential threats associated with the reuse modifications are relatively new processes, when such processes are considered for permitting or deployment, stakeholders and tribal representatives should be given the opportunity to comment on it and to make their issues, needs, and concerns known. Information about the process and potential related technologies, including alternatives analysis, should be made widely available for public comment. Stakeholder involvement in answering the obvious question “Will it do any harm?” can be substantive. To sustain the constructive relationship, this question must be addressed carefully and honestly.

In some instances, one can cite the examples where the process has been tried before and report on its success or failure in each situation. In the case of an evolving process and management system, one may be proposing a solution that is believed to be likely to work but has not been tried previously in a parallel situation. In this situation, accurate and honest information should be given. All of the reasons why the process and technology are likely to work should be explained, as well as the details of the possible failure scenarios. How likely is the technology to fail? What damage might be done? There should be public discussion about the alternatives. It is possible that tribes and stakeholders will embrace an opportunity to try a new solution to a situation, particularly if there is a good chance that it may succeed where other solutions are likely to fail. Proponents should be open about the potential threats and benefits. The affected tribes and stakeholders must be given the opportunity to weigh the potential threats against the potential benefits, since they are often the ones most directly affected by the contamination and by the success or failure of the technology. In certain cases, they are also the ones who bear the cost of the cleanup or, at the very least, as taxpayers in practice serve as the insurer of last resort.

In 1997, the Tribal and Stakeholder Working Group, working with the U.S. Department of Energy (DOE) Office of Science and Technology, developed a set of principles for the integration of tribes and stakeholders into the process of evaluating and developing new technologies for the treatment of mixed low-level waste. Below is discussion of the applicable principles and how they translate to a situation wherein landfill PCC changes are being considered for the remediation of subsurface contamination.

- Minimize effluents—Clean up contamination as quickly as possible. Avoid the generation of reaction side products and new contaminants.
- Minimize effects on human health and the environment—Protect present and future drinking water supplies. Minimize the potential for accidents.
- Minimize waste generation—Minimize the production of waste from the cleanup effort.

- Address social, and cultural considerations—Minimize land use and habitat destruction in the cleanup process. Discuss the transport of chemical reagents with tribes and stakeholders, and adapt such transport to address their concerns. Respect the social, cultural, and spiritual values of specific sites. Minimize noise and traffic. Protect local vistas. Include the costs of tribal and stakeholder participation in cost estimates and budgets. Include the costs of compliance with intergovernmental agreements in cost estimates and budgets. These cost estimates may also include evaluations of the energy use throughout the remedy's life cycle. If possible, these could include comparative remedy evaluations that are presented at stakeholder meetings.
- Provide timely, accurate, complete, and understandable information in a time frame to consider prior to final decisions and determinations so stakeholders may have an impact on the PCC and CC processes: Explain the technology screening and evaluation process. Provide information about any previous applications of the technology. Provide information about the hazards and threats and also potential hazards and threats, as well as benefits and potential benefits. These evaluations could include impacts on local and private wells, transportation, dust, noise, and air buffer zones. Keep the tribal and stakeholder representatives involved and informed throughout the evaluation, selection, permitting, and PCC/CC processes. The upper levels of management of the company implementing the PCC need to understand the community concerns and be vested in the closure/PCC/CC processes. Independent technical advisory resources should be made available to the tribes and stakeholders whenever feasible.
- Incorporate tribal and stakeholder involvement into the responsible party's procurement process, the permitting process, and the performance evaluation of contractors.

When an evolving process such as progressive and modified PCC is considered for application to a waste containment situation, there are uncertainties about the efficacy and risks of the technology in a given situation. Public acceptance of new processes and technologies is more likely if tribes and stakeholders are involved in a timely and meaningful manner in the evaluation process. Such involvement will enable the early identification of significant issues and the joint resolution of these issues. In turn, public involvement promotes faster and more efficacious closure or containment and increases public acceptance of novel approaches to such cleanup. However, public participation and involvement does not guarantee concurrence by the party responsible for the management (therefore liability) of the closed facility. This document encourages a partnering relationship, as discussed in Section 2, that allows the responsible party to consider the needs of the neighbors and the residents to better understand the technical consideration that has been considered in the final determination of the PCC selection with agency concurrence.

8.0 FINDINGS AND RECOMMENDATIONS

During preparation of this document, the Team reviewed and evaluated published literature, shared state-specific and industry experience, and considered the consequences of maintaining the existing course of PCC. The Team identified the following findings and recommendations:

Finding. The Team believes that communities can realize significant benefit from the reuse of former landfill properties, such as brownfield-type redevelopment, especially following the processes outlined in this document.

Recommendation. The Team recommends that land reuse be a planning element (Section 2.1.1) of the waste management industry in support of the surrounding community resource availability and service capacity (ITRC 2006b).

Finding. The Team supports the concept of **reducing** or **ending** PCC using the methodology described in this guidance, which is consistent with EPA regulations and guidance and is predicated on a performance-based approach consistent with statutes, regulations, and guidance.

Recommendation. Regulatory agencies should consider using the performance-based approach presented in this guidance or another performance-based approach to evaluate and potentially end PCC.

Finding. This ITRC guidance is not intended to be interpreted as a rule, regulation, or statute and does not have to be universally applied to demonstrate its value.

Recommendation. The Team recommends that states use this document as guidance but equate landfill performance to their own specific state requirements.

Finding. Wastes contained within the landfill structure may represent a potential **risk**; however, exposure to the wastes can be managed and evaluated on a site-by-site basis to determine whether such a condition represents a threat to HH&E based upon each state's statutes and regulations.

Recommendation. Extending the PCC term should be based on “relevant environmental factors” that include an evaluation of threat at a POC/POE rather than the source, consistent with EPA 1998. This evaluation should use site-specific data with a specific end-use design to determine whether the landfill unit represents a threat.

Finding. Alternative final covers may be effective as part of post-landfilling operations and can complement construction and implementation of bioreactor technology (see ITRC 2003 and 2006a). The consideration of alternative final covers and the timing of cover placement to support post-landfilling operations is consistent with existing regulatory flexibility, provided their performance is protective of HH&E. These technologies alone or in combination can decrease the PCC period and facilitate entering CC, relative to traditional landfills and the 30-year PCC period. The Team recognizes that FA will be evaluated annually in accord with federal and state regulations.

Recommendation. The Team recommends that FA funding should be reevaluated using, in part, the outcome(s) of this four-module evaluation. This should occur, at a minimum, 10 years prior to any projected end of PCC. The intent of this evaluation is to ensure that the amount of FA is adequate to cover any reasonably anticipated PCC period based on the performance evaluation of the landfill.

Finding. Reducing and ending PCC, according to this guidance, is based on the outcome of the four-module evaluation process. This guidance contains a methodology supported by the Team and used to assess waste containment, management, and monitoring systems in the evaluation of the performance of PCC. In addition, Team research indicates that alternative final covers and bioreactors (see ITRC 2003 and 2006a) may accelerate stabilization of MSW.

Recommendation. The Team recommends that alternative final covers and bioreactors be proactively used to accelerate the stabilization of MSW. This can potentially end PCC earlier than the traditional 30 years based on performance evaluation using the modular evaluation process.

Recommendation. The Team recommends using a 30-year PCC period as a basis for initial FA planning.

Finding. FA is not required during CC. Covenants, deed restrictions, or other land-use control mechanisms may ensure that the land is used only accordingly and that appropriate CC is provided. For the purpose of CC, covenants, deed restrictions, or other land-use control mechanisms are only as effective as the government's ability and resources to enforce them. These mechanisms may be tied to the land, and ultimately are the owner's responsibility. State environmental agencies should have a legal mechanism for notification when a land-use control has been violated, allowing the state agency an opportunity to investigate any environmental or health consequences of a land-use control violation.

Recommendation. The Team recommends that States develop a template/administrative mechanism they can use and adjust to track and evaluate the environmental effectiveness of land-use controls placed on a landfill site. This might be best accomplished through a national organization that represents the states (see Section 4.8.2).

Finding. The Team recognizes and appreciates the need for timely and finalized national guidance regarding data evaluation methodologies (e.g., statistical analysis of groundwater monitoring data at RCRA facilities [Unified Guidance]) for measuring landfill performance.

Recommendation. The data evaluation methodologies should include, but not be limited to, techniques to address landfill gas, leachate, groundwater, or other landfill elements. The Team also recommends that adequate funding be appropriated to complete this project in no less than one year.

Topics currently unaddressed include the following:

- Leachate analysis for limiting landfill-specific constituents of concern and for evaluating the advisability of optimizing or ending PCC
- Landfill gas analysis for limiting landfill-specific constituents of concern and for evaluating the advisability of optimizing or ending PCC
- Suitable statistical method to test exceedence of a maximum contaminant level (MCL) after successful completion of corrective action
- Establishing the proper use of null hypothesis for proving completion of corrective action
- Developing better statistical methods for data sets that include a large percentage of nonquantified data points (nondetectable or trace observations).

A guidance of this nature must be maintained by incorporating the most current information possible. Funding should be provided to maintain the current nature of the document.

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Appendix A

Acronyms

ACRONYMS

ADEQ	Arkansas Department of Environmental Quality
ASTM	American Society of Testing and Materials
ASTSWMO	Association of State and Territorial Solid Waste Management Officials
CC	custodial care
C&D	construction/demolition
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CM	confirmation monitoring
CMMP	cap monitoring and maintenance plan
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
EREF	Environmental Research and Education Foundation
FA	financial assurance
FR	Federal Register
GCCS	gas collection and control system
HH&E	human health and the environment
ITRC	Interstate Technology & Regulatory Council
LCRS	leachate collection and recovery system
LFG	landfill gas
MCL	maximum contaminant level
MDL	method detection limit
MSW	municipal solid waste
MSWLF	municipal solid waste landfill
ND	nondetect
NSPS	new source performance standards
PCC	post-closure care
POC	point of compliance
POE	point of exposure
POTW	publicly owned treatment works
PQL	practical quantitation limit
QL	quantitation limit
RCRA	Resource Conservation and Recovery Act
RL	reporting limit
RP	regulated parameter
SM	surveillance monitoring
SWMU	solid waste management unit
TOT	time of travel
UCL	upper confidence limit
UPL	upper prediction limit
WMU	waste management unit

Appendix B

Glossary

GLOSSARY

confirmation monitoring—involves demonstrating that data on which the evaluation was performed are complete and document the existence of the trends that the evaluation was based on.

custodial care—involves property management activities that are typical of any property, such as paying property taxes, controlling access, complying with local zoning ordinances, and complying with the property-use restrictions identified in the deed to the property.

point of compliance—a monitoring point established by the appropriate regulatory authority to measure the regulatory performance of a waste management activity.

point of exposure—the closest location at which a receptor could be exposed to the source and receive a dose in a credible pathway from the WMU. Each state should apply this definition according to its own statutes and regulations. The Team does not support defining a credible POE as the leachate collection system or leak detection system that is part of the unit.

surveillance monitoring—provides long-term monitoring at a reduced level to document that the decision to end post-closure care was appropriate.

Appendix C

State Survey

STATE SURVEY

7. Does your state or organization have [check all that apply] that pertain to post-closure care?		
	Statutes	6
	Regulations	10
	Policies	1
	Guidance	1
	Business Practice	0
	None	0
8. Please provide the citation or reference for your answer to the previous question.		
	Kansas Administrative Regulations (K.A.R.) 28-29-12, 121, 321 at: < www.kdhe.state.ks.us/waste/download/sw_laws_apr2004.pdf >.	
	Public Resources Code 43509(a) Title 27, CA Code of Regs.(27 CCR), 20920-37, 20950, 21090, 21180, 21900	
	R.61-107.258 Municipal Solid Waste Landfill Regulations	
	Kansas Statutes Annotated (K.S.A.) 65-3406(a)(18) Kansas Administrative Regulations (K.A.R.) 28-29-12(e), 121(p), 321(c)& (d)	
	Regulation 22.1301, 22.1302, and 22.1303	
	Title 132	
	N.J.A.C.7:26-2A9 Closure and Post-closure Care of Sanitary Landfills	
	Kansas Statutes Annotated (K.S.A.) 65-3406(a)(18) Kansas Administrative Regulations (K.A.R.) 28-29-12(e), 121(p), 321(c)-(e)	
	ADEM Administrative Code 335-13	
	40 CFR 258.61	
	Statutes : The Illinois Environmental Protection Act 415ILCS 5/1 et seq. Sections 22.17 & 22.19(b) Regulations : Title 35 Ill. Adm. Code Sections 807, Subpart E (pre-Subtitle D landfill) and 811.110, 811.111, 811.704 and 811.705	
	10 CSR 80-3.010(17)(B)	
9. If you answered None to question 7; is your state or organization preparing to promulgate regulations, or develop policy or guidance, or develop written business practices that further define post-closure care requirements?		
	NA	
10. If you answered Yes to the previous question; what is your schedule for completion?		
	NA	
11. Does your state see the need for guidance even if there are not current or pending regulations?		
	Yes	5
	No	4
12. Do your state's regulations governing post-closure care contain flexibility for: Check all that apply.		
	Duration of PCC	6
	Monitoring Requirements	8
	Financial Assurance;	8
	Liability Transference	5
	Land Re-use	7
	Property End-use	8

13. What regulatory mechanisms govern the application requirements of post-closure care in you state: Check all that apply.		
	Compliance Order	2
	Consent Decree	2
	Covenants	2
	CD (Certificate of Designation)	0
	Voluntary Cleanup Agreement	0
14. Is the decision to end the post-closure care period in your state based solely on the potential for a threat to human health and environment?		
	Yes	5
	No	5
15. If you answered Yes to the previous question; is the owner/operator required to reevaluate the need for post-closure care if the end-use (i.e., the use of the site after the end of the post-closure care period) of the site changes?		
	Yes	2
	No	2
	Uncertain	1
16. If criteria for ending post-closure care in your state are not specific to a particular end-use, please briefly explain your state's methodology for establishing criteria for ending post-closure care.		
	PCC is required for a minimum period of 30 years and until the waste no longer poses a threat to public health and safety and the environment. PCC period is based on potential threat of the waste irregardless of current end use but on potential end use.	
	The ability of the site to meet regulatory standards outlined in the regulations.	
	Regulations and statues. Also, answer to question # 13 for Nebraska is regulations and statues. None of the answer give me that option for question # 13.	
	Ground Water Issues, Gas Issues and other Environmental Issues. Normally End Use of the Facility is not known when the landfill closes and goes into post-closure care.	
	Criteria for ending post-closure care have not been developed yet. Kansas will probably follow EPA guidelines, if/when promulgated. The criteria will probably focus on leachate quantity & quality, landfill gas quantity & quality, groundwater quality	
	Completion of the 30-year period and no impacts to groundwater.	
	Thirty years has been used to date without question.	
	15 year minimum for all landfills, with 30 year minimum for MSWLFs, maybe reduced if not a threat to human health and environment or an adjusted standard from the Ill. Pollution Control Board.	
	Time and no monitored change in the environment.	
17. Which of the following elements of post-closure care can be reduced before the end of the post-closure care period?		
	Leachate Management	6
	Gas Collection	5
	Groundwater Monitoring	6
	Cover System Maintenance	3
	Cover System Monitoring	3
	Financial Assurance	4
	Inspections	4
	Reporting	3
	Access Control	2
	Gas Monitoring	6
	Community Awareness	1

18. Do your state's regulations include specific criteria used to evaluate the need to extend or shorten the post-closure care period?		
	Yes	6
	No	5
	Uncertain	0
19. Please list criteria you use for extending the post-closure care period		
	No criteria to extend the PCC period since care continues until the waste no longer poses a threat to public health and safety and the environment.	
	If environmental standards are out of compliance, PC period may be extended until remediation is achieved.	
	Threat to human health and the environment	
	Quality of Ground Water and Gas production in addition to other Environmental concerns.	
	Specific criteria not established. The post-closure care period may be increased if "necessary to protect public health, safety, and the environment".	
	Continuing groundwater impacts	
	Protection of human health and the environment	
	Monitored releases into the environment in groundwater, surface water, soil gas or air emission are used to extend the period.	
20. Please provide the criteria your State uses to shorten the post-closure care period.		
	Demonstration by responsible party that the waste no longer poses a threat to public health and safety and the environment.	
	Threat to human health and the environment	
	No Pollution and no Gas for two to three years continuously.	
	Kansas has not shortened post-closure care on any facilities that I am aware of. Since a 30-year post-closure period is specified in State statutes, legislative action would be necessary to shorten post-closure care.	
	Overwhelming evidence of no groundwater impact.	
	Demonstration that the site is not a threat to human health or the environment.	
	Monitoring similar to item 19 is grounds to petition for shortening the period.	
21. Please provide the regulatory citation or reference location for the previous two questions on the post-closure care period.		
	27 CCR 20950, 21900	
	R.61-107.258	
	Title 132, Chapter 3	
	N.J.A.C.7:26-2&.9(c)5,6	
	See response 8.	
	ADEM Administrative Code 335-13	
	Title 35 Ill. Adm. Code 811.111(c)	
	10 CSR 80-2.030 (4)(F)	
22. Do your state's regulations provide for the periodic adjustment of financial assurance estimates?		
	Yes	9
	No	2

23. If you answered yes to the previous question, please provide the citation or reference for the financial assurance estimates.		
	27 CCR 21840, 21890	
	Amount of time left in PC period	
	Regulation 22.1403	
	Title 132, Chapter 8	
	N.J.A.C.7:26-2A.9	
	K.A.R. 28-29-2101(h)	
	Title 35 Ill. Adm. Code 811.705	
	10 CSR 80-2.030 (4)(F)	
24. Referring to your previous answer; please provide the criteria you use to evaluate adjustments to financial assurance.		
	Cost estimates changes due to cost or maintenance or monitoring requirements.	
	Inflation may require increased FA; changes to the Closure Plan may require FA adjustments; Reduction of FA may be needed if cost estimate exceeds max cost of post-closure care over the remaining post-closure period.	
	Site-specific information	
	Two year update of the Post-closure and Care plan.	
	site conditions, unit costs, and inflation	
	Alabama does not have financial assurance regulations at this time.	
	Changes in operation (corrective action), reduced time requirement, and inflation	
	10 CSR 80-2.030 (4)(F)	
25. Do your post-closure care requirements establish periodic adjustments to the financial assurance mechanism?		
	Yes	8
	No	1
	Undetermined	0
26. If you answered Yes to the previous question please explain or provide a citation or reference for its location.		
	Mechanism must be adjusted for inflation and increases in costs.	
	see Previous answer #24	
	Regulation 22.1403	
	Inflation and post-closure plan changes	
	Same two year updates.	
	K.A.R. 28-29-2101(h)	
	Alabama does not have financial assurance regulations at this time.	
	35 Ill. Adm. Code 811.705 requires annual updates	
	10 CSR 80-2.030 (4)(E)	
27. Are there events during post-closure care (e.g. extending the time frame), which trigger a recalculation of the value of financial assurance or restart the clock on maintaining financial assurance.		
	Yes	5
	No	0
	Undetermined	3

28. If you answered Yes to the previous question; please explain or provide the citation or reference for its location.		
	CA is currently investigating the requirement for financial assurance beyond the initial 30 year period. Current interpretation of CA regulations is inconsistent.	
	The need for assessment and remediation activities.	
	Same as in 24.	
	Groundwater and/or gas contaminations issues	
	Every Two Years the Plan needs to be updated.	
	Alabama does not have financial assurance regulations at this time.	
	35 Ill. Adm. Code 811.705 lists inflation, site changes, or corrective actions	
	10 CSR 80-2.030 (4)(C)	
29. If you found that you could not answer one of the previous questions because a Yes or No or multiple choice did not provide your answer; please list the question number and answer below.		
	13. Compliance is required by regulation. Closure permits are sometimes issued.	
	Question 13 We go as per our Regulations.	
	17. Any or all of these measures can be reduced if the situation warrants (e.g., capping greatly reduces the amount of leachate to be managed).	
	Alabama does not have financial assurance regulations at this time.	
30. Would you be interested in attending a classroom style training course which contains an element on the topic of post-closure care?		
	Yes	7
	No	1

Appendix D

State Post-Closure Care Regulations and Guidance

STATE POST-CLOSURE CARE REGULATIONS AND GUIDANCE

Table D-1. State Post-Closure Care Regulations and Guidance

from Performance-Based System for Post-Closure Care at MSW Landfills, Environmental Research and Education Foundation, 2006

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
ALABAMA Department of Environmental Management Land Division Solid Waste Branch www.adem.state.al.us	Alabama Environmental Regulations, Division 13, Chapter 4 Applicability: All MSW landfills.	Following closure of each LF unit, the owner or operator must conduct post-closure care. Post-closure care must be conducted for a minimum of 30 years; or a minimum of 5 years if closed prior to October 9, 1993, or the effective date of §258.1 of 40 CFR 258, Solid Waste Disposal Criteria, whichever is later; except as provided under 335-13-4-.20(3)(b). The length of the post-closure care period may be: (1) Decreased by the Department 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 Department; or (2) Increased by the Department if the Department determines that the lengthened period is necessary to protect human health and the environment.
ALASKA Department of Environmental Conservation Division of Environmental Health Solid Waste Management www.state.ak.us/local/akpages/ENV.CONSERV/home.htm	18 AAC 60.397. Post-Closure Care Requirements for a Class I or Class II MSWLF.	Per Subtitle D.
ARKANSAS Department of Environmental Quality Solid Waste Management Division www.adeg.state.ar.us	ADPC&E Regulation Section 22.1302 – Post-closure care Requirements.	Per Subtitle D.

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
ARIZONA Department of Environmental Quality www.adeq.state.az.us	Arizona Revised Statute (A.R.S. § 49.762). AHWMA/RCRA Post-Closure Permit Application Completeness / Technical Evaluation Checklist. Applicability: Post-closure facility with no active hazardous waste management units.	Per Subtitle D, "The Arizona revised statutes adopt the Federal criteria for MSWLFs (40 CFR 258) by reference. The rationale for determining the length of time between inspections should be provided as part of the post-closure plan.
CALIFORNIA Environmental Protection Agency www.calepa.ca.gov and Integrated Waste Management Board www.ciwmb.ca.gov and State Water Resources Control Board www.swrcb.ca.gov	CCR, Title 27 ("Combined Regulations of the State Water Resources Control Board (SWRCB) and the California Integrated Waste Management Board" (CIWMB), Division ("Solid Waste"), Subdivision 1 ("Consolidated Regulations for Treatment, Storage, Processing, or Disposal of Solid Waste"), Chapters 1 through 6 (169 pages). § 20950-21200: Closure and post-closure standards § 21769-21900: Closure and post-closure plans	Post-closure maintenance for the purposes of reducing impacts to health and safety, shall be conducted to ensure the integrity of the final cover and environmental control systems. The landfill shall be maintained and monitored for a period of not less than thirty (30) years after the completion of closure of the entire solid waste landfill. Any areas in which final cover is placed prior to the closure of the entire landfill shall be maintained in accordance with an approved post-closure maintenance plan, but the thirty (30) year monitoring period shall not commence until closure of the entire landfill is complete. The operator of a solid waste landfill may be released from post-closure, after a minimum period of thirty (30) years upon demonstration to and approval by the CIWMB, the EA, and the RWQCB that the solid waste landfill no longer poses a threat to the public health and safety and the environment.
COLORADO Department of Public Health and Environment Hazardous Materials and Waste Management Division www.cdphe.state.co.us/cdphehom.asp	Regulations Pertaining to Solid Waste Disposal Sites and Facilities – 6 CCR 1007-2.	For MSWLFs, the post-closure care period shall be established by the Department and the governing body having jurisdiction per Section 3.6, shall be based on the operating history of the site, and shall be at least thirty (30) years.

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
<p>DELAWARE Department of Natural Resources and Environmental Control Division of Air and Waste Management Solid and Hazardous Waste Management Branch www.dnrec.state.de.us/dnrec2000</p>	<p>Delaware Regulations Governing Solid Waste.</p> <p>Applicability: Sanitary landfills that accept household waste.</p>	<p>The owner or operator of a sanitary landfill must continue post-closure care for 30 years after the completion of closure. At any time during the post-closure care period the Department may remove one or more of the post-closure care requirements described in Section 5.K.2 below if it determines that the requirement(s) is / are no longer necessary for the protection of human health and the environment. At any time after the first five years of the post-closure care period, the Department may reduce the length of the post-closure care period or terminate post-closure care if it determines that such care is no longer necessary. Prior to the time that the post-closure care period is due to expire, the Department may extend the post-closure care period if it determines that the extended period is necessary to protect human health and the environment.</p>
<p>FLORIDA Department Of Environmental Protection Waste Management</p>	<p>Chapter 62-701, F.A.C., Solid Waste Management Facilities.</p> <p>Applicability: Any landfill that receives wastes after January 6, 1993.</p>	<p>The owner or operator of any landfill which receives wastes after January 6, 1993, shall continue to monitor and maintain the integrity and effectiveness of the final cover as well as other appurtenances of the facility in accordance with an approved closure plan for 30 years from the date of closing. Before the expiration of the long-term care monitoring and maintenance period, the Department may extend the time period if the closure design or closure operation plan is found to be ineffective. The owner or operator of a landfill may apply to the appropriate District Office of the Department for a permit modification to reduce the long-term care schedule or eliminate some aspects of long-term care. The Department will grant such modification if reasonable assurance is provided to the Department that there is no threat to human health or the environment and if the landfill meets certain criteria.</p>

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
<p>GEORGIA Department Of Natural Resources Environmental Protection Division www.dnr.state.ga.us</p>	<p>GA Rule 391-3-4</p> <p>Applicability: All MSW landfills.</p> <p>Guidance Document: Release from Five-Year Minimum Post-Closure Care For Solid Waste Facilities Eligible for Five-Year Minimum Post-Closure Care.</p> <p>Applicability: Facilities eligible for consideration of reduction from 30-year post-closure care period to 5-year minimum post-closure care period, i.e. "facilities which are not contaminating groundwater and which cease to accept solid waste prior to being classified as an "existing MSWLF or landfill unit," as defined in Rule .01."</p>	<p>The owner and/or operator of all landfills must conduct post-closure care for at least thirty (30) years after the Director has authorized the Closure Certificate, provided however, that the Director may reduce the post-closure care period to 5 years for those facilities which are not contaminating groundwater and which cease to accept solid waste prior to being classified as an "existing MSWLF or landfill unit", as defined in Rule .01. The Director may extend the post-closure care period where necessary to adequately protect human health and the environment.</p> <p>Requirements include verification that post-closure care activities have been conducted in accordance with the approved Post-Closure Care Plan, verification of the integrity of the final cover, verification that the environmental monitoring systems were adequately designed to detect ground-water and surface water contamination and/or methane migration, and verification of compliance with the Rules for Solid Waste Management, Chapter 391-3-4.</p>
<p>HAWAII Department of Land and Natural Resources Land Division</p>	<p>§11-58.1-17</p>	<p>Per Subtitle D.</p>
<p>IDAHO Division of Environmental Quality www.state.id.us/deg</p>	<p>Idaho Statutes Title 39 Chapter 74 39-7416.</p>	<p>Per Subtitle D.</p>
<p>ILLINOIS Environmental Protection Agency Bureau of Land www.epa.state.il.us/land</p>	<p>APPENDIX F TO LPC-PA2 "Instruction for Closure Plan and Post-Closure Care Plans for Putrescible & Chemical Waste Landfills." Last Modified April 24, 2000</p> <p>Applicability: Not specified</p> <p>35 IAC Section 807.524</p>	<p>Post-closure care plan must, at a minimum, include schedules and monitoring/maintenance criteria for cover, and gas, leachate, and GW monitoring systems. Also cost estimate and criteria for reducing frequency / ceasing inspection / monitoring.</p> <p>The Agency shall certify that the post-closure care period has ended when it determines: (1) That the post-closure care plan has been completed; and, (2) That the site will not cause future violations of the Act or this Part.</p>

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
INDIANA Department of Environmental Management Land Quality www.in.gov/idem	329 IAC 10-23-3 Nonrule Policy Document WASTE-0026- NPD: Post-Closure Uses of Solid Waste Disposal Facilities. Also: Post-Closure Permit Application Guidance (incorporated as noted in 329 IAC 3)	Per Subtitle D. WASTE-0026-NPD presents the current criteria developed by the IDEM to evaluate demonstrations for post-closure use of solid waste disposal facilities as required by 329 IAC 10-23-3. Post-closure use inspection required twice annually, or as specified in the site approved post-closure plan. Guidance on how to prepare and requirements for a post- closure permit application (applies to Hazardous Waste Landfills only).
IOWA Department Of Natural Resources Environmental Protection Division www.state.ia.us/government/dnr/index.html	IAC 567-Chapter 113.26(13) and (14).	These post-closure actions are required for a minimum of thirty years following closure. The Department may extend the monitoring and reporting period if it appears that continued maintenance and monitoring are warranted.
KANSAS Department of Health and Environment Division of Environment Bureau of Waste Management www.kdhe.state.ks.us/waste/solid_waste.html	KAR Article 29 Section 28-29-121. Applicability: Municipal landfills receiving waste on or after October 9, 1991.	Following closure of each MSWLF unit, the owner or operator shall conduct post-closure care. Post-closure care shall be conducted for 30 years, except as provided under paragraph (2) of this subsection. The length of the post-closure care period may be increased by the director if the director determines that the lengthened period is necessary to protect human health and the environment.
KENTUCKY Department for Environmental Protection Division of Waste Management www.nr.state.ky.us/nrepc/dep/waste/dwmhome.htm	401 KAR 48:090 Operating Requirements for Contained Landfills Section 13: Closure and Closure Care Requirements.	“The closure period shall be at least two years following the cabinet’s acceptance of the owner’s certification of closure.” “Maintenance and Operation of the leachate collection system in accordance with the requirements, if applicable, until leachate is no longer generated.”
LOUISIANA Department of Environmental Quality www.deq.state.la.us	LAC 33: Part VII. Applicability: All solid waste facilities.	Per Subtitle D.

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
MAINE Department of Environmental Protection Bureau of Remediation and Waste Management www.state.me.us/dep/rwm/homepage.htm	06-096 Solid Waste Management Rules: Chapter 401 Landfill Siting, Design and Operation. Applicability: All MSW landfills.	The licensee shall submit a post-closure monitoring and maintenance plan to the Department as part of the closure plan required in Section 5. The plan must cover a period of at least 30 years following closure unless extended by the Department due to identified threats to public health, safety, or the environment.
MARYLAND Department Of The Environment www.mde.state.md.us	Title 26, Subtitle 04, Chapter 07 of the Maryland regulations.	Per Subtitle D. Pre-Subtitle D landfills are subject to post-closure monitoring and maintenance by the permittee as specified in this regulation, for a period of time not less than 5 years after the complete installation of the landfill cap. This time period may be extended by the Department if significant maintenance situations occur at the landfill during the 5-year period after closure.
MASSACHUSETTS Department of Environmental Protection Bureau of Waste Prevention www.state.ma.us/dep	Guidance document "Guidelines for Determining Closure Activities at Inactive Unlined Landfill Sites", issued July 17, 2000, revised July 6, 2001. Purpose is to clarify closure provisions of 310 CMR 19.000 ("Solid Waste Management Facilities Regulations"). Applicability: Sites closed prior to July 1, 1990 are the focus of these guidelines.	Clarifies 310 CMR 19.000 by providing guidance on procedures and criteria used by MADEP when reviewing requests for site closure. Specifically addresses permitting, materials used during closure, and length of time for closure activities. Per Subtitle D § 19.142(3) provides provisions for shortening the Post-closure care period following a review of relevant information. The review includes a consideration of the quantity and quality of leachate. Groundwater monitoring results, waste characterization, waste stability, design and location of the facility.
MICHIGAN Department Of Environmental Quality www.michigan.gov/deq	1994 PA 451 Part 115.	After the final closure of each unit, the owner and operator of a type II landfill shall conduct post-closure care for not less than 30 years.
MINNESOTA Pollution Control Agency www.pca.state.mn.us/waste/index.html	Minnesota State Rules for Solid Waste Chapter 7035.	Post-closure care must continue for at least 20 years after the date of completing closure. During the post-closure care period, based on the results of sampling, analysis, and other pertinent information, the commissioner may reevaluate and modify the closure document to the extent post-closure care is needed at the facility.

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
MISSISSIPPI Department Of Environmental Quality www.deq.state.ms.us/newweb/homepages.nsf	Regulation SW-2: Nonhazardous Solid Waste Management Regulations & Criteria, Section IV "Landfill Requirements" Adopted 1993, amended February 22, 1996 Applicability: MSWLF units that receive waste after October 9, 1991.	Per Subtitle D.
MISSOURI Department of Natural Resources Division of Environmental Quality Solid Waste Management Program www.dnr.state.mo.us/homednr.htm	10 Code of State Regulations - CSR 80-2.030. Landfill Closure Guidance Technical Bulletin. Applicability: Not specified	Per Subtitle D. All owners or operators applying for closure approval must have a department approved closure/post-closure plan.
MONTANA Department of Environmental Quality www.deq.state.mt.us	ARM Title 17 Chapter 50, Subchapter 5.	Per Subtitle D.
NEBRASKA Department of Environmental Quality www.deq.state.ne.us	Title 132 Integrated Solid Waste Management Regulations, Chapter 3. Applicability: MSW landfills accepting waste after October 1, 1993.	Per Subtitle D.
NEVADA Department of Conservation And Natural Resources Division of Environmental Protection ndep.state.nv.us/index.htm	NAC Chapter 444.	Per Subtitle D.

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
NEW HAMPSHIRE Department of Environmental Services Waste Management Division www.des.state.nh.us	“New Hampshire Solid Waste Rules”, includes: Env-Wm 2507.03 “Basic Closure & Post-Closure Requirements” and Env-Wm 2507.05 “Post-Closure Inspections, Monitoring, Maintenance, and Reporting Reqs.” Effective October 29, 1997. Applicability: Defined by 40 CFR 258	The post-closure period of a landfill shall be the period of time required to demonstrate the facility has achieved the performance standards specified in Env-Wm 2507.04. Water quality monitoring may be periodically reduced by WMD during post-closure period if conditions at site merit. LCS maintenance and leachate management required until landfill no longer produces leachate. Also requirements for cover repair, slopes, gas system, storm water management, financial assurance, annual reporting (WMD provides “MSW Landfill Post-Closure Inspection Form”).
NEW JERSEY Department of Environmental Protection Division of Solid And Hazardous Waste www.state.nj.us/dep/dshw	NJAC 7:26 Applicability: existing sanitary landfills in operation after January 1, 1982	Per Subtitle D.
NEW MEXICO Environment Department www.nmenv.state.nm.us	20 NMAC 9.1 Applicability: Closure after October 9, 1991.	Per Subtitle D.
NEW YORK Department of Environmental Conservation www.dec.state.ny.us	6 NYCRR Section 360-2.15.	Per Subtitle D. Quarterly inspections and inspections after major rainfall events (5-year storms) shall be performed on all facility components during the minimum 30-year post-closure period, unless specific department approval is given to eliminate some or all of these requirements, to ensure that the facility is functioning as intended.
NORTH CAROLINA Department of Environment and Natural Resources Division of Waste Management www.ehnrc.state.nc.us	Section 1605.1627 of Solid Waste Management Regulations.	Per Subtitle D.

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
NORTH DAKOTA Department of Health Environmental Health Section www.health.state.nd.us/ndhd/environ	33-20 NDAC.	The post-closure plan must address facility maintenance and monitoring activities for a post-closure period of thirty years. The department may require an owner or operator to amend the post-closure plan, including an extension of the post-closure period, and implement the changes. If the permittee demonstrates that the facility is stabilized, the department may authorize the owner or operator to discontinue post-closure activities.
OHIO Environmental Protection Agency www.epa.state.oh.us	Ohio Administrative Code 3745-27-14 Post-closure care of Sanitary Landfills Interoffice Communication on Compliance Monitoring & Enforcement Guidance.” Applicability: Closed landfills	“The Owner/Operator/Permittee license shall conduct post-closure care activities at the sanitary landfill facility for a minimum of thirty years. Required frequency of inspections at closed landfills by EPA inspectors and health department personnel. Changes to the regulations have been submitted which contain comment indication that the director may release the owner operator or permittee from continuing post-closure care provided that demonstrations that requirements are no longer necessary can be made.
OKLAHOMA Department of Environmental Quality www.deq.state.ok.us	252:515	Post-closure shall be performed for 30 years. The Department will not approve the certification of post-closure performance if testing shown the presence of elevated levels of any constituent, if evidence of contamination resulting from site operations is found to exist, if prior maintenance or monitoring of the site is found to be inadequate, if the site is producing leachate which must be treated prior to discharge, or if other conditions are present that indicate a need for additional post-closure monitoring and care.

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
<p>OREGON Department of Environmental Quality www.deq.state.or.us</p>	<p>340 Oregon Administrative Rules OAR 094-013(2) per Subtitle D.</p> <p>Solid Waste Landfill Guidance Section 11.</p> <p>Applicability: MSW landfills – differentiated between Subtitle D and non-Subtitle D.</p> <p>Memorandum of Agreement Between The Oregon Department of Environmental Quality, Lane Regional Air Pollution Authority and The United States Environmental Protection Agency Concerning Regulatory Innovation and the Oregon Green Permits Program.</p> <p>Applicability: Facilities regulated by ODEQ.</p>	<p>The post-closure plan should identify and describe the post-closure activities required to properly monitor and maintain the closed landfill site.</p> <p>The Green Permit Program tests the use of regulatory incentives to encourage higher levels of environmental performance and the adoption of environmental management systems (EMS). The program is based on the use of EMSs such as ISO 14001, and a “tiered”, or multi-level system in which greater demonstrated environmental performance is acknowledged with increasing regulatory flexibility and other “benefits” to the facility (including the potential for more effective and efficient permit conditions through modifications or waivers of certain regulatory requirements).</p>
<p>PENNSYLVANIA Department of Environmental Protection www.dep.state.pa.us</p>	<p>Title 25 PA Code Chapter 273, adopted 19 September, 2000.</p> <p>§ 273.191: Post-closure land use plan.</p> <p>§ 273.322: Closure.</p>	<p>Generally per Subtitle D.</p> <p>A permit application shall contain a detailed description of the proposed use following closure of the proposed facility, including a discussion of the utility and capacity of the revegetated land to support a variety of alternative uses, and the relationship of the use to existing land use policies and plans. The description shall explain the following: (1) how the proposed post-closure land use is to be achieved and the necessary support activities which may be needed to achieve the proposed land use; and (2) the consideration which has been given to making the proposed post-closure land use consistent with landowner plans and applicable State and local land use plans and programs.</p>
<p>RHODE ISLAND Department of Environmental Management Office of Waste Management www.state.ri.us/dem</p>	<p>Solid Waste Regulation No. 2.</p>	<p>Post-Closure plan must address requirements for a minimum of thirty years.</p> <p>Leachate treatment or disposal must be addressed for a minimum of 30 years or for as long as leachate is capable of adversely impacting the environment.</p>

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
SOUTH CAROLINA Department of Health and Environmental Control Bureau of Land and Waste Management www.scdhec.net/lwm	Reg. 61-107.258. Applicability: All MSW landfills.	Per Subtitle D.
SOUTH DAKOTA Department of Environmental and Natural Resources www.state.sd.us/denr/denr.html	Chapter 74:27:15.	The owner or operator shall provide post-closure care for 30 years. The board or secretary may grant variances to the provisions of this chapter case by case. Demonstrations for variances for MSWLFs must meet the requirements of 40 CFR. Part 258, as published on 56 Fed. Reg. 50,978 to 51,119, inclusive (October 9, 1991).
TENNESSEE Department of Environment and Conservation www.state.tn.us/environment	Chapter 1200-1-7.	For Class I and Class II disposal facilities, post-closure care must continue for 30 years after the date of final completion of closure of the disposal facility or parcel unless a shorter period is established in the approved closure/post-closure care plan. The post-closure care period may be reduced or extended based on cause by amendment of the approved closure/post-closure care plan as provided in rule 1200-1-7-.03(2)(e).
TEXAS Commission on Environmental Quality www.tceq.state.tx.us	Texas Administrative Code Title 30, Part 1, Chapter 330, Subchapter J.	The executive director may allow the owner or operator to stop managing leachate if the owner or operator demonstrates to the approval of the executive director that leachate no longer poses a threat to human health and the environment. Length of post-closure care period per Subtitle D.
UTAH Department of Environmental Quality www.deq.state.ut.us	Solid Waste Guidance Document Activities on Closed Landfills. Applies to landfills that are regulated under Utah Administrative Code (UAC) R315-302-3 and Utah Solid Waste Permitting and Management Rules (Rules). Applicability: MSW landfills closed after July 15, 1993.	Per Subtitle D.

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
VERMONT Agency of Natural Resources Waste Management Division 802-241-3444 www.anr.state.vt.us	State of Vermont Agency of Natural Resources Department of Environmental Conservation Waste Management Division Solid Waste Management Program 10 V.S.A. §6605. Solid Waste Management Rules: Procedure Addressing Post-Closure Care and Post-Closure Certification at Solid Waste Landfills (effective 8 February, 1999).	Generally per Subtitle D, for non-MSWLFs, and MSWLFs which closed prior to October 9, 1993, the closure plan shall contain specifications and estimated costs for 20 years of post-closure care. Post-closure care at a landfill is considered an “operation”, and therefore a facility must be certified, in five years intervals, through the post-closure period. A permittee may make a written request for post-closure care to be terminated at the conclusion of the current certification period. The request must be accompanied by satisfactory demonstration that: (a) the post-closure care requirements contained in the post-closure plan have been completed; and (b) continued post-closure care is unnecessary to protect human health and the environment.
VIRGINIA Department of Environmental Quality www.deq.state.va.us	9 VAC 20-80-250 Effective 23 May, 2001	Per Subtitle D.
WASHINGTON Department of Ecology www.ecy.wa.gov	Ch. 173-351 WAC.	Per Subtitle D.
WEST VIRGINIA Division of Environmental Protection www.dep.state.wv.us	33-01.	Per Subtitle D.
WISCONSIN Department of Natural Resources www.dnr.state.wi.us	Solid Waste Rules (Chapters NR 500 to 520, Wisconsin Administrative Code), established 1988, revised 1996. A Study of the Future of Solid Waste Management: A Report to the Wisconsin Legislature.	Generally per Subtitle D. Regulations State that current post-closure requirements are 40 years of post-closure care and that an evaluation should be conducted to assess the need to increase the 40-year period for new MSW landfills and lateral expansions.

State and Department State Contact	Applicable Regulations/Guidance Site Applicability	Comments
<p>WYOMING Department of Environmental Quality Solid and Hazardous Waste Division deq.state.wy.us</p>	<p>Solid Waste Guideline #16: Landfill Closure and Post-Closure Process.</p> <p>Applicability: All sanitary landfills.</p> <p>Solid Waste Management Rules Chapter 2 - Sanitary Landfill Regulations.</p> <p>Applicability: All MSW Landfills.</p>	<p>Owners can petition the SHWD to terminate the post-closure period earlier if they can demonstrate that the landfill has been stabilized. In all cases, the minimum post-closure period for these facilities is automatically extended until such time that the SHWD approves a petition to terminate the post-closure period. This petition must be accompanied by relevant information and demonstrate that the facility has been stabilized in a manner protective of human health and the environment. Also includes minimum documentation requirements and performance criteria for petition to terminate the post-closure period. Termination of the post-closure period does not release landfill owners and/or operators from future liability related to the site.</p>

Table D2. Common Non-Subtitle D Regulations Applicable to MSW Landfills During the PCC Period

from *Performance-Based System for Post-Closure Care at MSW Landfills*, Environmental Research and Education Foundation, 2006

Statute/Regulation	Applicability
<p>40 CFR Part 60, Standards of Performance for New Stationary Sources Subpart WWW, New Source Performance Standards (NSPS) Subpart CC, Emissions Guidelines (EG) for MSW landfills Subpart GG, Standards for Performance for Stationary Gas Turbines</p> <p>40 CFR Part 62, Subpart GGG, Federal Plan for the EG 40 CFR Part 63, Subpart AAAA, Draft Maximum Achievable Control Technology (MACT)</p> <p>National Emissions Standards for Hazardous Air Pollutants (NESHAPS) 40 CFR Part 51.165, Review of New Sources and Modifications 40 CFR Part 52.21, Prevention of Significant Deterioration</p>	<p>These regulations may apply to the gas module.</p> <p>NSPS requires that best available technologies (BAT) are used to control emissions from specific sources, including MSW landfills. Guidelines for EG rules are to be developed by State or Local agencies. Subpart GG only applies at sites with LFGTE.</p> <p>40 CFR Part 62, Subpart GGG applies in jurisdictions that did not get their EG rules done in time or for Federal lands. 40 CFR Part 63, Subpart AAAA establishes MACT standards for MSW landfills.</p> <p>NESHAPS includes MACT regulations affecting landfills. Permitting regulations relating to air quality (installation of BACT, ambient monitoring, and air dispersion monitoring) that can apply to MSW landfills.</p>
<p>40 CFR Part 403, General Pretreatment Regulations for Existing and New Sources of Pollution</p> <p>40 CFR Part 122, National Pollutant Discharge Elimination System (NPDES) (40 CFR Parts 123, 124, and 125 are related)</p> <p>Sector L: Landfills and Land Application Sites, Multi-Sector General Storm Water Permit for Industrial Activities (Federal Register Volume 65 No. 210, October 30 2000, page 54746)</p> <p>40 CFR Part 122.26(g), No Exposure Exclusion</p>	<p>These regulations may apply to the leachate, groundwater and/or cap module(s).</p> <p>Specify requirements for pre-treatment prior to discharges to publicly owned treatment works (POTW). This requirement may be applicable if leachate is treated by a POTW, or if groundwater is discharged to a POTW (e.g., during corrective action).</p> <p>These requirements may be applicable to off-site leachate discharges or if an on-site leachate treatment system exists. These requirements are typically related to stormwater discharges to surface water, which relates to the cap module.</p> <p>Provides stormwater control requirements and monitoring and sampling requirements for stormwater under permit conditions (and mechanisms for waiver of requirements).</p> <p>If a condition of no exposure exists at a landfill regulated under the NPDES Stormwater Program, then permits are not required for stormwater discharges</p>

<p>40 CFR Part 122.26 (b) (16) Stormwater Phase II – Stormwater Discharges Associated with Small Construction Activity - Construction General Permit</p> <p>40 CFR Part 445, Landfill Point Source Category: Subpart B, RCRA Subtitle D Non-Hazardous Waste Landfills</p> <p>40 CFR Part 141, National Primary Drinking Water Regulations 40 CFR Part 143, National Secondary Drinking Water Regulations (40 CFR Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants, is related)</p> <p>Safe Drinking Water Act Section 1453 – Source Water Protection Program</p>	<p>if a certification is submitted to the permitting authority (EPA or State agency with authority).</p> <p>Requires permits for land disturbance of equal to or greater than one acre</p> <p>The regulations establish maximum daily and monthly average effluent limitations attainable by the application of best practicable control technology currently available (BPT) or best conventional pollutant control technology (BCT) for MSW landfill point sources. These standards apply to surface water discharges.</p> <p>Part 141 establishes maximum contaminant levels (MCLs) for drinking water. Part 143 establishes secondary drinking water standards (SDWS). These regulations thus establish contaminant specific concentration limits in water and are often used as criteria for evaluating groundwater.</p> <p>Requires States to develop programs to assess land use impacts to public water supplies and to implement management measures to protect drinking water quality.</p>
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Table D-3. EPA and Other Relevant Guidance Documents Potentially Applicable to Post-Closure Care at Subtitle D Landfills
 from *Performance-Based System for Post-Closure Care at MSW Landfills*, Environmental Research and Education Foundation, 2006

Document	Applicability
<p><i>Landfill Gas Emission Model: User's Manual</i> (Ver. 2.0) U.S. EPA Control Technology Center (EPA, February 1998)</p>	<p>Provides guidance for use of the Landfill Gas Emissions Model (LanGEM) that is used to calculate emission rates for methane, carbon dioxide, and hazardous air pollutants from MSW Landfills.</p>
<p><i>Methods for Evaluating the Attainment of Cleanup Standards, Vol. 2: Groundwater</i> U.S. EPA Office of Policy, Planning, and Evaluation (EPA, July 1992)</p>	<p>Describes methodologies to evaluate groundwater remedies, although some of the methods described may be applicable to demonstrate continued protection of groundwater quality will occur at a MSW landfill.</p>
<p><i>Handbook of Groundwater Protection and Cleanup Policies for RCRA Corrective Action</i> U.S. EPA Office of Solid Waste and Emergency Response (EPA, September 2002)</p>	<p>Guidance for understanding EPA policies on protecting and cleaning up groundwater at RCRA facilities. Although this document is intended for application at Subtitle C (i.e., hazardous waste facilities), many policies and procedures can be applied to groundwater issues at Subtitle D facilities.</p>
<p><i>Economic Analysis of Final Effluent Limitations: Guidelines and Standards for the Landfills Point Source Category</i> (EPA, November 1999)</p>	<p>Assesses the economic impact of the final effluent limitation guidelines and standards for the landfills industry point source category. The two major sources of information for this analysis were 1) data on industry baseline financial and operating conditions, and 2) projected costs of complying with the rule.</p>
<p><i>Environmental Assessment for Final Effluent Limitations and Discharge: Guidelines and Standards for the Landfills Point Source Category</i> (EPA, January 2000)</p>	<p>This environmental assessment quantifies the water quality-related benefits associated with achievement of the Best Available Technology (BAT) limitations promulgated by EPA to regulate nonhazardous landfills. Using site-specific analyses of current conditions and changes in discharges associated with the regulation, the EPA estimated instream pollutant concentrations for 26 priority and non-conventional pollutants from direct discharges using stream dilution modeling.</p>
<p><i>Planning and Implementing RCRA/CERCLA Closure and Post-Closure Care When Wastes Remain on Site</i> U.S. Department of Energy (DOE, October 1999)</p>	<p>Describes procedures used to develop closure and post-closure care requirements at DOE facilities. States that the crucial aspect of devising an effective monitoring approach is identifying when monitoring and maintenance activities need to be changed or can be reduced. Decision rules are a tool for defining criteria or boundaries for decreasing monitoring requirements. The post-closure core team will determine when monitoring and maintenance activities can be reduced.</p>

Document	Applicability
<p><i>Risk Assessment Guidance for Superfund (RAGS)</i> U.S. EPA Office of Emergency and Remedial Response (EPA, 1989)</p>	<p>These manuals were developed for use in the remedial investigation/feasibility study (RI/FS) process at Superfund sites, although the analytical framework and specific methods described in the manuals may also be applicable to other assessments of hazardous wastes and hazardous materials. These manuals are companion documents to EPA's <i>Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA</i> (October 1988), and users should be familiar with that guidance.</p>
<p><i>RBCA Fate and Transport Models: Compendium and Selection Guidance</i> ASTM (ASTM, 1999)</p>	<p>This guidance document catalogs and describes non-proprietary fate and transport models that are readily available and in common use for risk-based corrective action (RBCA) at the time of publication. It is meant to function as a compendium and resource guide, assisting the user in the model selection process.</p>
<p><i>Close Out Procedures for National Priorities List Sites</i> U.S. EPA Office of Solid Waste and Emergency Response (EPA, January 2000)</p>	<p>The purpose of the guidance is to briefly summarize key elements of the various close out options for actions at sites.</p>
<p><i>Introduction To AP-42, Vol. 1, 5th Ed., Chapter 2, "Solid Waste Disposal," Section 4, "Municipal Solid Waste Landfills"</i> U.S. EPA Office of Air Quality Planning and Standards (EPA, November 1998)</p>	<p>Provides guidance for estimating air emissions from Solid Waste Disposal facilities including MSW landfills.</p>
<p><i>A National Roadmap for Vadose Zone Science and Technology: Understanding, Monitoring, and Predicting Contaminant Fate and Transport in the Unsaturated Zone, Addendum #1, "Documentation of Stakeholder Involvement"</i> Idaho National Engineering and Environmental Laboratory (DOE, August 2001)</p>	<p>This roadmap is a means of achieving a reasonable scientific understanding of how contaminants of all forms move in the vadose zone. This understanding is needed to reduce the present uncertainties in predicting contaminant movement, which in turn will reduce the uncertainties in remediation decisions. The technical content of the roadmap is captured in 61 activities. Each activity represents an area for which critical research objectives and application requirements can be clearly stated.</p>
<p>"RCRA, Superfund, and EPCRA Call Center Training Module: Introduction to Closure/Post-Closure," 40 CFR Parts 264/265, Subpart G (EPA, October 2001)</p>	<p>This document is used to train call center workers in making sure they know the difference between closure and post-closure and how to apply the appropriate regulations when assisting call center callers.</p>
<p>"RCRA, Superfund, and EPCRA Call Center Training Module: Introduction to Groundwater Monitoring," 40 CFR Parts 264/265, Subpart F (EPA, October 2001)</p>	<p>This document is used to train call center workers in making sure they understand the standards and specific requirements for groundwater monitoring programs at interim status and permitted facilities.</p>

Document	Applicability
<p>“RCRA, Superfund, and EPCRA Hotline Training Module, Introduction to Other Laws that Interface with RCRA” U.S. EPA Office of Solid Waste and Emergency Response (EPA, October 1999)</p>	<p>Provides a summary of how other Federal environmental laws and regulations apply to RCRA facilities.</p>
<p><i>Decision Tool For Landfill Remediation</i> Air Force Center for Environmental Excellence (USAF, August 1999)</p>	<p>This report traces the overall remedial decision process for landfills through flowcharts, textual descriptions, of the process, and explanatory notes that accompany the flowcharts. In addition, this report identifies both the process requirements and the opportunities for selecting cost-effective alternative solutions based on site-specific factors, regulatory requirements, and current guidance.</p>
<p><i>Landfill Covers for Use at Air Force Installations</i> Air Force Center for Environmental Excellence (USAF, August 1999)</p>	<p>A primary objective of this report is to provide state-of-the-art information and references from the current literature on the governing regulations, selection, design, and construction of landfill covers. This material will help identify more cost-effective approaches and reduce remediation costs.</p>
<p><i>Vegetated Landfill Covers and Phytostabilization: The Potential for Evapotranspiration-Based Remediation at Air Force Bases</i> Air Force Center for Environmental Excellence (Hauser and Gimon, 2001)</p>	<p>This document includes a map of the US showing regions in which the ration of potential evapotranspiration (PET) to precipitation suggests that a alternative capping system would be successful.</p>
<p><i>Assessment and Recommendations for Improving the Performance of Waste Containment Systems</i> (EPA, December 2002)</p>	<p>This broad-based study addressed three categories of issues related to the design, construction, and performance of waste containment systems used at landfills, surface impoundments, and waste piles, and in the remediation of contaminated sites. The categories of issues addressed are geosynthetics, natural soils, and field performance.</p>
<p><i>Guidance for Comparing Background and Chemical Concentrations in Soil for CERCLA Sites</i> (EPA, September 2002)</p>	<p>This document recommends statistical methods for characterizing background concentrations of chemicals in soil and determining statistically significant difference between background samples and site related contamination. It is intended to supplement guidance included in EPA RAGS Vol. 1.</p>
<p><i>Municipal Solid Waste Landfill Strategy</i> (EPA, May 2002)</p>	<p>The EPA’s Office of Solid Waste and Emergency Response (OSWER) has developed this strategy for Municipal Solid Waste Landfills in order to set out the agency’s priorities and initiatives for its municipal solid waste landfill (MSWLF) program over the next five years. The priorities that OSW identifies in this Strategy include landfill studies, regulatory changes to the Federal MSWLF rules, and the development or revision of technical and guidance manuals.</p>

Document	Applicability
U.S. Environmental Protection Agency State RCRA Vision Workgroup, on the draft white paper "Beyond RCRA: Prospects for Waste And Materials Management in the Year 2020" (EPA, January 2002)	This paper is intended to provoke discussion and facilitate a public dialogue to explore possible directions for the mid- to long-term future of the RCRA program. The primary focus of the RCRA Vision Paper is to suggest broad outlines for what the program of the future might look like, and the forces that might shape it unconstrained by the current legal and institutional structure.
<i>Comprehensive Stewardship Plan</i> Fernald Environmental Management Project (DOE, August 2001)	Stewardship is necessary to ensure that all remedial efforts employed continue to be effective and protective of human health and the environment following the completion of site remediation. Developing a plan prior to closure allows for improved management of site closure both before and after site remediation is complete. It also allows for more accurate development of a baseline scope, schedule and cost for
"Standards for Owners and Operators of Hazardous Waste Treatment, Storage, or Disposal Facilities, 40 CFR 264.90-99) (EPA, 2002)	Not applicable to Subtitle D facilities, but outlines requirements for groundwater monitoring programs that may be transferable.
<i>An Analysis of Performance-Based Systems for Encouraging Innovative Environmental Technologies (Case Studies)</i> Interstate Technology and Regulatory Council Policy Work Team (ITRC, December 1997)	This reports presents information on the various mechanisms that are being used by State and Federal agencies in applying performance-based standards to enhance clean up of contaminated sites as well as lowering the cost.
<i>Technology Overview Using Case Studies of Alternative Landfill Technologies and Associated Regulatory Topics</i> Interstate Technology and Regulatory Council Alternative Landfill Technologies Team (ITRC, March 2003)	This document compiles case studies to present an overview of alternative covers being used at MSW and hazardous waste facilities and will be used to support the ITRC ALT Team's forthcoming technical/regulatory guidance document on alternative landfill covers. A key aim of the case studies is to present examples of the flexibility used in the regulatory framework for approving alternative covers. The document includes a section on the development and potential application of the Ending Post-Closure Care Model.
<i>Optimization of Groundwater Monitoring Constituents for Detection Monitoring Programs for RCRA Waste Disposal Facilities</i> ASTM D7045-04 (ASTM, 2004)	Provides a general method for selecting effective constituents for Detection Monitoring programs at RCRA waste disposal facilities taking into consideration physical and chemical characteristics of the source, the hydrogeological setting, and site-specific geochemistry.
<i>Long-Term Stewardship Science and Technology Roadmap</i> (DOE-INEEL, March 2002)	The mission of DOE's Long-Term Stewardship Program is to manage residual risks and reduce future environmental liabilities associated with the government's continuing operations at many DOE sites. Advances in science and technology will be needed to fulfill this stewardship commitment. The Idaho National Engineering and Environmental Laboratory (INEEL) has been directed by DOE to facilitate a national road-mapping process that will provide the scientific consensus for future research investments in the area of long-term stewardship.

Document	Applicability
<p><i>Groundwater Technical Enforcement Guidance Document (TEGD)</i> OSWER-9950.1 (EPA, 1986)</p>	<p>The TEGD was distributed by the Office of Waste Programs (OWPE) and specifically addresses RCRA groundwater monitoring.</p>
<p><i>RCRA Ground-Water Monitoring: Draft Technical Guidance</i> (EPA, November 1992)</p>	<p>This manual has been developed by the Agency to update and supplement information contained in the <i>TEGD</i>.</p>
<p>“Ready for Reuse” Corrective Action (CA) Measure and Certification,” RCRAinfo database code CA800 (EPA Region 6, September 2002)</p>	<p>Ready for reuse is a new measure of remedial progress in the corrective action process. It is intended to be a cross-programmatic benchmark for cleanup programs and is a technical determination that recognizes when a property has been characterized and remediated to the extent that its condition is protective for redevelopment or revitalization based on current or planned reuse. First certificate was issued on 2 July 2002 at the Sheffield Steel Corp. facility in Sand Springs, OK.</p>
<p><i>Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soil</i> (EPA, November 2002)</p>	<p>Makes the following changes to the EPA’s CA program under RCRA: (i) environmental indicators (EIs) reflect current as opposed to future or potential conditions, so agencies do not need to consider future land uses in determining whether a site meets EIs for vapor intrusion; and (ii) the risk level set by the agency for carcinogenic exposures is different than the default risk level used in other contexts.</p>

Appendix E

Logic and a Corresponding General Methodology for Statistical Comparisons in PCC Monitoring Programs

LOGIC AND A CORRESPONDING GENERAL METHODOLOGY FOR STATISTICAL COMPARISONS IN PCC MONITORING PROGRAMS

1.0 INTRODUCTION

The MSW industry, as the term is used in the appendix, has become increasingly dependent on statistics to provide an objective basis when making decisions regarding remedial/enforcement actions or determining potential threat to human health and the environment. Many statistically based decisions are associated with groundwater-related environmental issues, largely because there is a significant database of literature associated with groundwater environmental statistics (Gilbert 1987; Gibbons and Coleman 2001; Davis and McNichols 1987; Gibbons 1987a, 1987b, 1994, and 1996; Davis 1994; EPA 1988 and 1992; ASTM D6312-98; ASTM D7048-04). There are two primary advantages of performing statistically based evaluations on environmental data. First, it offers a degree of standardization to the decision process for both the regulator and regulated communities. Second, it makes decisions associated with environmental data more defensible in dispute resolution. For example, exceeding an environmental standard in one of five samples is a very different problem than exceeding an environmental standard in one out of 500 samples.

The approaches described in this appendix are important for two primary reasons:

- Decisions should be based on comparison of the standard to the true concentration (based on a series of analytical results), not simply to a single measured concentration. Of course, without infinite sampling the true concentration can never really be known; however, statistical analysis provides a means of estimating the true concentration distribution from a series of measured concentrations.
- Second, because all environmental data queries are treated as being equal, exceeding an environmental standard in one of five samples is a very different issue from exceeding an environmental standard in one out of 500 samples.

As statistical methods have become incorporated into state and federal regulation and guidance (e.g., EPA 1988 and 1992; ASTM D6312-98), the need for improved statistical approaches to related problems of long-term PCC monitoring has grown. Unfortunately, far less statistical work has been done in this area, and corresponding environmental impact decisions are often still based on the comparison of individual measurements to fixed standards or, at best, simple normal confidence bounds, and the decision to continue monitoring a closed facility is based on a single measured concentration exceeding an environmental standard. In addition, recent literature has shown that the chemical characteristics of MSWs are ultimately predictable over time, especially after capping of a landfill. Therefore, an important element of this appendix is the statistically based evaluation methodologies for MSW leachate. The objective of this discussion is to provide defensible statistical applications for both source (i.e., leachate) and groundwater data to provide a defensible tool in optimizing the management of, or determining when to end, the primary elements (i.e., modules) monitored during PCC.

Finally, it should be noted that, in general, prediction intervals are most useful for comparison of new measurements to background. This distinction is important as it underlies why prediction limits have received considerably less attention in long-term site assessments and corrective

action monitoring, where interest is more focused on assessing long-term trends and comparisons to regulatory standards (see Gibbons and Coleman 2001 and long-term monitoring optimization methods, such as the MAROS system [Aziz et al. 2004]). Recently, Bhaumik and Gibbons (2006b) derived simultaneous prediction limits based on the gamma distribution that can be easily adapted to the problem of nonnormally distributed monitoring constituents with a wide variety of detection frequencies. Given the parametric form of these prediction limits, they can be used regardless of the background samples size and even when the majority of the data are not detected (and at various reporting limits). Accordingly, the use of gamma prediction limits may have future application consistent with the objectives of evaluating the modules monitored during PCC.

1.1 Purpose

This appendix describes the statistical theory that underlies the monitoring of the post-closure process and presents a reasonable, technically sound approach to evaluating data collected at landfill sites for the purpose of predicting long-term environmental behavior. The goal is an approach that can be applied readily and that accommodates the variability that is common in landfill and surrounding environmental media monitoring data. This appendix addresses how analytical measurements can be used in evaluating the PCC monitoring program, including the determination of trend, comparisons to average and extreme values of the distribution to regulatory standards, minimum number of data points, frequency of collection, etc. In addition, there is a discussion regarding the handling of censored data (i.e., data reported below the laboratory limit of quantification), testing distributional assumptions, and testing for outliers to ensure that the probability of detecting a real exceedence is large, while the probability of falsely concluding that there is an impact is small. Since many of the statistical methods recommended in this document relate to determination of trends and calculations of appropriate statistical maximum concentrations in source liquids (e.g., leachate), some of the methods recommended herein are fairly new in terms of application.

This appendix addresses statistical methods that implement EPA's approach to detecting a release at an MSW landfill and statistical methods for evaluating post-closure improvements in leachate quality at a landfill.

As the science of environmental statistics progresses over the coming years, other methods may be applicable that are not discussed herein. For example, methods for analyzing censored data (i.e., data sets with nondetect and/or trace-value measurements) are currently being developed for a wide range of statistical procedures, such as trend analysis, estimation of the mean and standard deviation, and development of confidence limits (Helsel 2005). Also, computer-intensive methods such as bootstrapping and Monte Carlo analyses may play an increasingly important role in environmental statistics. As stated previously, it is the intent of this document to present an approach that can be readily applied, while minimizing statistical errors that could lead to incorrect decision making. Data analysis methods that are not presented in this document may be appropriate in some instances and should be addressed on a case-by-case basis.

1.2 Organization

An overview of the general statistical approaches is provided in nontechnical terms that are applicable to either leachate or groundwater. Following the general overview, a description of

specific methods and procedures that lead up to the hypothesis-testing phase of analysis is provided. These methods include the treatment of censored data (i.e., data reported below the laboratory limit of quantification, the quantitation limit [QL] or practical quantitation limit [PQL]), the testing of distributional form, and the determination of outliers. These three steps are integral to any statistically rigorous analysis of environmental data. In each case, the recommended specific approach is presented, and key technical papers and guidance are provided in the references so the reader can review more detail on a specific approach or procedure, as necessary.

Hypothesis testing is presented with a discussion of statistical methods for trend testing (e.g., determining whether concentrations are increasing or decreasing over time). The use of nonparametric methods for evaluating source data like leachate is stressed throughout due to problems associated with nondetected and/or nonquantifiable measurements and the frequent case of nonnormally distributed (i.e., non-bell-shaped curve) data. As part of the discussion, new results on determining sample sizes for trend analyses are presented. These computations allow the user to select both the number and frequency of sampling necessary to detect a trend of a given magnitude, with power of 80 percent or more (i.e., false negative rate of 20 percent or less). The 80 percent power recommendation originates in the EPA Interim Statistical Guidance (EPA 1992) for development of detection monitoring programs in groundwater for multiparameter monitoring programs. In selecting the appropriate number of measurements required to achieve the referenced statistical power, it is important to recognize that each sample must be independent from every other sample (e.g., replicate source samples like leachate collected on the same day do not satisfy the requirements of independence).

Following the determination of trend, attention is turned to the challenge of testing the hypothesis that source concentrations of a constituent (or DAF-adjusted source concentrations) exceed a regulatory standard, groundwater background concentrations, or both. This evaluation is recommended to include the development of normal, lognormal, and nonparametric confidence intervals for the mean of the distribution (i.e., average exposure concentration) and for calculated maximum exposure concentrations.

Alternatively, when the groundwater background concentrations of a constituent (e.g., concentrations in unimpacted upgradient and downgradient wells) already exceed a regulatory standard, the problem of comparing the mean of the source concentration distribution or a series of individual measurements to background is discussed. This evaluation is recommended to include the development of normal, lognormal, and non-parametric prediction limits for a future mean concentration (i.e., source concentration or dilution attenuation factor [DAF]-adjusted source concentration) or for a series of future individual measurements.

Following the discussion of determining confidence and prediction intervals for a single media and constituent, the discussion is extended to the case of determining confidence and prediction intervals for a linear regression model. This approach is useful when the data exhibit a statistically significant downward trend and it is necessary to determine the confidence interval or prediction interval for current concentrations or for future concentrations, assuming a similar rate of change in the mean of the concentration distribution over time (i.e., using trend-adjusted means).

The previous discussion of sample size determination for trend testing of the source is extended to the case of determining the required sample size necessary for developing confidence intervals and prediction intervals. Again, much of this work is new to the literature and is essential to the development of a statistically rigorous PCC program that jointly minimizes both false positive and false negative rates at nominal levels.

2.0 TECHNICAL FOUNDATION

Leachate. Biodegradation of MSW in landfills has traditionally been considered to occur in five, more or less, sequential and predictable phases in which the chemical and biological processes occur as described by Farquhar and Rovers (1973), Ehrig (1984), Pohland and Harper (1986); Kjeldsen et al. 1989), and others. By the time a lined landfill (or phases of a lined landfill) close, existing data support the conclusion that leachate quality is either beginning to improve or has been improving for a period of time. Therefore, the overall leachate chemistry for a lined landfill that has closed (or for different phases of a lined landfill) would be represented somewhere on the down-trending portion of the curve illustrated in Figure E-1. In other words, the maximum concentrations that would be generated by the waste mass have already occurred. This conclusion is based on either the landfill cover performing as designed to minimize infiltration through the cover (presently and in the future) or liquid recirculation (bioreactor technology) effectively reducing leachate concentrations through enhanced biodegradation during operation of the landfill. The ability to confirm these conclusions through a rigorous analysis of the source chemistry (i.e., leachate) is described below.

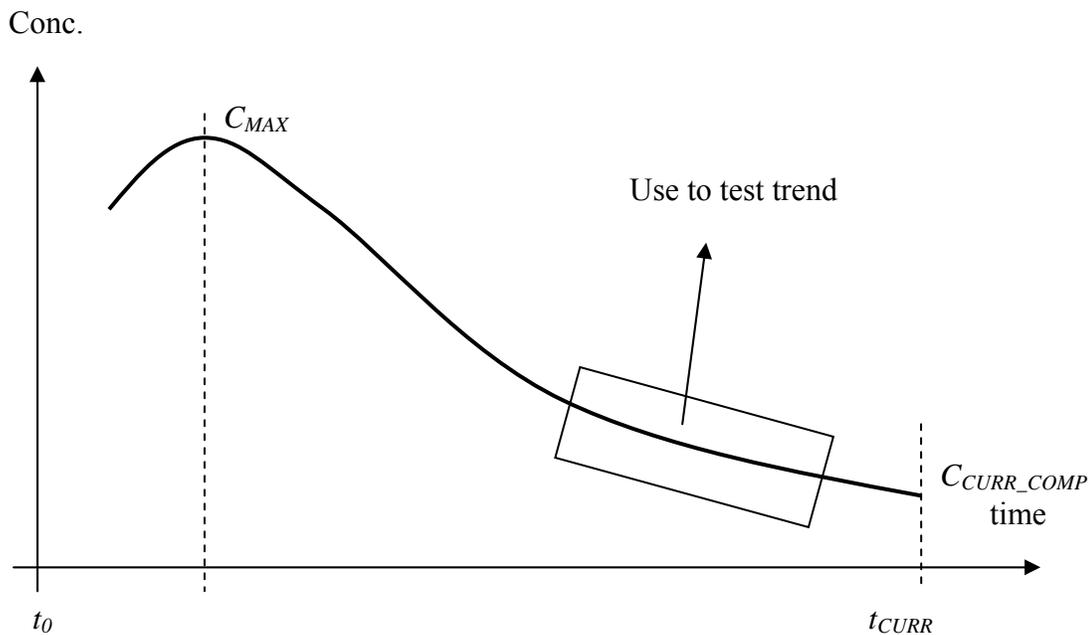


Figure E-1. Leachate condition and terms used.

Terms shown on Figure E-1:

- C_{CURR_COMP} is the current concentration of a parameter calculated from composite data.
- t_{CURR} is the current time (i.e., time of evaluation), measured from t_0 .

- t_0 is the start of landfill operations.
- C_{MAX} is the maximum concentration of a parameter calculated from composite or sump-specific data or obtained from a look-up table of literature maximum values.
- In addition (not shown on the figure), C_{CURR_SUMP} is the current concentration of a parameter calculated from sump-specific data.

The distribution shown on Figure E-1 is intended to correspond to the general Pohland Curve that represents a predicted change in biochemical oxygen demand over time in a landfill that undergoes decomposition following the phases previously discussed. The computation of the maximum leachate concentration (C_{MAX}) for a regulated parameter (RP) for a composite or sump-specific data series is presented. The computed leachate C_{MAX} concentration may also be compared to relevant performance-based groundwater standards or background groundwater quality. Each of these statistically computed values can be used in a performance-based evaluation of threat to HH&E at a relevant POC or POE.

Groundwater. A discussion of using combined Shewhart-CUSUM control charts and prediction limits is also provided for nonsource evaluations (i.e., groundwater) since this statistical approach is appropriate when comparing future groundwater measurements to groundwater background or to confirm that groundwater conditions are improving (or not getting worse) when modification to a landfill system is made that may affect groundwater quality (e.g., LFG collection). The combined Shewhart-CUSUM control chart is the method that will be used to identify statistically significant changes in the concentrations of RPs at each groundwater monitoring location. See Gibbons 1999a and 1999b for a complete review.

2.1 Data Preparation

2.1.1 Censoring

One of the most difficult problems in the analysis of environmental monitoring data involves the incorporation of nondetects into estimates of summary statistics (e.g., mean and standard deviation) and corresponding tests of hypotheses and interval estimates. More often than not, environmental monitoring data consist of a mixture of results that can and cannot be accurately quantified. There are some differences of opinion regarding the appropriate method or methods for incorporating the censored data in computing summary statistics, testing hypotheses, and computing interval estimates.

The statistical methods described herein have application for determination of leachate source summary statistics (e.g., mean and standard deviation) as well as that of data collected from a groundwater matrix.

Leachate Data. In the case of source evaluation, the concern related to the use of censored data (e.g., data reported below the limit of quantitation, QL or PQL) may be significantly influenced by matrix interferences since MSW leachate may have elevated total dissolved solids and relatively high ionic strength, which can significantly increase the reported PQL or detection limit (e.g., method detection limit [MDL]). Many parameters that have elevated health-based standards can be present in leachate at levels at or above the detection and quantitation limits and still be protective of HH&E. In these instances, parameters can be addressed relatively easily statistically. The real challenge is to provide a meaningful and defensible statistical evaluation

for those parameters that have very low health-based standards (e.g., where the MCL is less than the PQL or MDL) since a mechanism to demonstrate protection of HH&E at these low levels is somewhat more complex. The following approach is recommended:

- a. Report leachate data to the MDL (or other laboratory-derived detection limit) instead of the PQL and report “J” values (i.e., estimated concentrations between the detection limit and the PQL). Any nondetect (ND) result means that the relevant parameter was not detected below the detection limit (e.g., MDL). Any ND result means that the parameter is not expected to be present in leachate. Consideration to potential concentration “masking” due to dilutions should be considered (see “b”).
- b. For any result that is reported as ND from a diluted sample, impute the detection limit (e.g., MDL) for statistical calculations (i.e., use the reported MDL or detection limit concentration in the statistical computation). This approach is reasonable and conservative because it is assumed that the parameter is present in the leachate at the detection limit concentration until the result is ND for an undiluted sample (see “c”).
- c. For any result that is reported as ND from a sample that is undiluted, the ND should be treated as zero for statistical calculations. This approach is reasonable because an analytical result below the detection limit means there can be no judgment regarding the presence of the parameter in the sample (when the sample is undiluted). Given this uncertainty, analytical results below the detection limit may be treated as zero, which is consistent with programs where an ND below the detection limit is substituted with zero for statistical calculation (e.g., Washington State Department of Ecology, *Water Quality Program Permit Writers Manual*, July 2004). Furthermore, the calculation of statistical intervals when NDs are present is adjusted by Aitchinson’s method (1955). This approach is practical especially where a relevant parameter is infrequently detected, even if it cannot be directly verified. Aitchinson’s method places the probability mass of the distribution corresponding to NDs at zero, which is consistent with the nonstatistical approach of imputing zero for NDs.
- d. Any “J” value result (from a diluted or undiluted sample) should be used as if it is an actual quantified detection for statistical calculations. This approach is conservative because censored data are treated as actual detections since it is assumed a parameter is present in leachate until the result is ND for an undiluted sample.

Groundwater Data. Independent of the statistical method used by the facility, it is recommended that laboratories report the data down to the MDL, including any estimated data. The lab should report all PQLs and MDLs. It is often recommended that NDs be replaced with the value of their respective QL or PQL. For groundwater monitoring data, replacing ND data with the laboratory PQL may be construed to be overly conservative. Therefore, replacing NDs with a numerical value between the PQL and the MDL (such as one-half of the PQL) is recommended and consistent with existing guidance (e.g., EPA 1992). Using another imputed value for NDs may be appropriate based upon site-specific conditions and could be considered. In addition, there may be other methods appropriate for handling data falling between the MDL and PQL.

2.1.2 Screening for Outliers

It is common to find outliers in environmental data. Outliers, those values that do not conform to the pattern established by other observations, can arise from errors in transcription, errors in data coding, analytical instrument failure and calibration errors, or underestimation of inherent spatial or temporal variability of the constituent. Some outliers are true values that are part of another

population (for example, they may represent a release rather than background conditions) or that lie at the extreme end of the distribution. Determining outliers between difference matrices associated with a PCC program may be challenging because some of the testing will include source matrices (e.g., leachate). For example, outliers are more easily determined when there is an expected baseline, such as in groundwater, where anthropogenic compounds are expected to be ND and naturally occurring metals are anticipated to be detected within an expected concentration range. In a matrix that is more highly variable in concentration and magnitude where baseline is more difficult to establish (e.g., leachate), the determination of outliers can be more challenging because concentration variability of the source matrix is possible.

The recommended method for testing for outliers is Dixon's test. However, for source matrices (e.g., leachate), Dixon's test may need to be applied only if a visual inspection of the data indicates anomalous results either high or low. Plots of log-transformed data can hide outliers, so visual identification of an outlier as a prerequisite to outlier analysis may not be protective. In other words, the outlier analysis for a source matrix primarily involves verification that proper analytical laboratory quality assurance/quality control was followed for the analytical method and that reported data are within specified limits of precision and accuracy.

2.1.3 Testing for Distributional Form

An assumption of many of the statistical methods used in environmental monitoring is that the measurements are continuous and normally distributed or can be suitably transformed to approximate a normal distribution. There are several approaches to testing this assumption, varying from graphical methods such as normal probability plots to hypothesis testing. The recommended method for testing for normality is the single-group or multiple-group versions of the Shapiro-Wilk test.

2.1.4 Trend Analysis

Prior to comparison to groundwater background or regulatory standards, tests for decreasing trends in selected leachate decision parameters should be performed. The recommended test for trend is Sen's test, which provides both an estimate of the rate of change and a test of the null hypothesis of no trend (see EREF 2006, Attachment D, and Gibbons and Coleman 2001, Chapter 16). Alternatively, the usual Mann-Kendall approach of verifying significance of the slope can be used.

2.2 Clarification of PQLs, MDLs, and RLs

There is often confusion regarding the meaning and appropriate application of the terms "practical quantitation limit," "method detection limit," and sometimes "reporting limit" (RL). It is common that data results be summarized as not detected or that results be summarized by the laboratory as ND. It is common to assume that data reported as ND are not detected above the detection limit (e.g., MDL). However, many times data are routinely reported ND at the MDL (or other detection limit), PQL, or RL depending on permit requirements or other factors. Therefore, a clear understanding of the terms MDL and PQL is important so that the appropriate analytical data are used in the statistical application.

The sections below provide a general overview and clarification of the terms MDL and PQL but do not cover all the intricacies of how they are generated. It is suggested that any additional clarification be provided by the analytical laboratory being used to ensure proper generation and application of the data being supplied.

2.2.1 Practical Quantitation Limits

A reasonable definition of the what constitutes a PQL is provided in Subtitle D Rule [40 CFR §258.53(h)(5)]:

Any practical quantitation limit (PQL) used in subsequent statistical analysis shall be the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions that are available to the facility.

In using this reference to the use of PQLs in a Subtitle D application, EPA was not placing emphasis on the “lowest concentration” but rather was qualifying with terms that stress values that provide interlaboratory consistency for data reliability and usability. In its 1989 proposed rules on Primary Drinking Water Standards, EPA explained that MDLs are the lowest (although not necessarily reliable) concentrations attainable by a laboratory under ideal conditions, while PQLs on the other hand are intended to be more attainable through routine, interlaboratory conditions.

Furthermore, subsequent to its promulgation of Subtitle C groundwater monitoring regulations in 1987 but prior to its promulgation of the Subtitle D groundwater monitoring regulations in 1991, EPA provided further insight into its position on PQLs in its 1989 proposed Clean Water Act—Maximum Contaminant Level Goal Regulations. In the preamble to these regulations, EPA emphasized the value of PQLs vis-à-vis MDLs and the limit of quantitation. There, EPA stated that while MDLs are specific to a single laboratory under ideal conditions, the basis for setting PQLs is (a) quantitation, (b) precision and accuracy, (c) normal operations of a laboratory, and (d) the fundamental need (in the compliance monitoring program) to have a sufficient number of laboratories available to conduct the analysis. This same analysis holds true to groundwater monitoring pursuant to the Subtitle C and D regulations. A suggested reference on this topic is Gibbons and Coleman 2001.

A significant concern is the potential regulatory agency view that the lowest limit a laboratory is willing to quantitate is an appropriate PQL. This definition is not consistent with EPA’s intent as discussed above. Another concern is establishing a prescriptive definition that a PQL is simply a multiplier of the MDL without understanding its limitations. This definition is complicated by the fact that certain important variables are not considered during derivation of an MDL based on existing protocol. Since existing protocol ignores many of the variables affecting the quantitation limit, agencies specifying the need for these prescriptive values are using them without full knowledge of their limitations.

2.2.2 Method Detection Limits

By definition, the MDL is intended to be the concentration at which there is a 99 percent confidence that a measured concentration is different from zero. If MDL studies as specified in

40 CFR 136B were accurate in all situations and the laboratory never reported below the MDL, the potential of falsely reporting the presence of an analyte would be 1 percent. However, the MDL study design has well-documented limitations:

- The MDL is a statistical approach using a single set of measurements to represent lab performance in virtually all circumstances for a given method. These circumstances are by definition changing over varying time frames and thus have differing degrees of influence on the detection limit at different times.
- Sample matrix effects are not included. MDL studies are normally performed using reagent-grade materials, but chemical and physical interferences can significantly affect actual detection capabilities. For example, false positive results at low concentrations due to matrix effects are fairly common with gas chromatography and high-pressure liquid chromatography methods.
- In the MDL study design, it is assumed that the variance between the MDL and the MDL spike concentration is constant and linear. In situations where this is not true, the calculated MDL concentration will not have the expected statistical confidence.
- The EPA MDL protocol does not require evaluation of MDL spike recoveries. Because of the mathematics involved in the MDL calculation, a method that results in reproducibly lower recoveries for one analyte relative to others will produce a lower MDL. In this instance, it may result in a calculated MDL that may not be detectable from noise in the analytical background.
- There is no allowance for evaluation of laboratory blank data to truth the MDL.
- There is no estimate of uncertainty in measurement at the MDL. In some cases we may be comparing data at or near a laboratory MDL to a numeric standard of some type (regulatory, risk based). With no measure of confidence in the value reported, an evaluation of this type becomes impossible to implement.

The main problem with using a MDL as an RL is the variability that is observed in intralaboratory or interlaboratory studies that follow EPA guidance. The procedure also assumes that the standard deviation will remain constant regardless of the spike concentration, an assumption that is typically without merit because of matrix effects. Consequently, the laboratory MDL does not provide a consistently repeatable and accurate MDL.

In summary, the above elements of detection and quantitation should be carefully considered to ensure the most appropriate statistical limits and estimates are established that allow appropriate regulatory decisions to be made.

3.0 GENERAL STATISTICAL APPROACH

A primary difference between groundwater detection monitoring statistics and leachate source statistics is the basic premise that in groundwater detection monitoring anthropogenic organic compounds, for example, are not expected to be present, whereas the same premise is not necessarily true for leachate. From that perspective it is reasonable that different approaches for how data are censored must be considered. In this appendix, the recommendation to report leachate source data to the MDL rather than the PQL is to make the approach conservative relative to potential threat. For groundwater detection monitoring data, using only data at or above the PQL for environmental decisions is appropriate because the data must be at

quantifiable concentrations prior to evaluating whether or not a potential impact has occurred (ASTM D6325-98 and EPA 1992).

Although elements of groundwater monitoring statistics can apply to various source materials, little focus has been applied specifically to MSW leachate data evaluations. Leachate evaluations typically do not focus on statistically characterizing important source characteristics such as historic maximum concentrations, true current concentrations, parameter trends, and comparison of statistically based maximum and current concentrations to regulatory or calculated health-based standards. The methods described in this appendix provide the foundation for making regulatory decisions based on key statistical evaluations of the source.

In the following, the logic and a corresponding general methodology for statistical comparisons in PCC monitoring programs are described. Specific recommendations are provided which will work well in most cases but may not be optimal in all possible situations. Complete statistical details of all methods are presented in attachments to EREF 2006, which also include a description of alternative methods and general discussion of strengths and limitations of the various alternative approaches.

3.1 Leachate Concentration Evaluations

The following sections describe how to statistically compare composite leachate data (for RPs) with leachate data from individual sumps. This comparison is made to determine whether composite leachate data are representative of the entire WMU such that composite data can be statistically compared to relevant performance-based groundwater standards. Such standards may be (a) federal drinking water MCLs, other applicable federal or state standards, or potentially background groundwater quality for Detection Monitoring Appendix I and II parameters where no specific published standard exists; or (b) an appropriately calculated health-based standard.

3.1.1 Comparison of Composite Leachate with Individual Sump Data

The 95 percent upper prediction limit (UPL) is used when composite leachate data are compared to sump-specific data to confirm that the composite data are representative of a site's sump-specific data. The UPL is used to determine whether composite data are representative of individual sampling locations that went into the composite (e.g., individual leachate sumps). Here, a UPL for the next k measurements is computed, where k is the number of individual monitoring locations being compared to the distribution of the composite samples. If, for example, a leachate sump RP exceeds the composite 95 percent UPL, then it is concluded that the composite data are not representative of the concentrations found at that particular leachate sump for that particular RP.

The composite 95 percent UPL is calculated from the mean of at least the eight most recent data points from the composite sampling location (e.g., tank, discharge line, etc.). For any UPL calculations where the data have a significantly decreasing trend, the composite 95 percent UPL from a linear regression of the data is used to adjust for the effect of the decreasing trend. It is emphasized that the linear regression model is used simply for computing a limit adjusted for trend. It is not used for detecting a trend. Sen's nonparametric test is used to determine trend, and the general linear model is used to adjust the concentrations for trend. In other words, the proposed approach is to get a point estimate of the current concentration mean.

If composite data from a single source are not available, individual sump data using at least the most recent four events from each sump is pooled and a composite 95 percent UPL is calculated for each RP. For any UPL calculation where the data have a significantly decreasing trend, the composite 95 percent UPL from a linear regression of the data is used to adjust for the effect of the decreasing trend. The following general procedure should be followed in determining UPL concentrations for any leachate source data set:

1. If the test of normality cannot be rejected (e.g., at the 99 percent confidence level), background is equal to the 95 percent confidence normal prediction limit.
2. If the test of normality is rejected but the test of lognormality cannot be rejected, background is equal to the 95 percent confidence lognormal prediction limit.
3. If the data are neither normally nor lognormally distributed or the detection frequency is less than 50 percent, compute the nonparametric UPL, which is computed as a particular order statistic (i.e., ranked observation) of the background measurements (e.g., the maximum). Note that if the detection frequency is zero, the UPL is equal to the appropriate QL for that constituent (i.e., median QL within the applicable data set), which is the lowest concentration that can be reliably determined within specified limits of precision and accuracy by the indicated methods under routine laboratory operating conditions.
4. The minimum number of leachate samples required to developing a 95 percent confidence normal or lognormal prediction limit is eight.

3.1.2 Calculation of Maximum and Current Leachate Concentrations

Maximum Concentrations. The statistical maximum concentration of each RP in leachate (C_{MAX}) is calculated as the 95 percent upper confidence limit (UCL) of the mean of the distribution for the entire composite or sump-specific data series available for the RP. At least eight data points are required, there must be a five to ten year separation between the first and last sample included in the calculation, and no more than two post-closure data points may be included in the data series. Samples should be collected semiannually.

The following general procedure should be followed:

1. Compute percentage of results less than the detection limit (i.e., NDs) using minimum of eight data points.
2. Apply Dixon's test for outliers.
3. If outliers are identified, investigate data for errors or other explanation of unexpected result.
4. Remove outliers that represent erroneous data.
5. Apply Sen's test for trend. If a significant trend is identified, then skip to Step 10.
6. If no trend is present and the percentage of NDs is greater than 50, test for normality or log normality using the Shapiro-Wilks W test at the 95 percent confidence level.
7. If the data are normally distributed, use Aitchison's method to adjust for NDs and compute the normal 95 percent UCL of the mean of the distribution.
8. If the data are log normally distributed, then log transform the data and use Aitchison's method to adjust for NDs and compute the lognormal 95 percent UCL of the mean of the distribution.

9. If data are neither normal nor log normal distributed or have a detection frequency of 50 percent or less, replace ND results with the detection limit value (or other imputed value) and then compute the nonparametric 95 percent UCL of the mean of the distribution.
10. If a statistically significant trend is confirmed, then determine the best fit slope for concentration vs. time using least-squares linear regression analysis.
11. Describe the long-term mean at the end of the monitoring period of record based on the linear regression best fit value, and compute the 95 percent UCL of the mean of the distribution for the current estimated value, under the conservative assumption of normality, imputing ND values as specified in earlier sections.
12. Note that if the detection frequency is zero, the 95 percent UCL will be set to the appropriate QL for that constituent (e.g., the median QL within the applicable data set), which is the lowest concentration that can be reliably determined within specified limits of precision and accuracy by the indicated methods under routine laboratory operating conditions.

Current Concentration. A statistical current concentration for each leachate RP ($C_{\text{CURR_COMP}}$ or $C_{\text{CURR_SUMP}}$) is calculated to represent current leachate concentrations for that RP across the entire WMU as the 95 percent UCL for the mean of the four most recent composite or sump specific data points. The general procedure outlined for C_{MAX} above is used. Where these data will have a significantly decreasing trend, the 95 percent UCL from a linear regression of these four data points is used to adjust for the effect of the decreasing trend.

3.1.3 Accounting for Trend

If trend analysis indicates that the concentrations are decreasing significantly over time, then the UCL for a single population will exhibit an upward bias because the current estimated concentration is the lowest measurement in the series and deviations from the trend line will be smaller than deviations from the mean. There are several possible ways to adjust for trends in environmental monitoring data. The most rigorous approach is to compute a UCL for the time-versus-concentration regression line itself. In this way, the UCL becomes a continuous function of time, and point in time comparisons to regulatory standards can be made. Assuming linearity, it is also possible to predict the value of the UCL some time in the future. Note that such extrapolations are based on the strong assumption that the rate of change in the future is identical to the rate of change in the past, which may or may not be the case.

3.1.4 Comparison of Leachate Concentrations to Health-Based Standards

In application of statistical methods for leachate, the user has interest in performing a conservative statistical test to compare either the current RP leachate concentration (composite or sump-specific 95 percent UPL or 95 percent UCL for the mean) or the maximum RP leachate concentration (i.e., 95 percent UCL of the mean) to a health-based standard or background groundwater quality. The health-based standard of an RP can be an MCL or, if an MCL does not exist, a calculated health-based standard or equivalent should be used. If the 95 percent UCL of the mean for a RP is below the standard, the user has 95 percent confidence that the true concentration in leachate is below the regulatory standard and that RP is not a threat to human health and the environment.

It is important to note that in some cases background groundwater concentrations may already exceed the regulatory standard (i.e., the background groundwater 95 percent UPL is greater than

the regulatory or calculated health-based standard). In this case, comparison of leachate quality data (i.e., the mean) should be made to groundwater background (i.e., 95 percent UPL) and not to the regulatory or calculated health-based standard. If the mean for a RP in leachate is below the 95 percent UPL in groundwater background, the user has 95 percent confidence that the true concentration in leachate is below groundwater background and that RP is not a threat to human health and the environment.

Similarly, for each RP for which an appropriate regulatory standard (or equivalent) is not available or not able to be calculated, background is set to an appropriate intrawell or interwell 95 percent UPL (or intrawell combined Shewhart-CUSUM control chart or prediction limit); if the detection frequency is zero, the 95 percent UPL for the RP is equal to the appropriate QL (i.e., the median QL within the applicable data set). In this case, comparison of leachate quality data should be made to groundwater background and not to the regulatory standard. Note that groundwater regulations may be based on comparison to background, and it is therefore important to know the state's policy (i.e., some state regulations are based on nondegradation of groundwater resources).

The following is a summary of when a source RP comparison will be to a regulatory or calculated health-based standard or groundwater background:

- If groundwater background (i.e., the 95 percent UPL) for RP is greater than the regulatory or calculated health-based standard or if no standard can be adequately calculated, then leachate concentration comparisons will be made to groundwater background (i.e., 95 percent UPL). Leachate concentration comparisons would also be made to groundwater background for states that require such comparisons (e.g., nondegradation requirements).
- If groundwater background (i.e., the 95 percent UPL) for RP is less than the regulatory or calculated health-based standard, then leachate concentration comparisons will be made to the regulatory or calculated health-based standard.

3.2 Groundwater Monitoring Statistics

For groundwater statistical comparisons to background, a control-chart method or prediction limit (normal, lognormal, nonparametric, or gamma) is recommended. Specifically, for intrawell groundwater data evaluations, this statistical approach is appropriate when comparing future groundwater measurements to groundwater background (i.e., classic detection monitoring approach) or to confirm that groundwater conditions are improving (or not getting worse) when modification to a landfill system is made that may affect groundwater quality (e.g., LFG collection).

Selection of the appropriate method depends in part on the proportion of background data that are nonquantifiable. For this reason, the first step in developing an intrawell control limit is calculation of the detection frequency for each indicator parameter at each monitoring location. It is important to reemphasize that for groundwater statistical evaluations, ND represents data that were not detected below the PQL (i.e., data are nonquantifiable). Specifically, estimated data (i.e., data that may be reported below the PQL) should not be used in groundwater statistical computations. NDs should be replaced with one-half of the PQL or some other imputed value depending on site-specific conditions.

Detailed guidance regarding the performance of intrawell statistical comparisons is provided by ASTM Standard D6312-98, which is briefly summarized below.

- For the chemical parameters with 100 percent ND results for the initial eight background samples (and subsequent background data sets), the intrawell control limit used is a nonparametric prediction limit. In this case, the nonparametric prediction limit is the median PQL reported with the ND results.
- For chemical parameters detected in fewer than 25 percent of background samples, the nonparametric prediction limit is the appropriate control limit, and the maximum result detected above the PQL is adopted as the prediction limit.
- For indicator parameters that are detected in at least 25 percent of the background measurements at a monitoring location, a control limit is established using the combined Shewhart-CUSUM control chart, imputing the median QL for NDs.

The Shewhart-CUSUM control chart procedure is a widely used intra-well comparison method (Gibbons 1999b) that EPA recommends for identifying a statistically significant increase in chemical concentrations at a single monitoring location (EPA 1992). Gibbons (1999b) describes application of Shewhart-CUSUM control charts when multiple comparisons are made at individual monitoring locations and provides methods for controlling error rates while maintaining the desired power for decision making. A minimum of eight background samples is needed before the Shewhart-CUSUM control chart can be used. As explained in detail by Gibbons (1999b), the set of background samples ($n \geq 8$) provides the mean and standard deviation used to compute a standardized difference value for each subsequent measurement from the same location. The standardized difference values are then compared to the control limits established to achieve the desired error rates and power for the multicomparison statistical procedure applied at each chemical monitoring location.

The objective of any statistical program should be to minimize the sitewide false positive rate while managing the false negative rate in manner that is protective of HH&E (i.e., calculating statistical power, which is one minus the false negative rate) for a variety of statistical methods and verification resampling options. In many cases, this can routinely be achieved through parameter reduction or minor adjustment of the Shewhart control limit (SCL) multiplier and CUSUM limit (h). In the statistical evaluation approach discussed in EPA 1992 (Section 5, “Strategies for Multiple Comparisons”), EPA recommends that a statistical method be selected which has a sitewide false positive rate of 5 percent per event while managing the false negative rate using an EPA-referenced power curve.

A simulation test should be performed before the control chart factors (i.e., h and SCL) and sampling design are established to ensure that the test procedure provides power of at least 50 percent at 3 standard deviation units above background and 80 percent power at 4 standard deviation units over background, and a false positive rate of no more than 10 percent for the effectiveness decision for the monitoring location on an annual basis. These error rates are consistent with EPA recommendations and standard reference power curve (EPA 1992) for groundwater monitoring decisions. Maintenance of such error rates may require passage of one or two verification resamples in the presence of an initial exceedence of a control limit. Simulations to establish appropriate control chart design cannot be completed until the background data have been collected and must include the effects of verification resampling.

Complete details of the methodology are presented in Gibbons 1994 and 1999b and ASTM D6312.

As discussed herein, the challenge in the application of statistical methods to environmental monitoring data is the simultaneous presence of nonnormal distribution of constituent concentrations and the presence of NDs. Recent work extends the literature on simultaneous prediction intervals to the case of the gamma distribution, which can accommodate a wide variety of nonnormal distributions (with skewed right tails) and the presence of NDs (Bhaumik and Gibbons 2006a and 2006b). Gamma prediction limits are excellent candidates for routine application to groundwater monitoring networks at waste disposal facilities and/or other relevant environmental monitoring applications (e.g., leachate or other source characterization) (Aziz et al. 2004). The use of gamma prediction limits may be an excellent alternative to the methods for groundwater monitoring statistics described herein.

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Appendix F

Case Studies

CASE STUDIES

1. EXAMPLES OF PERFORMANCE-BASED APPROACHES IMPLEMENTED TO END POST-CLOSURE CARE

To terminate the PCC requirements for two closed pre-Subtitle D landfill sites in Arkansas, the owner/operator used a performance-based evaluation of the sites to determine whether technical justification existed to extend PCC activities beyond the permit term or ending PCC was protective of HH&E (ADEQ 2004a and 2004b). Although pre-RCRA facilities may not be able to use the methodology described in this report (in part due to a potential lack of data), the closure of these two sites presented a timely opportunity to discuss with regulators the kinds of data and approaches being considered by those developing a performance-based approach. The evaluation considered the natural geologic setting, engineered barriers to mitigate mobility of hazardous constituents (e.g., slurry wall and geosynthetic cap), leachate quality, and leachate production. A conservative approach was used to address the potential for hazardous constituents to migrate to a defined groundwater POC. In 2003, the Arkansas Department of Environmental Quality (ADEQ) provided approval to terminate operation of the leachate and LFG management systems and to monitor groundwater for a defined list of constituents of concern for an SM period. In September 2004, the owner/operator received official notification from ADEQ of its “approval of permit void status” at the sites. ADEQ did not impose any further stipulations on PCC such as cap or fence maintenance. The owner/operator thus terminated their respective PCC obligations at the sites and will henceforth provide site maintenance in a manner consistent with any other disused property, including providing assurance that institutional controls on reuse of the property are in place and complied with.

These efforts represent an important precedent with regards to the EREF project approach. At both sites, a process very similar to that developed for the EREF model (EREF 2006) was used, albeit to a limited degree. Consideration was given to recent leachate quality (which generally met drinking water standards), groundwater quality at the site, and leachate and LFG production. At one site, the TOT for conservative (i.e., unattenuated) parameters to travel from the landfill to the groundwater POC was calculated. This was used to demonstrate that, if a leachate release had occurred such that it would cause impacts to HH&E, it would already have been detected during groundwater monitoring at the POC. Because of historical groundwater quality at the site, it was concluded that such a release had not occurred. At the other site, it was shown that current leachate quality did not represent a threat to HH&E and that the cap was an effective barrier to limit infiltration (i.e., leachate production was de minimus and LFG production had significantly decreased since closure of the site). As an additional safeguard, it was also shown that natural (i.e., underlying lignite layer) and engineered controls (i.e., slurry wall) are expected to mitigate any diffusion of leachate into local groundwater prior to reaching the POC.

Although these efforts cannot be considered to represent full “case study” implementation of the EREF model process, they nevertheless represent recognition by a state agency that the process is reasonable and can be implemented to the satisfaction of regulators. Of particular significance is the fact that ADEQ recognized that the landfills were not an identified threat to HH&E and that progression to providing CC outside of a regulated PCC program is logical (i.e., the regulated PCC period can end without perpetual care of the cap being required).

2. CLEAN CLOSURE OF TWO SMALL CONSTRUCTION/DEMOLITION LANDFILLS

A less common approach to reducing, ending, or avoiding PCC is to remove all waste from a landfill and dispose it in another permitted landfill. This approach is sometimes called “clean closure.” The feasibility of this approach depends on a variety of factors such as the following:

- Type and tonnage of waste to be removed
- Distance to the final disposal facility
- Excavation costs, hauling costs, and tipping fees
- Costs to restore the empty landfill site to an acceptable condition
- Reduced or avoided costs for landfill maintenance and monitoring
- Revenue from land sale or use after clean closure
- Other considerations (inconveniences/aesthetic concerns during waste removal, perceived increases in nearby property values after waste removal, etc.)

Common evaluation methods such as decision matrixes, cost/benefit analyses, public input, etc. are usually applied, as appropriate, to weigh the alternatives. Two small construction/demolition (C&D) landfills in Kansas have used the clean closure approach. A brief description of each site is provided below.

2.1 The City of Mount Hope

Mount Hope, Kansas operated a small C&D landfill 1993–2004. During the most recent five full years on record (1999–2003), the city reported a cumulative total disposal of only 83 tons of waste. Disposal generally occurred only after cleanup of severe weather events.

In 2004 state regulations required C&D landfill owner/operators to submit updated design and operations plans. Some owner/operators of small facilities, such as the City of Mount Hope, decided to close their landfills instead of incurring the surveying and engineering costs involved with developing updated plans.

Rather than construct a final cover over the waste and then conduct at least 30 years of PCC, the city decided to have the waste removed. Four 20-cubic-yard roll-off boxes were filled and hauled to a landfill about 135 miles away. While the final destination was not by any means the closest landfill, it is owned and operated by the hauler, so the additional hauling cost was offset by reduced disposal costs. The disposal costs are undisclosed but probably in the \$15–\$20/ton range typical for this area.

Subsequently, state regulatory staff inspected the empty landfill and determined that it was clean. The city decided not to backfill the depression because of a plan to use it for an open burn pit for disposal of tree limbs and brush. The state cancelled the landfill permit and released the city from closure cost FA.

2.2 The Kansas Army Ammunition Plant

The Kansas Army Ammunitions Plant near Parsons, Kansas, removed waste from an unpermitted solid waste management unit (SWMU) and consolidated it into a permitted

industrial landfill at the plant during 2005. The primary reason for this consolidation was to reduce the number of SWMUs at the plant and thus to reduce RCRA corrective action (maintenance and monitoring) costs.

The SWMU contained waste nominally described as C&D waste, but testing suggested that it also contained other types of waste. However, during consolidation the waste was visually inspected, and no unacceptable waste was identified.

The total volume of waste in the SWMU was approximately 10,000 cubic yards. The haul distance to the industrial landfill was approximately 3 miles. The industrial landfill is owned by the same entity as the SWMU, so disposal fees were not charged. Costs to restore the SWMU area to natural conditions after waste removal were minimal and involved backfilling the area with soil and seeding the surface.

3. BRADFORD LANDFILL—TERMINATION OF POST-CLOSURE CARE PERIOD

On August 25, 2003, the New Jersey Department of Environmental Protection (Department), Division of Solid and Hazardous Waste, authorized the following administrative action concerning the Bradford Sanitary Landfill, located in Monroe Township, Middlesex County, New Jersey:

To terminate the balance of the post-closure care period for the Bradford Sanitary Landfill in accordance with the solid waste regulations, N.J.A.C. 7:26-2A.9(c)5iii.

The solid waste regulations at N.J.A.C. 7:26-1 et. seq. require that the PCC period for sanitary landfills that operated on or after January 1, 1982 be continued for 30 years from the date of closure. The Bradford Landfill is an unlined 2-acre landfill that was in the twentieth year of the post-closure maintenance phase. The landfill had accepted primarily C&D materials and ceased accepting these materials in 1982. The Department had subsequently reviewed and approved soil boring and test pit logs accompanied by an “as-built” certification statement prepared by a New Jersey-licensed professional engineer that certified that a minimum of 2 feet of final cover had been installed on the landfill.

Meanwhile, previous groundwater monitoring results from the landfill wells indicated that no contaminants of concern were being released to the environment. To that end, the landfill’s New Jersey Pollutant Discharge Elimination System/Discharge to Groundwater permit was terminated by the Department on February 8, 1998 following a 30-day public comment period and publication of a public notice in a local newspaper. Subsequently, pursuant to N.J.A.C. 7:26-2A.9(c)5i, the landfill owner/operator petitioned the Department to reduce or terminate the balance of the PCC period, provided that it has been adequately demonstrated that the reduced period is sufficient to protect HH&E. With the termination of the facility’s NJPDES permit and approval of the engineer’s final cover certification, the Department was in a position to prepare a public notice and a fact sheet concerning the proposed reduction of PCC period.

In accordance with N.J.A.C. 7:26-2A.9(c)6, a Notice of Public Comment Period concerning the above administrative action was published in the *Star-Ledger* and the *Home News & Tribune* on January 21, 2003, commencing a mandatory 30-day public comment period. Within this time frame, an opportunity was provided to any interested person to comment on this administrative

action. The public comment period concluded on February 20, 2003. During the public comment period, no comments pertaining to the proposed termination of the balance of the post-closure period for the Bradford Sanitary Landfill were received.

Finally, the solid waste closure and post-closure regulations at N.J.A.C. 7:26-2A.9(c)4 require the following:

Upon closure of the sanitary landfill, a detailed description of the landfill shall be recorded, along with the deed, with the appropriate county recording office. The description shall include the general types, locations, and depths of wastes on the site, the depth and type of cover material, the dates the landfill was in use and all other such information as may be of interest to potential landowners, and shall remain in the record in perpetuity. The deed shall also provide notice that any future disruption of the closed landfill shall require prior approval from the Department in accordance with N.J.A.C. 7:26-2A.8(j).

The property owner's attorney submitted a copy of the deed recording for the Bradford Landfill to the Division in July 2003. The Division reviewed the deed and found that it satisfied the requirements set forth at N.J.A.C. 7:26-2A.9(c)4.

Based on the foregoing, the property owner of the Bradford Landfill had satisfied all of the requirements to terminate the balance of the PCC period for said landfill, pursuant to N.J.A.C. 7:26-2A.9(c)5iii. A closure termination notice was forwarded to the landfill owner on August 25, 2003.

Lastly, any unused funds remaining in the facility's escrow account after complete and proper closure and PCC operations (even when accounting for a reduction in the post-closure period) were paid into the Sanitary Landfill Facility Contingency Fund, pursuant to N.J.A.C. 7:26-2A.9(g)18.

Additional References

ADEQ (Arkansas Department of Environmental Quality). 2004a "Approval of Permit Void Status for Western Waste Industries Hoot Class 1 Landfill, Permit 0146-S, AFIN 46-00071," letter dated September 8, 2004.

ADEQ. 2004b. "Approval of Permit Void Status for WM Shannon Road Class 1 Landfill, Permit 0090-SR-1, AFIN 35-00542, letter dated September 9, 2004.

Appendix G

Response to Comments

RESPONSE TO COMMENTS

Iowa

3. Section 2.1.2, p. 19: I might suggest changing the first sentence in your definition of landfill stability to, “A landfill is functionally stable when it reaches a near steady state in which any releases do not present a significant threat to human health and the environment.” I think some people could argue that a threat still exists, but that threat shouldn’t be significant. Moreover, while some releases are to be expected, I think those releases will be in a near steady state in which they don’t change much, or continue decreasing.

Our definition now reads: A landfill is functionally stable when it does not present a threat to human health and the environment at the point of exposure. Potential threats to human health and the environment must be assessed considering leachate quality and quantity; gas composition and production; cover integrity, and/or groundwater quality. Potential threats to human health and the environment should be assessed in the context of a proposed end use and a proposed level of post-closure care, which may vary from no care, to some level of extended care that is designed to assure that no factor(s) change that could increase potential threats to human health and the environment. We believe that an evaluation of threat at the point of exposure is a better measure of landfill stability than waste steady state. For example decreasing contaminant concentrations indicate reducing threat but do not necessarily reflect steady state. Done

4. Section 2.1.2, p. 19: In the last paragraph and several other places in the draft, it is stated that the threat is determined at the point of exposure and not at the source. Some states have anti-degradation laws which our legislatures have passed that requires no degradation of groundwater compared to the upgradient or surrounding water quality. Thus, this should probably be pointed out in the text as a caveat. For example, in Iowa we’d want to make sure that any plume of contamination didn’t extend beyond the property boundary of the MSWLF, even though the neighbors well (the point of exposure) is another 500 feet away.

Agreed. We have added the following. The point of exposure must also be consistent with applicable state laws (e.g., some states do not allow degradation of groundwater immediately below the landfill).

5. Appendix D, Iowa, p. 105: The correct reference for Iowa in the regulations column should be IAC 567-Chapter 113.26(13) and (14).

Corrected—IAC Iowa Administrative Code.

6. Appendix D, Iowa, p. 105: The correct length of post-closure for a MSWLF in Iowa is 30 years, rather than 10. Only CCR landfills in Iowa start with a post-closure period of 10 years. Both types of landfills can have their post-closure periods extended depending on site conditions, so that portion of the text under comments is correct.

Corrected.

7. All: I just want to repeat my gratitude for your team undertaking this project. It’s very timely and a subject too important for states and the feds not to flesh out. Thanks again!

Thank you.

Pennsylvania 1

9. General Comment: I realize that this document is intended to address how to end Post Closure Care (PCC) at landfills. However, I believe the points raised should give us cause to rethink the current practice of landfill disposal. The very problems this document seeks to address are the very reasons why alternative landfilling methods or waste disposal practices are needed so that we do not continue to create more perpetual care facilities rather than find ways to terminate, in a regulatory sense, the perpetual care obligation. It is just my opinion, and the following comments reflect this opinion, that we should not be looking to terminate PCC and defer to some non-regulatory Custodial Care (CC) approach. Rather, I believe the document provides a good framework for evaluating the degree of PCC

that needs to be maintained and provides flexibility to reduce and/or relax certain PCC activities and, therefore, costs. However, I also believe the document lays out a better justification for why PCC should not be terminated except for those few specific cases where it can truly be determined that the cap integrity is no longer needed to protect the public from access to or releases from the waste. Rather, I see CC as the least prescriptive form of PCC that we could justify unless or until the waste is fully stabilized. Since most landfills are really only entering into a dormant phase—so long a their cap and liner systems remain intact—I don't believe we would ever reach a point where we could terminate PCC. These perpetual care facilities are, and will be, problems. I believe the document should emphasize this point and then build on it to promote alternative practices or methodologies. I believe Section 5.0's discussion should be much more robust as this is really the only way to get out from under the burden of perpetual care. It may not address all, or even many, of the existing facilities, but if we stop the proliferation of long term care facilities, and reduce the costs associated with the new alternatives, it should ease the burden on the regulatory agencies and regulated community from the remaining facilities.

Thank you. We are endeavoring to create training to facilitate these and other options relating to the evaluation and ending PCC.

10. Throughout: Typos/punctuation errors. As this is a draft, I am assuming that additional proofing will be done and that you are looking for technical comment rather than proofreading.

Yes.

11. Executive Summary, p. iv, First paragraph, second line: "... , or ever, pose a threat..." The "or ever" should be stricken or else how do you ever end PCC?

Agreed. We have struck "now, or ever." Done.

12. Executive Summary, p. iv, Fourth paragraph: First line should be, "Even if PCC ends, an obligation for continued monitoring is required to maintain the property." Let's not prejudge that PCC will end and let's remove the emphasis on land use as driving custodial care. The obligation should remain to insure the validity of the PCC performance evaluations, not to satisfy the planned land use.

We have modified the sentence to read, "Even though the formal regulatory Post Closure Care ends, an obligation for continued management is required to maintain the property according to the potential threat at the point of exposure." This has eliminated the land use as the driving factor. This is further clarified in Section 2.1.1. Done.

13. Introduction, Section 1, p. 2: General comments on the concept of CC. The narrative states "... the owner/operator still has an obligation to maintain the property..." "Ending regulatory PCC does not necessarily mean that the owner's responsibility at the site will end..." and "CC will be initiated following a demonstration that the threat ... is acceptable..." Obligations and responsibilities remain and the threat, however acceptable, also remains. How is CC anything other than reduced PPC? Later on in Section 4.8, the document admits that some care of the cap will continue to be required in order to maintain the validity of the leachate, gas and ground water PCC performance evaluations and, therefore, maintain the protection of public health and the environment. If CC is required, how can the requirements of 258.61a1 be met such that responsibility and liability under PPC can be released? Unless the case can be made that no maintenance of the cap integrity is needed to prevent or minimize unacceptable impacts from leachate or gas or direct contact with the waste, why wouldn't the landfill be in a stage of reduced PPC? Required CC just seems to be reduced PPC without the liability and responsibility on the landfill operator. This transfers liability to the public if conditions change and the operator or landowner doesn't step up, or no longer exists. I believe more distinction needs to be made between PPC/CC issues with dormant (dry tomb) landfills and fully degraded, stabilized landfills. This subject is touched on later in the document. However, no convincing argument is made for why CC should be outside the realm of regulatory authority other than to remove financial liability and regulatory responsibility from the landfill owner/operator.

The following paragraph has been included in the introduction to provide clarification of the relationship between PCC and Custodial Care: "The decision process presented in this guidance is structured upon the evaluation of a series of modules based on regulatory requirements and the major elements associated with

a solid waste landfill. Regulatory Post Closure Care is predicated on a monitoring and evaluation system associated with determining if a potential release from a landfill has or may negatively impact human health and the environment (HHE). The fundamental assumption during PCC is that the landfill still has the potential to have a release and present a threat at the point of exposure (POE). The opportunity to end PCC and initiate Custodial Care (CC) is predicated on the conclusion, based on results from the modular evaluation process, that the landfill is stable, predictable and will not present a threat at the POE. Therefore, CC is a program designed to assure that land use is consistent with that which was predicted during regulatory PCC and that there are no unacceptable changes to the property according to covenants, deed restriction or land use controls. If during CC there are unacceptable changes to the property the guidance recommends re-evaluating the land use and the potential impact to the landfill and the potential for releases that could present a threat to HHE (an unacceptable threat at the POE). In summary, regulatory PCC is based on the assumption that protecting against and managing potential negative impacts or releases from landfills, while custodial care is managing a period where there should be no negative impacts from a landfill. The team believes that after a period of time, and potentially several iterations through the modular process, it will become obvious when it is appropriate to end PCC and initiate CC. The transition from regulatory PCC to CC is based on the results derived from modular performance-based evaluation presented in this guidance.”

14. Introduction, Section 1.0, p. 3, Last paragraph: This can all be done as part of post-closure land use and can be done while conducting PCC. This point should be recognized. There seems to be an underlying tone to the document that PCC prohibits end uses and that eliminating PCC and allowing CC will promote more reuse of closed landfills. I don't believe this is necessarily the case.

The team believes and encourages alternate use of the property during PCC and CC. Nothing in this document intends to limit alternate land use that protects HH&E in accordance with applicable rules and regulations. There needs to be planning as early as possible, including the projected land use, which evaluated against the threat at the point of exposure, established a basis for the evaluation. If that land use changes during PCC the threat level may change accordingly. Done.

15. Introduction, Section 1.2, p. 5, Second paragraph from the bottom: Again, the narrative indicates that cap maintenance programs can be a requirement of CC and form a basis for terminating PPC. See comments on Section 1.0, page 2 above. How is this anything other than a lesser degree of PPC without any regulatory mandate to perform? The threat identification needs to assess the status of the landfill as dormant versus stabilized and the likelihood that a failure of the cap would result in reactivation of the leachate and gas generation processes. If this is a real possibility, why should a PPC requirement be converted into a CC requirement? The only one benefiting from this is the industry. Rather, perhaps we should be recognizing that dry tomb landfills, unless managed in an alternative way, will and should be under some form of perpetual care and that alternative landfill operations, as discussed in Section 5.0, or other forms of waste disposal, which are not discussed and maybe should be, are where the regulatory authorities and the industry should be heading for any new facilities. In other words, we have a problem with these landfills which will not be easy for anybody, including the industry, to get out from under and we should be looking to other technologies so that we don't have any further proliferation of these perpetual care problems. Keeping the PPC obligations and financial requirements in place indefinitely may push the industry to implement these alternatives rather than giving them a way to get out from under the problems associated with their current practices after they've made their money.

See response above. The team believes that state's role to oversee the progress of PCC has a manpower and additional resource requirements. It is important to consider resource saving in a case where (1) no threat exists without PCC and (2) a threat potential is acceptable and requires no further monitoring. The process of optimizing or ending post closure care is a resource saving early in the evaluation process. For example agencies will expend fewer man hours reviewing less frequent reports. Done.

16. Introduction, Section 1.3, p. 7, Second bullet: “After a site has closed, effective management of existing PCC funds are critical to ensure proper protection of the environment, the financial health of private and public landfill owner/operators, and to provide for future funding of extended PCC periods at MSW landfills, where needed.” Why is this a consideration other than it impacts the waste industry's financial liability? To have credibility with the public, we should not be allowing financial considerations enter into how and when we decide to terminate PPC

requirements. It's the cost of doing business. Reducing this cost may be short-sighted or merely transfer the long-term liability to the public rather than the industry. We have many large landfills and posting financial assurances has not been a problem for the industry. It becomes a concern for them only when they cease operating a facility and it becomes an expense and liability rather than a revenue generating operation. Yet, they want to get out from under financial responsibilities they were willing to assume to get their permits. What is this telling us?

We agree that financial considerations should not outweigh protection of human health and the environment, but on the other hand, financial consideration should not be ignored simply because we do not have an adequate mechanism to formulate a basis for making the proper decision. Continuing PCC should not simply be the default. We sometimes disregard the fact that often the taxpayer has a direct financial obligation to the county-owned and -operated landfill. There are no formalized or structured methodology, and only limited criteria, available to evaluate the performance of PCC. The team will not speculate on what seems to be underlying rationale for someone's ability to pay or not, or incentive to pay or not. Done.

17. Elements of PCC, Sections 2.1 and 2.1.1, pp. 15–18: Similar to comments on Section 1.0 above, it should be pointed out that end use planning and identification are compatible with current PCC requirements. While it should be a factor in considering when to reduce or eliminate certain PCC elements, end use beyond a fenced-in, big green hill is not prohibited under PCC and does not require CC in order to be realized. Again, there seems to be an underlying tone in the document that PCC requirements prevents future use of a closed landfill and that terminating PCC and going under CC is the only way to see these sites become reusable. The document never says this, but I believe it is implied. I don't mean to say that this is done with intent, but I believe some clarifying statements would help to dispel any such inferences on the part of the reader.

There is nothing in the guidance that intends to limit the use of a closed landfill or a landfill in PCC or CC, only that future uses are protective of HHE and the end-use strategy. The team believes there needs to be adequate planning, as early as possible, including the projected land use, which, evaluated against the threat at the point of exposure, establishes a basis for the evaluation. If that land use changes during PCC, the threat level may change accordingly. Land use projection is a large part of establishing the criteria for evaluating the performance of a closed landfill. The following language has been added to the introduction: "Team discussions and research found that no state was able to clearly define when no further regulatory oversight would be needed; therefore, we have created the custodial care option to encompass the few remaining control mechanisms necessary, after ending PCC, to assure land use changes do not cause a change in the threat to HHE." Done.

18. Elements of PCC, Section 2.1.2, p. 19: Landfill stability, functional stability. When is a landfill stable merely because it's containment systems are intact and the waste mass is dormant versus fully degraded and stabilized? If dormant, and that dormancy is dependent upon maintenance of the cap, why should PPC be discontinued? Reduced or relaxed, maybe. It has only ceased to present a threat because its cap remains intact. PPC should be discontinued and CC only relied upon for a fully stabilized landfill—waste mass has been degraded to the extent that it won't produce gas and leachate quality will not be concern should the cap be breached. We have large landfill operators (national firms) that failed to maintain the integrity of their caps on closed portions of landfills where they were actively operating in other portions. I can't see CC working unless there are strong regulatory requirements—the CC requirements don't have to be necessarily prescriptive but the obligation to implement CC should be. Paying taxes, mowing the grass and abiding by local land use requirements just is not going to do it.

The team sees the evaluation of the performance during PCC as a long-term evaluation. Cap integrity, as a functional component of the landfill, must be maintained either actively during PCC or passively during later land use. Ending PCC should be considered only if no maintenance or monitoring is required or there are adequate mechanisms within the state and local land use planning authorities to assure the land use conditions are maintained and monitored. Failure to implement an appropriate PCC mechanism will preclude ending PCC. In addition please see the response to Comment # 13.

19. Elements of PCC, Section 2.3/2.0, p. 24, Types of long-term stewardship, Middle of the paragraph: No, long-term stewardship doesn't imply a constant level of PCC will always be required; rather it implies that some amount of PCC will always be required. I also disagree that no effort will be taken to reduce the threat potential. As the

document argues later on, the burden of financial assurance is a concern to the industry. If we don't give the industry an easier way out, they will either change technologies to end the proliferation of these long-term perpetual care facilities or they will implement alternative technologies to reduce their threat and thereby reduce their liability, or both. Further, if the containment systems are of finite life, how do we justify terminating PCC and substituting CC based on the elimination of threat? If long-term stewardship is not protective, how can the performance-based approach be protective?

Ending PCC may be nothing more than the result of repeated applications to optimize PCC. As one sees the performance within each module improve or stabilize and finally show nothing of concern ending PCC may seem the only reasonable conclusion. This document should emphasize optimizing PCC rather than assuming an end. In addition CC can, and may well, include provisions for monitoring to ensure the key elements associated with threat management are maintained. The team does not see a regulatory authority as a mechanism to leverage the industry into new technology development nor the government to require other forms of waste management. The language you are referring to has been removed from the document. Done.

20. Elements of PCC, Section 2.3, p. 25, Second bullet, Performance-Based Approaches: If the evaluation depends on the continuing functionality of the cap, how is this anything other than a snapshot of the condition of the landfill that lies somewhere between a perpetual care facility and a fully stabilized landfill? This approach is good for evaluating when to end or reduce some PCC elements, but unless the evaluation has determined that the cap no longer needs to be maintained, I don't see terminating PCC. Rather, I see implementing CC as a reduced form of PCC and still requiring the regulatory oversight and financial responsibility, which could be reduced accordingly.

Agreed, however protecting the cap and maintaining the cap are different. By avoiding intrusion into the cap, we can maintain cap integrity CC can provide that in some cases. If continued cap reconstruction and maintenance are required, PCC is a better system to assure finances are available to perform the maintenance.

21. Performance Based Evaluation of PCC, Section 4.6, p. 50: The last two sentences of this section state that it is unlikely that routine monitoring and maintenance of the cap system will ever be completely eliminated given the overall importance of the final cover on the performance on the closed facility. That said, how do we justify terminating PCC and relying on a non-regulatory approach to maintain the landfill systems to the extent necessary to eliminate threats to public health and the environment? Also, if in CC, how does the regulatory agency pull the landfill and, more importantly, the owner/operator back into the PCC mode?

State environmental agencies should have a legal mechanism for notification when a land use control has been violated. This allows the state agency an opportunity to investigate any environmental or health consequences of a land use control violation. The team recommends that states should develop (if not already in place) a template they can use, and adjust to their own use, to track and evaluate the environmental effectiveness of land use controls placed on a landfill site. This might be best accomplished through a national organization that represents the states (see Section 4.8.2). States should ensure their administrative mechanisms contain the ability to transition a facility from CC to Regulatory Based PCC or other applicable regulatory authority, as needed. Done.

22. Performance Based Evaluation of PCC, Section 4.7, p. 51, Last bullet: 40 CFR 258.61e doesn't really have anything to do with assurance of adequate long-term maintenance and use of the property so as not to disturb the cap after PCC is ended. All 258.61e does is require a certification that PCC has been completed in accordance with the approved PCC plan. This would be a requirement to terminate PCC, but would have nothing to do with any "de minimus" level of care after the termination of PCC, which is what is implied by the inclusion of the reg citing in this narrative.

The citation and suggestion have been removed. Done.

23. Performance Based Evaluation of PCC, Section 4.8, p. 52: As discussed in comments above, how and when does continued maintenance of the cap become less of a PPC activity and something that can be handled under a non-regulatory CC scenario? Is the landfill dormant or stabilized? There needs to be more discussion on when this PCC-

to-CC transition can occur. For instance, Section 4.8.1 says there must be a history of good performance. What timeframe are we talking about? A couple of years or a couple of decades? The second bullet in 4.8.1 ignores maintaining impermeability of the cap. Unless the waste is stabilized to the extent increased leachate and gas production is not anticipated should the cap's impermeability degrade, don't we need to worry about maintaining full cap integrity and not just the top (vegetative) layer? This surveillance monitoring period is the critical factor in determining when PPC can end. There should be some guidance on how and when to determine this point. See also comment on section 6.1.

There is currently not sufficient detail to calculate answers for you. We agree that further guidance is necessary. It is the intent of the team, given resources, to develop an expert system to help owners and operators make these much needed calculations. Done.

24. Alternate Landfill Management Strategies..., Section 5.0, p. 56: I believe the discussions preceding this section point to the need to emphasize alternate landfill or waste disposal technologies to get us away from perpetual care landfills. Rather than making it easier for an operator to end PCC requirements by transferring regulated PCC activities to non-regulated CC, the difficulty in dealing with dry tomb landfills and getting out of regulatory oversight should stress the need to change the way things are done.

Agreed. We have since emphasized optimizing PCC and have included necessary final cap maintenance in CC. Done.

25. PCC Monitoring at MSW Landfill Sites, Section 6.1, p. 61: This may work for leachate, gas and groundwater monitoring, but how will it work for cap maintenance? As commented before, CC contemplates some sort of (reduced or relaxed, but still required) ongoing cap maintenance activity even though PCC is terminated. See comments on Section 4.8. How does this section support the CC required post-PCC cap maintenance approach when the performance standards would indicate only a fully stabilized (not just stable or dormant) landfill would qualify?

See responses to Comments 18, 19, and 21.

26. Financial Assurance, Section 7.1, p. 65: I don't fully see the link between assessing PCC obligations and the financial assurance instrument. The dollar amount that needs to be provided by the instrument, yes, but not the instrument itself. This may need more explanation.

This section is meant to be a list of mechanisms available. The mechanisms are the critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

27. Financial Assurance, Section 7.1.1, p. 66: We have not had a good experience with corporate guarantees. Disregarding outright fraud, the financial conditions of companies can change rapidly. The annual evaluation may be too little and too late to provide adequate protection. We've seen national companies post a corporate guarantee and then declare bankruptcy in the next year or two. We just don't have the expertise or resources to monitor each company to the degree necessary. Nothing beats having actual collateral in place or at least a third-party surety whose primary business it is to monitor the credit worthiness of their customers. We've even seen surety companies go bankrupt or lose their credit standing, but at least that gave us the chance to go to the actual landfill operator and have them post a new financial assurance. The point here is to protect the financial interests of the public by not having the state assume the financial costs to close and maintain disposal sites, not to make it cheaper for the waste industry to provide financial assurances. The waste industry is a business and cost is one of the ways to promote a change in the waste disposal hierarchy.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

28. Financial Assurance, Section 7.2, p. 66: The concern about adequacy of financial assurance for providing long-term care and protection when an owner/operator is unable or unwilling is a valid concern. The additional concern of

the need to extend financial assurance requirements to a wider variety of facilities doesn't really have a place in this document. Not really sure what the concern is or why it is even mentioned here.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

29. Financial Assurance, Section 7.2.1, p. 69: The difficulty in providing/obtaining long-term care funding is exactly why these type of disposal facilities/practices should cease. Yes, we will have the existing facilities to deal with, but let's not keep creating more of them. The market knows that these problems will not go away and thus doesn't want to be saddled with the long term liability. Why, then, should the regulatory agencies be willing to find ways to release the owner/operator of the liability? The solution is not to make it easier to end PPC and reduce or eliminate the associated financial obligations. The solution is to operate facilities differently or use different disposal technologies. This PPC/CC approach gives us a roadmap to deal with the existing facilities to minimize long-term costs, but let's stop creating the problem. I believe the financial costs are the primary driver to get this done. Tell the regulated community that we may have some way to minimize PPC by not requiring leachate and gas collection when it is no longer necessary and maybe reducing monitoring costs, but you will not be released from liability until the landfill has stabilized (not just become stable/dormant). This should drive them to these alternate technologies. The fact that operators could be forced to liquid trusts that would not be good use of cash or result in low returns has no place in our evaluation. That is the cost of doing business. Change the way of doing business to make better use of funds. This is the message we should be relating here.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

30. Financial Assurance, Section 7.2.2, pp. 69–70: We have only large landfill operators or municipal authorities in our region. They've not had any trouble posting the necessary financial assurances in order to get their permits. Tighter restrictions is just the true cost of doing business. Passing this on to the consumer also merely reflects the true cost of the service they are provided. If the companies aren't making as much money as they want to, or the public finds itself paying more than they care to, then maybe these can be drivers to alternative technologies. There is no reason to find ways to make a poor technology cheaper to implement merely to mask the problems inherent in it. Again, I believe these points should be used to show why we need to get away from the current method of landfilling - it is more expensive than we realize or want to admit, and the potential problems are long term and won't ever really go away.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

Pennsylvania 2

32. Section 1.0, p. 2: Unless we have a fully stabilized waste mass, it seems that cap maintenance will always be necessary. But the draft guidance seems willing to say that this can be done outside of a regulatory, post-closure care requirement as part of "custodial care," which is more or less property maintenance under local zoning and land use requirements. We know that we have trouble with active operations maintaining their caps. It'll never happen if we don't have a regulatory mechanism to require it. Plus, how can you tell if the cap is intact without routine monitoring of leachate, gas, and groundwater?

See responses to Comments 18, 19, and 21.

33. Appendix F, p. 136: Five case studies were mentioned that ended post-closure using the draft guidance. Two small landfills were closed under "clean closure." Before this draft guidance is finalized, we recommend case studies be performed using much larger municipal waste landfills (100+ acres) and not involving clean "closure."

We appreciate your recommendation, and it will be considered for future opportunities. Unfortunately, these types of studies do not exist at the writing of this document.

Wyoming (Dale Anderson)

35. Section 4.5, p. 46: The document states that a history of the final cover performing to design standards would be beneficial before reduction of groundwater monitoring requirements would likely be approved (see page 46). In Wyoming, every MSW landfill that is in the post closure period is unlined. Presumably, other states also have a number of unlined landfills in the post closure period. Based on direct observation and measurement, some of the final covers at these landfills in Wyoming have significant settling and cracking of the compacted clay barrier layer. Therefore, it is very unlikely that the final cover is performing as designed. Again presumably, similar situations will or have arisen at unlined landfills in other states. Given these observed failure issues, it would be difficult to establish an appropriate leachate generation rate for a time of travel calculation for the groundwater module, absent information regarding how the final cover is actually performing even after corrective action to repair observed problems. It is suggested that the document provide a brief discussion of this situation, including the potential need or desirability for final cover monitoring (at unlined landfills), appropriate or applicable monitoring methods, and reasonably achievable target performance standards.

All of these factors should be considered by your agency when or if regulatory PCC should be terminated or optimized. With no leachate collection or recovery system your next level of monitoring of the performance of the cap and landfill is within the groundwater. Without an estimate of flux through the cap material, or having an impermeable cap which is functioning as designed, there is considerable uncertainty in any calculation for leachate generation rate.

Army Asiello

37. Army concurred as is. Air Force has some editorial comments (attached), and Navy also concurred with some editorial comments that they are vetting with the team. Please consider this e-mail as DOD concurrence with these editorial comments.

Thank you.

38. General: The document appears to exclude landfills that do not have liners or leachate/gas collection systems. This eliminates from consideration a number of DoD landfill sites closed with waste in place and only groundwater monitoring, soil cover, and institutional controls maintenance as part of PCC. Comments on pages 4, 8 and 19 suggest ways in which the document could expand its applicability to these landfills.

Section 4.5 Step 2 points out that “Since an unlined unit without an LCRS does not have an expected preferential release point (i.e., sump) the time of travel (or TOT) should be measured, at a minimum, from the mid-point of the unit to the POC. Consideration of migration pathways from the landfill unit to the saturated zone should be discussed with local regulatory agencies regarding the total time that groundwater monitoring will be required at the facility. Based on the outcome of either of these evaluations, a determination is made of the need to continue monitoring groundwater for potential leachate impacts. The assumption, intrinsic to a performance-based evaluation, is that the source is appropriately characterized and that appropriate leachate indicators have been identified for use in the groundwater module.” The guidance document is primarily predicated on subtitle D landfill data and associated information, however the team believes that, as presented, the modular evaluation process may be adapted to landfills that include other configurations (e.g., no liners).

39. Section 1.0, p. 1: Omit space in “threat s” before “40 CFR 258.61” in second orange fact block.

Done.

40. Section 1.0, p. 1: Is “USEPA” in second orange fact block a document? If so, italicize.

Done.

41. Section 1.0, p. 1: Move “40 CFR Part 258” to previous line, between “guidance” and “at least.”

Done.

42. Section 1.0, p. 1: Add a fifth bullet: “Sampling.”

Sampling is a function in each element or module. It is not a functional element of a landfill performance system.

43. Section 1.1, p. 4: Use only the first sentence as the definition of landfills. The second sentence defines containment systems. In the second paragraph, change “and” to “and/or” before “leachate.” I would change the first sentence in the third paragraph to, “This text supports the position that a solid waste landfill is a performance-based system that is constructed and/or managed to minimize potential impacts from site-specific leachate, landfill gas, and/or groundwater.” Change the last sentence to, “Accordingly, optimization and/or discontinuation of the PCC program is based upon a defensible site-specific characterization of gas management requirements, leachate quality and quantity, groundwater quality, cap maintenance, and maintenance of institutional controls.”

The recommended change has been incorporated.

44. Section 1.3, p. 7: In first bullet, replace semicolon with a comma and delete “in fact.”

Done.

45. Section 1.3, p. 7: Omit second bullet, covered by other bullets and 1.3 discussion.

We will not delete this bullet but have revised it to more fully reflect our intent.

46. Section 1.4, p. 8: The first paragraph could be amended to note that landfills could have any one or all of the components of a containment system.

The “e.g.” is intended “for example.”

47. Section 1.3.1, p. 9: Third paragraph, add that the waste characterization occurs before PCC.

Done.

48. Section 1.3.2, p. 11: Add “PCC” between “of” and “changes” and delete “in PCC.”

This changes the intent of the sentence. Rejected.

49. Section 2.1.1, p. 17: On section title, either omit underline or use throughout document.

Thank you.

50. Section 2.1, p. 19: The definition of landfill stability in section 2.1.2 could be changed by replacing “and” with “and/or” before groundwater quality in the second sentence.

You must consider each module as part of the evaluation and document its relevance to the performance evaluation of the landfill.

51. Section 2.1.3, p. 23: In fifth paragraph, third sentence, change “and” to “an.”

Done.

52. Section 2.1.3, p. 23: In fifth paragraph, last sentence, omit space in “threat s.”

Done.

53. Section 3.0, p. 32: In fourth paragraph, third sentence, insert “while” between that” and “Clean Air Act.”

The sentence has been replaced previously.

54. Section 4.1, p. 37: Define End Use Strategy: What steps are necessary after PCC ends and end use changes?

The following language has been highlighted in a text box. “Note that, if end-use conditions change (e.g., if the landfill is converted from a restricted, fenced site to an open-access facility such as a park) after the PCC evaluation is performed, then some or all modules would need to be reevaluated to determine whether the changed end-use condition would produce a different outcome to the evaluation.”

55. Section 4.5, p. 43: Step 2, Evaluate Change acknowledges that a closed landfill may not include a liner/LCRS. Is it possible to alter the Landfill Gas module for cases in which no Landfill Gas monitoring system exists?

If a landfill gas monitoring system does not exist you must work with your regulators to establish an appropriate evaluation process.

56. Section 4.6, p. 47: In orange fact block, paragraph (f), last sentence, change “threat)s” to “threats.”

Done.

57. Section 4.7, p. 52: First full paragraph, last sentence, change “Brownfield’s” to “Brownfields.”

Done.

58. Section 7.0, pp. 67–68: Italicize subtitles consistently—some subtitles are italicized and some are not.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

59. Section 7.0, 7.3, p. 70: In subparagraph a), change “complete” to past tense.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

60. Section 9.0, p. 76: Fourth paragraph, after “Confirmation Monitoring” add “and Surveillance Monitoring.”

Findings and recommendations have been significantly revised.

61. Section 9.0, p. 76: Sixth paragraph, omit space in “post -landfilling.”

Findings and recommendations have been significantly revised.

62. Section 9.0, p. 76 Fifth paragraph, add a period at the end of the last sentence.

Findings and recommendations have been significantly revised.

63. Section 9.0, p. 76: Seventh paragraph, do you need the comma after “Even though”?

Findings and recommendations have been significantly revised.

64. General: Choose one way to express the term “post closure care” and stick with it. I saw it written as “Post Closure Care,” “Post-closure Care,” “Post-Closure Care,” “post-closure Care,” etc. Please decide whether it should all be capitalized and/or hyphenated and do not waiver.

Done.

65. General: State or “States” is sometimes capitalized and sometimes not throughout the document.

Done.

66. General: A semi-colon (;) is used to separate to complete sentences or to separate items in a list that begins with a colon(:). It should not start the list. Issue in several places.

Thank you.

67. General: Misused, missing and misplaced parentheses throughout the document.

Thank you.

68. General: Affect and effect not used properly in several areas.

Thank you.

69. General: Please decide if LCRS stands for Leachate Collection and Recovery System or Leachate Recirculation System and then be consistent throughout.

LCRS = Leachate Collection and Recovery System.

70. General: Several sentences do not end with periods.

Thank you.

71. General: Section 7 has some subsections underlined, some italicized and some with no special treatment at all. In Chapter 2, subsections were in bold and sub-subsection were in bold and underlined. In chapter 6, subsections were in bold, sub-subsections were underlined but not in bold. Chapter 4 has a 4.1 and a 4.3 but no 4.2. This is not an exhaustive list of the large amount of style issues throughout the document.

Thank you.

72. Section 3.0, p. 27: “Regulatory Overview and Flexibility, starting at page 27, is very poorly written. One paragraph is particularly difficult to understand. I have excerpted it here and written my parenthetical comments in green.

Thank you. The paragraph has been revised by the team.

73. Section 3.0, p. 27: “Regulations were written with greater care (greater care than what?) and considering to the best available knowledge and experience (“Considering to?” Do they mean “in consideration of?”). Advances in technology and the need to optimize resources encourage innovative decisions using alternatives techniques (What are “alternatives techniques?”). Fortunately, we have the flexibility built into the system to allow us to make decisions based on new information and improved management techniques, however this does require we correctly identify and understand the parameters (parameters to what exactly?) and properly evaluate performance to defensibly request (request from whom?) and demonstrate (demonstrate to whom?) alternatives.”

The paragraph has been revised to clarify the team’s intent.

74. Section 3.0, p. 31: The section at page 31 that includes quotes from various state regulations to demonstrate flexibility in rationales for changing the duration of the post closure care period should be summarized in a sentence or two and then footnoted with a reference to where the reader might find more specific examples if they are interested.

The state rationale is important to the reader. The quotes remain.

75. Section 1.1, p. 4: Careful attention should be given to identify the specific areas that require quality management controls. This discussion must also address where oversight is needed to ensure data quality, and where internal coordination of quality assurance and quality control (QA/QC) activities among different organizational units need to occur.

The detail you suggest is indeed important. However, it is state specific and beyond the level of detail of the guidance. There are a variety of existing guidance documents available that contain this information.

76. Section 1.3, p. 6: The documents should also mention “bioreactor landfills” as these type of landfills may have different monitoring requirements. A bioreactor landfill operates to rapidly transform and degrade organic waste. The increase in waste degradation and stabilization is accomplished through the addition of liquid and air to enhance microbial processes. This bioreactor concept differs from the traditional “dry tomb” municipal landfill approach. Consequently the monitoring approaches may vary from the “dry tomb “ landfills.

Bioreactor landfills certainly have a place and will help degrade waste at an accelerated rate. The team has published a bioreactor guide previously. See www.itrcweb.org, Guidance Documents, Alternative Landfill Technologies.

77. Section 2.1.3, p. 23, 3rd paragraph, 3rd line: Correct “threat s” to “threats.”

Done.

78. Section 4.3, p. 40: There appears to be several long, run-on sentences in the document which makes it difficult to follow the thought. For instance, the following sentence on page 40, last paragraph, is a long run-on sentence: “For example, if limiting leachate generation...” Such sentences should be changed to a more reasonable length for improved readability and understanding.

Thank you.

79. Section 4.4, p. 40: Gas monitoring should be based on gas dynamics at the site. If the amount of gas generation is significantly variable over a wide volume range, then the monitoring frequency must be adjusted rather than having a fixed monitoring schedule.

Agreed. Variability of gas generation rate forms the basis to adjust the frequency. You should negotiate this with the state regulator responsible for the site.

80. Section 4.5, p. 43: For groundwater that is relatively immobile, leachate from the landfill may remain very localized. In this situation the need to frequently monitor may be considered for elimination. For example, localized perched water conditions or a highly fractured bedrock with trapped groundwater would be a candidate for infrequent monitoring. State or other regulations may still require some monitoring, however the frequency should be negotiated.

This guidance document is intended to provide a process to make decisions to successfully implement the prescribed administrative process. This guidance does not describe in detail all of the steps required to implement the associated tasks.

81. Section 4.5, p. 46: The methods used should be sensitive enough to detect confirmation monitoring parameters in groundwater down gradient from the landfill. If the detection limits aren't sufficient then the parameters might go undetected because of dilution effects.

Agreed, however the threat of a landfill must be based on measurable units applicable to the POE and consistent with your state laws.

82. Section 5.2, p. 57: There is a large readership for this document with varying levels of familiarity with this topic. Consequently, the Glossary Section, Appendix B, should be expanded to include phrases, technical terms, etc. For example, the term "inward gradient landfill" is not explained. It is difficult to determine meaning within context of use.

Thank you.

83. Section 6.0, p. 59: Recommend mentioning and using the Uniform Federal Policy for preparing Quality Assurance Project Plans (UFP-QAPP). This document, developed jointly by the U.S. Environmental Protection Agency (US EPA), the Department of Defense (DoD), and the Department of Energy (DOE), will enable responsible personnel to apply: the scientific method, the graded or common sense approach to project planning, the life cycle of data collection, and the team-based approach for development of performance and acceptance criteria for the quality of the data (not limited to lab data) and for the quality of the decision to be made for the environmental problem.

Thank you. It has been include in the Other Resources section of the document.

New York

85. ITRC's goal of trying to define when a landfill's post-closure care can be ended is certainly a laudable one and the draft document appears to be addressing the matter in a logical manner which would be consistent with the Department's regulations. There is currently a need for this guidance topic in that many states are beginning to address this matter at landfill sites nationwide and without some form of standard guidance on this subject, the potential exists to have 50 different approaches being developed. It makes far better sense to establish a standard recommended process for the various states to use rather than to have multiple independent approaches to this matter.

Thank you. We have included this statement in the Executive Summary of the document.

86. As a general comment, the reviewers believe that guidance document could be edited to be more succinct, this was especially true for the first 50 pages or so of the text. The remaining comments from Division staff are included in the attached ITRC form for your review and if you agree with them to send onto ITRC as the Department's ITRC POC.

Thank you.

88. Executive Summary, p. iv: First sentence delete the following " , or ever,".

Done

89. Executive Summary, p. iv: We suggest that the first two sentences be revised to basically say that the US EPA through the provisions of 40 CFR Part 258.61(b)(1) and (2) allows directors of approved states to either decrease or increase the traditional 30 year post-closure care period. These revised sentences should include the regulatory citation and indicate that these determinations are based on a determination of the landfill's threat to human health and the environment.

Thank you for the suggestions. They have been incorporated into the text.

90. Executive Summary, p. v: Last sentence, we suggest deleting the word “capacity” and in its place inserting the phrase “and sociological needs....”

Thank you. The phrase has been incorporated along with capacity.

91. Section 1.0, p. 1: It would be useful to the reader to include the complete title of the “USEPA (1998)” reference given on this page.

Thank you. We have incorporated the reference information.

92. Also in the third paragraph the reference to “40 CFR Part 256.61(a)(2)” should be changed to “40 CFR Part 258.61(a)(2)” and that the following quote from Part 258 should be included verbatim from the regulations to avoid confusion.

The citation has been changed and the full quote is included.

93. Section 1.0, p. 1: The second or lower boxed text containing the quote “Concentrations at the....threats” the quote is not in the cited regulations nor does the reference to the other USEPA document contain enough information to identify the source of the quote.

The quote is in USEPA 1993, the 1998 revision.

94. Section 1.3, p. 6, last paragraph, last sentence: Delete “PCC regulation” and replace it with the following phrase “PCC period requirement.”

The sentence has been revised previously.

95. Throughout this section the draft document refers to itself as a “report,” “manual,” and “guidance.” A consistent reference should be used.

Universal search has adjusted terminology for consistency using guidance.

96. Section 2, p. 13, first paragraph, first sentence: We believe that the regulatory performance requirement for the landfill’s leachate collection and removal system to ensure that the leachate head on the liner should not exceed 1 foot is important to state here. While this design criteria should not be a challenge to meet during a landfill’s post-closure period, especially if the landfill has been capped (a bioreactor landfill may be an exception here), the 1 foot head requirement should continue to be a performance goal of the LCRS during this time frame or at least until it has been demonstrated that the PCC period can be ended and a demonstration has been made and approved that there will be no adverse environmental or public health impacts associated with leachate head build up over the liner system from both a biological and geotechnical perspective. We suggest substituting this sentence for the first sentence here: “The purpose of the landfill’s leachate collection and removal system is to effectively collect and remove leachate throughout its active and post-closure life span ensuring that the leachate head above the liner is kept to less than 1 foot.”

We have replaced the sentence with your suggestion and slight modifications.

97. Section 2, p. 14, second full paragraph under the topic of “Cover System”: First sentence, delete the word “cap” and replace it with the following phrase: “the landfill’s final cover system...”. After the words “final cover system” insert the following: “system components....”

Language replaced with suggestions.

98. Section 2.1.1, p. 18: Second paragraph use of partial citation of 40 CFR Part 258.61©(3) is misleading to the reader. The entire regulatory citation should be used here.

Full citation added.

99. Section 2.1.2, p. 21–22: For Tables 2-1 and 2-2 to be more useful to the reader, more discussion relative to their applicability should be added to page the discussion under sub-section 2.1.2 on page 19.

Additional language has been added to clarify the existence of the tables.

100. Section 3, p. 27: Third paragraph, last sentence should be revised to read as follows: “... , however, this does address how we should correctly identify and understand the parameters that will allow us to properly evaluate PCC performance to defensibly support PCC alternatives.”

The change has been made.

101. Section 3, p. 29: First bullet: insert the word “typically” between the words “is” and “required.”

This is a quote from a state responding to the survey questions.

102. Section 3, p. 31: The utility of the series of bullets on this page should be evaluated. What is being conveyed here is somewhat duplicative to the text on the previous pages and perhaps a mere reference to the appendix that contains this information is all that is needed.

Given that all of the respondents list HH&E as the sole reason for post closure care, it is important to list others issues states consider when making a decision as important as ending PCC.

103. Section 4.1, p. 34, Figure 4-1: The flow chart on this page should include a box for “End Use Selection.”

Step one in the explanation of the evaluation process assumes the end use has been defined. Table 4-1 simply identifies the modules within a landfill system that will be evaluated. The importance of defining the landfill end-use is explained earlier in the guidance.

104. Section 4.1, p. 37: Fourth bullet should be revised as follows: “Leachate management data, including: LCRC design, historical leachate flow and analytical data....”

Historical leachate flow data is not necessary to evaluate the module. The historical data may be a point of negotiation between the owner and state regulatory agency.

105. p. 37: The fifth bullet insert the word “historical” before the word “flow.”

Historical leachate flow data is not necessary to evaluate the module. The historical data may be a point of negotiation between the owner and state regulatory agency.

106. p. 38: The first bullet insert the word “historical” between the words “schedule,” and “groundwater.”

Historical leachate flow data is not necessary to evaluate the module. The historical data may be a point of negotiation between the owner and state regulatory agency.

107. Section 4.3 (or 4.2?), p. 38: The “Leachate Management” section should be revised to reflect the concept of a double liner system. There are a number of PCC alternatives/concepts that can be afforded to a double lined landfill as compared to a single lined facility. For example the facility owner has an option of ending leachate management in the upper LCRC while continuing the operation of the lower LCRC or (leak detection system). There are added concepts for corrective action that are afforded to double lined landfills verses a single lined landfill. For example in the case of groundwater contamination from a leaking double lined landfill the lower LCRC (leak detection system) can be flooded to induce an inward gradient into the landfill (upper LCRC). While there are approximately (the last time we checked) 12 states that mandate double liner systems, facility owners are beginning to offer double liner systems in other states in order to ease permitting and siting opposition associated with new facilities and this trend may continue.

The methodology may be adapted to a double lined system. A facility in regulatory corrective action due to a release, that could potentially threaten HH&E, cannot continue to use this methodology to optimize or end post closure care, until the release is corrected.

108. Section 5.1, p. 56: In the first bullet, the term “functionally stable” should be defined. This bullet list of “proactive strategies for landfill management practices” could be expanded. For example; the strategy of sustainable landfill operations (similar to the Delaware SWA), the concept of pre-disposal waste stabilization/treatment (similar to that which is done at hazardous waste sites currently), and the concept of in-situ waste stabilization methods—not yet defined. The degree of proactive management approaches that optimize end use activities will be largely based on the value of the end-use plan to the community, so the document should end this discussion with a suggestion that other proactive approaches not mentioned may evolve with time.

See Section 2.1.1 for the definition of functionally stable. This document describes only a few of the landfill strategies possible.

109. Section 7, p. 64: From a general perspective the concept of “perpetual care” needs to be acknowledged in the document. This topic likely fits elsewhere in the discussions regarding PCC, but it is also important to be brought up under the Financial Assurance discussions. The basis for this is the known fact that many financial assurance mechanisms are not compatible or effective under a perpetual care approach.

The methodology within this document is intended to help the user evaluate the care required to manage threat at the POE. It could result in ending post-closure care or extending post-closure care. This section is meant to be a list of mechanisms available. The mechanisms are the critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

Nebraska

111. Section 4.8.2, p. 54: The 3rd paragraph of this sub-section states “The restrictive covenants are required to be submitted to the department before the final permit is issued which must demonstrate that the restrictive covenant has been filed with the state Register of deeds.” In Nebraska, a deed notice or covenant is filed at the time of closure and confirmed/approved within the required closure certification documentation submittal.

The timing of administrative mechanisms governing PCC will be unique to each state organization.

112. Section 4, p. 43: The 1st sentence of the 1st paragraph is incomplete.

The sentence has been deleted.

113. Section 5.1, p. 56: Item (iii) of the 1st paragraph indicates removal of the threat potential of the landfill altogether by means of “clean closure.” Case Study 2.0 in Appendix F provide the “clean closure” of two small C&D Landfills. It would be hard to imagine the clean closure of a MSWLF or reuse of a liner. Also, “clean closure” is generally used in relation to the closure of a hazardous waste management unit.

It may be the exception rather than the rule, however the option is available to try.

114. General comments: While the general concept of the “Ending Post Closure Care at Landfills” document seems reasonable, specific State regulations may prohibit the applicability of this guidance in part or in whole. I realize this document is to provide general information to facilities, however, specific States should be contacted prior to the facility pursuit of specific concepts within this document. Perhaps a disclaimer could be placed within this document identifying the varying acceptance limitations within a specific States regulations, or maybe it already is and I have missed it.

There is a general disclaimer at the front of the document. In addition all ITRC states have the option of reviewing the applicability of this guidance relative to their own state regulations. We refer to this review as the “Concurrence Review” by the states.

Oklahoma

116. p. 110: The applicable regulation for Oklahoma is 252:515 not 252:510 (510 has been revoked).

Change completed.

117. p. 110: In the comments section the second line should read: The Department will not approve the certification of post-closure performance if testing [shows] the presence of elevated levels of any constituent, if evidence of contamination resulting from site operations is found to exist, if prior maintenance or monitoring of the site is found to be inadequate, if the site is producing leachate which must be treated prior to discharge, or if other conditions are present that indicate a need for additional post-closure monitoring and care.

Change completed. Federal and many state regulations provide flexibility which would allow optimizing, or even ending PCC.

Illinois EPA

119. This document does not conflict with federal regulations or Illinois regulations.

Good

120. The regulations allow for the shortening or extending of the post-closure care period. It should be noted there are no descriptive requirements in the regulations to accomplish this provision. If it can be proven to the Regional Administrator or the Illinois Pollution Control Board that the unit is secure and will not harm human health and the environment, the regulations allow the permit to be modified and post-closure care period reduced.

Good. See Section 3.

126. This document could be a source to be used by permittees or the IEPA when deciding if a landfill, in post-closure care, is secure.

Thank you. That is its intended use.

128. Even if a PCC period is shortened they would still need financial assurance for the maintenance of the cap or what they call “Custodial Care.”

This guidance indicates that, once in custodial care, the regulatory program requiring PCC has been terminated along with Financial Assurance. However, state specific provisions must be considered.

129. The PCC time period for any landfill is set for 30 years. The Board (IPCB) has the authority to shorten or extend this time period. Each landfill should be evaluated on a case-by-case basis. The owner/operator should provide the supporting documentation to shorten their PCC if so desired. The ITRC document could/may provide guidance for industry or the Agency during this evaluation process.

The document’s intent is to describe a methodology to obtain information to confirm and monitor changes in PCC of a MSWLF. There is also a reference to the EREF document which provides additional detail for this evaluation.

130. If the permittee wants to limit the frequency of inspections and sampling they would submit a permit modification request with supporting documentation. If they want to eliminate it all together, again this would be a permit modification request.

Thank you.

131. I see the ITRC document as guidance for these issues to determine if it would be feasible to submit a modification. On the IEPA's side, this documentation could be used for guidance in determining approval of a modification request to the post-closure care permit.

Thank you.

132. This document mainly focuses on solid waste landfills not hazardous waste landfills. They imply that non-hazardous landfills have a better chance of reducing or eliminating PCC.

Thank you. However, the substantive information used to develop this document, and EREF, was obtained from published literature and data collected for MSW. Adaptation of this methodology to other wastes is predicated on the appropriate rules and regulations.

133. Appendix E: It might be necessary to have other professionals who are well versed in statistical procedures review this section.

Agreed, see final text.

134. The case studies where post-closure care has been terminated were for pre-Subtitle D landfills, "clean closed" C&D landfill, and a sanitary landfill that mostly accepted C&D material. There were no examples of hazardous waste landfills in the case studies.

We focused the document on MSW.

California Integrated Waste Management Board

136. For a large part, this report is a reiteration of the draft Environmental Research and Education Foundation (EREF) report, which this report relies on. Under current California (CA) regulations, an operator can request decreased post closure maintenance/care (PCM/PCC) at any time. The reduction in PCC must be justified (e.g., decrease flare operation with decrease in gas generation).

Agreed. thank you.

137. The report is inconsistent in its treatment of PCC and Custodial Care (CC). CC is described as the typical care any piece of property should receive. However, the report in several locations indicates the CC is appropriate when maintenance of the final cap is necessary to maintain landfill gas (LFG), leachate, and ground water (GW) in an acceptable threat. Maintenance of a final cap is much more than CC. If the cap needs to be properly maintained so that gas, leachate, and GW quality are acceptable, then the site needs to remain in PCC (albeit possibly at a less intensive level). CC should only occur if the absence of a cap will have no bearing on LFG, leachate, or GW.

The following paragraph has been included in the Introduction to provide clarification of the relationship between PCC and Custodial Care: "The decision process presented in this guidance is structured upon the evaluation of a series of modules based on regulatory requirements and the major elements associated with a solid waste landfill. Regulatory Post Closure Care is predicated on a monitoring and evaluation system associated with determining if a potential release from a landfill has or may negatively impact human health and the environment (HHE). The fundamental assumption during PCC is that the landfill still has the potential to have a release and present a threat at the point of exposure (POE). The opportunity to end PCC and initiate Custodial Care (CC) is predicated on the conclusion, based on results from the modular evaluation process, that the landfill is stable, predictable and will not present a threat at the POE. Therefore,

CC is a program designed to assure that land use is consistent with that which was predicted during regulatory PCC and that there are no unacceptable changes to the property according to covenants, deed restriction or land use controls. If during CC there are unacceptable changes to the property the guidance recommends re-evaluating the land use and the potential impact to the landfill and the potential for releases that could present a threat to HHE (an unacceptable threat at the POE). In summary, regulatory PCC is based on the assumption that protecting against and managing potential negative impacts or releases from landfills, while custodial care is managing a period where there should be no negative impacts from a landfill. The team believes that after a period of time, and potentially several iterations through the modular process, it will become obvious when it is appropriate to end PCC and initiate CC. The transition from regulatory PCC to CC is based on the results derived from modular performance-based evaluation presented in this guidance.” In addition, a previous response follows: See responses to Comments 13 and 21.

138. The report in several locations indicates that a “no threat” for LFG, leachate, and/or GW is acceptable for ending PCC and entering CC for that item. However, the report does not emphasize that the “no threat” level typically is BECAUSE of the current conditions of land use and cap. However, this may not be the case at that site at some future time, which is problematic because under CC, there is no regulatory agency oversight. How is a regulatory agency to know when site conditions change (e.g., new land use and/or deterioration of cap)? This is not well thought-out.

You are correct to point this out, and it is consistent with the team findings and recommendation. **Finding:** Financial Assurance (FA) is not required during Custodial Care. Covenants, deed restrictions, or other land use control mechanisms may assure that the land is only used accordingly, and that appropriate custodial care is provided. For the purpose of Custodial Care covenants, deed restriction, or other land use control mechanisms are only as effective as the government’s ability and resources to enforce them. These mechanisms may be tied to the land and ultimately are the owner’s responsibility. State environmental agencies should have a legal mechanism for notification when a land use control has been violated. This allows the state agency an opportunity to investigate any environmental or health consequences of a land use control violation. **Recommendation:** The team recommends that states develop a template/administrative mechanism they can use, and adjust to their own use, to track and evaluate the environmental effectiveness of land use controls placed on a landfill site. This might be best accomplished through a national organization that represents the states. (See Section 4.8.2.)

139. It appears that the primary purpose for CC is to establish that PCC financial assurance would not be required if States followed the recommendation of the report. As stated previously, if the “no threat” status is based only on current conditions (e.g., good cap, land use), CIWMB staff believes that PCC should continue with the commensurate financial assurance.

We recognize CIWMB’s concern about enforcing covenants or deed restrictions after ending PCC that might have an environmental or HH&E impact. That is why the team recommends state agencies evaluate their ability to develop the proper mechanisms to ensure land use restrictions are enforced. See responses to Comments 13 and 21.

140. Chapter 7, Financial Assurance, does not belong in this report. Information on FA should be contained in a separate, albeit related, report. The primary purpose of this report is to assess technical aspects of PCC and when to lessen or discontinue PCC. The issue of FA is separate and complicated. If FA is to be included, then a section on cost estimates should also be included.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

141. The report’s reliance on long-term institutional controls, while understandable, is problematic. There are many situations in which local agencies have ignored or not implemented institutional controls. Placing a site in CC where institutional controls (ICs) are necessary to maintain a low human health and the environment (HH&E) threat is not appropriate.

See responses to Comments 13 and 21. Please review the Findings and Recommendations that address these issues.

142. It appears the term “threat” is misused in the document. What the report means by threat is no current adverse impact, as opposed to the normal CA meaning of threat which is that threat is equivalent to (equals [=]) potential risk. The report appears to indicate that if there is no threat (i.e., no current impact) then PCC is not necessary. This is not consistent with CA standards. As long as there is a potential risk (i.e., threat) then PCC must continue. When the risk to HH&E is eliminated, then CC would be appropriate.

The team has provided a description of how threat is used throughout the document in a text box in Chapter 1.0. The description is based on the EPA reference included in the box. As it relates to leachate, “the threat posed by direct exposure to leachate released to groundwater, surface water, or seeps may be assessed using health-based criteria...” Modules are designed to preclude exit of PCC as long as an unacceptable threat exists. The distinction between acceptable and unacceptable threat may vary from state to state or site to site.

143. Section 1.3, p. 7: Please note that in CA the PCC period continues indefinitely until the operator demonstrates that the PCC can be discontinued. The State does not need to extend the PCC period.

Thank you.

144. Section 2.3, p. 24: In CA the current approach is Waste Stabilization or Inert Endpoint with Performance-Based Approaches. Therefore, as long as the waste poses a risk (i.e., threat) PCC must continue; however, by using a performance-based approach, an operator may be able to minimize the intensity of PCC.

The team considers that waste in place may pose a risk; however, with proper landfill controls the landfill may not pose a threat at the point of exposure (See section 1.1). By demonstrating that the landfill controls are effective in mitigating the potential threat at the POE, the facility may optimize PCC, or transition into CC.

145. Section 3, p. 28: Figures 3-1, 3-2, and 3-3 are incorrect in their represented percentages. The percentages are based on positive responses divided by total responses and total 100% for each pie chart. The correct percentages should be positive responses divided by number of states which responded. The total percentages should not equal 100% since each “pie piece” is a separate, distinct event and not part of a whole. A different chart than a pie chart should be used.

Thank you. We will include the total states responding rather than percentages.

146. Section 3, p. 29: The report states that “few states have created defensible criteria and performance expectation for ending post-closure care.” Please note that in CA, it is the responsibility of the LF operator to justify the minimization or elimination of PCC, not the State regulatory agencies.

As in the federal rule, the determination to extend the PCC period may be the responsibility of the agency, not the landfill operator. The point is that regardless of who will conduct the evaluation, there still are no criteria available. See response to Comment 80. Through communication with other states, due to the lack of criteria, some states are developing their own criteria. However the ITRC guidance support a site-specific evaluation methodology rather than uniform threat criterion.

147. Section 4.1, p. 37: This section indicates that if the end-use changes than the various modules would have to be reevaluated. However, the section does not explain how this is accomplished if the LF is in CC and there is no regulatory oversight (see response to Comment 4). The end use has a bearing only on the current level for PCC and is not an adequate justification for ending PCC since a change in end use can have a significant impact on the various modules and their viability (e.g., golf course has significant more irrigation and resultant impacts than nonirrigated open space).

The team believes that current and expected end use is an integral part of how to optimize and when to potentially end PCC. The previously referenced covenant or administrative mechanisms should include provisions for the reevaluation of threat based on a potential change of land use, unless previously determined to be acceptable, during the threat evaluation process during custodial care. See responses to Comments 13 and 21.

148. Section 4.1, p. 37: Please note that for many older landfills (i.e., constructed 1980s or earlier), much of the listed requirement prerequisites are unavailable (e.g., base grades, liner system, cell geometry, waste types, operational practices, etc.).

The team acknowledges that at some sites some data may not exist; however, this may not be a fatal flaw in implementing the process. In unlined landfills with no LCRS or gas management system, all systems must be considered, but the cover system and groundwater monitoring are the modules available to evaluate the performance of PCC.

149. Section 4.3, p. 39: Under Step 2, the report states that if there is an acceptable threat at the point of exposure (POE) then a new leachate strategy can be implemented. Please note that under CA standards, if a LF cannot pass Tier 2 (groundwater quality of the point of compliance [POC]), then the site is in violation of state standards (e.g., CA State Water Resources Control Board Non-Degradation Policy).

Thank you for the information. As previously indicated, we would expect states implement their program according to their own statutes and regulations.

150. Section 4.4, p. 41: Under Step 2, the report states that if there is an acceptable threat evaluation then a new LFG strategy could be implemented (Tier 2 evaluation). Please note that under CA standards, if LFG exceeds regulatory standards at the POC, then the site is in violation of standards and must address the violation (Tier 1).

See previous response.

151. Section 4.5, p. 43: The report indicates that if the LF is monitored for a sufficient period of time to detect a release using an estimate of the time-of-travel in ground water, then it can be defensibly estimated that no environmental impact has occurred. However, this approach does not take into consideration when the original “leak” initiated. Did it occur day 1 of waste placement? Would a “leak” first occur 10 to 20 years after closure? Non-impacts to ground water only indicate that a leak has not reached the GW monitoring wells. It does not indicate that it NEVER will reach the monitoring wells.

Your calculations should consider a release period which would contain your uncertainties with the release period, distance to the POC, or monitoring well, and the time of travel. In addition, evaluation of the groundwater module is predicated on results of the evaluation conducted pursuant to the leachate module, if an LCRS is present, or on a more conservative estimation based solely on the Time of Travel (ToT) in an unlined site without an LCRS is not present.

152. Section 4.5, p. 43: Under Step 1, one of the criteria is that the LF cannot be identified as a source of confirmed ground water impacts. This implies that if the LF cannot be definitely proven to be adversely impacting ground water, then the LF could discontinue the GW module. The burden of proof should be on the operator to prove that the site is not and cannot impact ground water to eliminate the GW module. If the LF could impact GW, than monitoring should continue albeit possibly at a reduced level.

The document recognizes that the burden of proof lies with the owner/operator to identify any source of groundwater contamination. The conservative nature of this approach adds the component of confirmation and surveillance monitoring to ensure that discontinuation of LF operations, e.g., LCRS or gas collection, is appropriate. Groundwater monitoring is not completed until surveillance monitoring for the other modules are complete.

153. Section 4.6, p. 48: The report indicates that if the final cover is “stable” then PCC could be discontinued. However, the report fails to address the fact that often the stability is based on current land use and site conditions. Should the land use or conditions change, then the cover may no longer be “stable.” This is an insufficient criterion for ending PCC and initiating CC (see next comment).

See responses to Comments 13 and 21.

154. Section 4.6, p. 50: The report states that it is unlikely that the requirements for routine monitoring and maintenance of the cap system will ever be completely eliminated. CIWMB staff (and SWRCB?) concurs with this statement. However, in several locations (e.g., pp. 51 and 52), the report indicates that PCC could be discontinued and CC could be initiated if only routine maintenance is needed. This is incongruent. If cap maintenance and monitoring is necessary to properly maintain the site so that it does not adversely impact HH&E, then the site should remain in PCC and not be put into CC (see previous comment).

The team disagrees. In fact, the team believes that some elements of ongoing observation and maintenance are appropriate for CC program. It may be that we have a lot to learn from brownfields. See responses to Comments 13 and 21.

155. Section 4.8, p. 52: The reference to Brownfields post-remediation care is not directly applicable. In most cases the waste at Brownfields is either removed or the contamination is treated and remediated. At LFs the waste remains in place and is not treated. Remediation implies that the site has been cleaned up. If undecomposed waste remains in place, the site is not remediated but only controlled.

At many brownfield sites, the waste remains in place, but the threat is managed. This would be the basis of the threat evaluation of the landfill using the modules and the process described.

156. Section 4.8.1, p. 53: The report states that if the LF does not currently pose a threat to HH&E under its defined end use conditions, then the site could be put into CC (i.e., no State regulatory agency oversight). This ignores the possibility (likelihood) of changes in land use and the potential resultant HH&E impacts. Until the waste no longer poses a threat and the need for a cap is eliminated, PCC should continue. (See preceding and following comments).

See previous responses above.

157. Section 4.8.2, p. 54: The reliance on deed restrictions is misplaced. In many cases, local governmental agencies do not adequately enforce deed restrictions. Furthermore, in CA there is limited authority for a regulatory agency to impose a deed restriction; the landowner must impose the restriction itself thereby making it easier to rescind the restriction in the future.

You are correct to point this out and it is consistent with the team findings and recommendation. **Finding:** Financial Assurance (FA) is not required during Custodial Care. Covenants, deed restrictions, or other land use control mechanisms may assure that the land is only used accordingly, and that appropriate custodial care is provided. For the purpose of Custodial Care covenants, deed restriction, or other land use control mechanisms are only as effective as the government’s ability and resources to enforce them. These mechanisms may be tied to the land and ultimately are the owner’s responsibility. State environmental agencies should have a legal mechanism for notification when a land use control has been violated. This allows the state agency an opportunity to investigate any environmental or health consequences of a land use control violation. **Recommendation:** The team recommends that states should develop a template/administrative mechanism they can use, and adjust to their own use, to track and evaluate the environmental effectiveness of land use controls placed on a landfill site. This might be best accomplished through a national organization that represents the states (see Section 4.8.2).

158. Section 5.1, p. 56: While bioreactors will likely enhance waste degradation and accelerate gas generation, there are still no long-term analyses of the efficiency of waste degradation. Current science indicates that waste degradation (i.e., LFG production) is not 100% complete in a bioreactor LF. Therefore, there will still be a potential for LFG to adversely impact HH&E. LFG maintenance and monitoring would likely be significantly reduced, but it is unlikely that all maintenance and monitoring would be eliminated as long as the waste remains undecomposed.

The team considers that waste in place may pose a risk; however, with proper landfill controls the landfill may not pose a threat at the point of exposure (see Section 1.1). By demonstrating that the landfill controls are effective in mitigating the potential threat at the POE, the facility may optimize PCC, or transition into CC.

159. Section 6.1, p. 61: The report in Section 6.1 (Methodology and Techniques) states that while any engineered or natural controls for any PCC component are still required at a site, then PCC will need to be continued. However, in several other locations in the report, the report states that CC can be implemented even if maintenance and monitoring of the cap is needed. These two statements are diametrically opposed.

The following revision to Section 6.1 has been made: “As long as engineered controls that require significant operational oversight are needed to protect HH&E (i.e., any care activity other than those defined under Custodial Care), the user cannot move past CM. Post-CM PCC monitoring and maintenance, albeit at a reduced level and frequency, will continue to be required unless all three of the following conditions can be met for the PCC module in question:

- All activities and requirements prescribed by the applicable regulatory authority as a part of the post-closure permit have been fulfilled and can be certified complete;
- No engineered control systems exist for which any significant monitoring or maintenance activities are required to protect HH&E (aside from de minimus care that can be provided under a Custodial Care program); and
- A successful analysis of potential future threats to HH&E has been completed, and CM was conducted for long enough to demonstrate that cessation of PCC activities is acceptable.

160. Section 6.2, p. 63: While proposing the use of statistics to help determine trends as beneficial, the report bemoans the practice of accepting analytical measurements as true concentrations when determining exceedences. However, LF operators often use analytical measurements to “prove” non-exceedences.

Agreed. The commenter and team provided significant edits to the document as well as Appendix. E. We have also added this issue of treating data inconsistently as a Finding and have provided Recommendations [for EPA] to complete the “Unified Guideline” for measuring landfill performance.

161. Section 7.0, p. 64: The premise of the discussion is identified as if states are finding it difficult to effectively oversee a “diverse array” of FA demonstrations. In numerous discussions between CA staff responsible for FA reviews and similar staff in other states, this has never been identified as a problem. The problems that have been raised on a consistent basis have focused on the funding of trust funds (and similar mechanisms) and the difficulties in gaining access to funds assured through insurance policies.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

162. Section 7.0, p. 64: This section fails to identify or discuss trust funds (In CA we also utilize enterprise funds and pledges of revenue for local government operators).

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

163. Section 7.1, p. 64: The author identifies that FA demonstrations are only designed to provide funds should the owner/operator fail to meet obligations. This is incorrect. The cash-value funds (i.e., trust funds, insurance for closure and PCC) are specifically developed, described and utilized to provide the owner/operator with a defined source of available funds to directly perform obligations, and, should the owner/operator fail to perform, these same funds are available to the regulatory agencies to secure contractors to perform the obligations for which the funds were established.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

164. Section 7.1, p. 65: The report states that the FA instrument is meant to be accessed only when the owner/operator is unable to fulfill its obligations regarding PCC and is not a primary means to fulfill PCC obligations. However, as identified in comment #30, this ignores the several owners/operators throughout the nation with insurance, trust funds (or enterprise funds in CA) which demand to access these funds for ongoing PCC requirements.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

165. Section 7.1, p. 65: The original comment in the report continues on to incorrectly identify that the FA demonstration is not the primary means to fulfill PCC obligations. As stated earlier (comment 30), the FA demonstration is the primary means to fulfill PCC obligations at a significant portion of the facilities.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

166. Section 7.1, p. 65: The initial PCC period is not the identified concern with any facilities that are meeting the current FA demonstration requirements. In contrast, the concerns identified with PCC are founded on the lack of financial assurance demonstrations for the vastly extended period of PCC remaining after the initial 30-years of PCC is completed.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

167. Section 7.1, p. 66: To accurately determine an owner/operator's ability to meet obligations assured by the Financial Test/Corporate Guarantee, item 3 should always identify that tangible net worth be at least six (6) times the sum of current, closure, PCC, and corrective action cost estimates assured in any state or region by any similar test, whether for hazardous waste, solid waste, mining operations, or any operations of the company, not just the facilities assured in the individual state receiving the test as the FA demonstration.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

168. Section 7.1.1, p. 67: The report fails to recognize the importance of utilizing FA demonstrations which are presented by financially independent third parties. One of the greatest positive aspects of the majority of the FA demonstrations (other than the test and captive insurance) is the financial "distance" of the demonstrations. This financial independence and distance greatly reduces the possibility that a failure of either the owner/operator or the provider of FA demonstration will result in the financial inability of the obligations of the facility to be met. With both the test demonstrations and captive insurance, the states are taking the risk (without any compensation) of a failure of the owner/operator to perform cascading through the "provider" of FA demonstration, and ultimately impacting the regulatory agency with the necessity of utilizing taxpayer funds to protect people and the environment.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

169–175. Section 7.1.2, p. 67: The entire discussion of captive insurance, separate from insurance in general is deceptive and inaccurate. The entire discussion should be stricken from the report. As it is currently included, the following are the associated comments:

- a. The inclusion of the phrase “a captive is a real and legally organized insurance or reinsurance company,” while accurate in its statement, is rather self-serving.
- b. The risk of loss of a captive insurer is carried completely by the parent corporation. This provides states with no third-party assurance for the financial assurance.
- c. The statement regarding lowering overall costs is meaningless for two reasons. First, the author previously stated that the FA demonstration is only intended to provide funds if the owner/operator fails to perform an obligation (which is the definition of surety coverage). And, second, if the owner/operator fails to perform, there is no financial capability of the captive insurer to independently provide the funds to perform the obligation (specific captives have declared that they carry zero dollars in reserve for claims, as they never have, and never will, have a claim to pay.)
- d. The discussion of professional liability, punitive damages and business risks are not the issue when presenting FA demonstrations to states for “closure,” “post-closure care,” and “corrective action.” Each of the previous events is insurable, and the exposures could reasonably be covered by a captive insurer with limited independent resources. Each of the latter assurances is a significant exposure which requires the payment of the exposure to be transferred from the owner/operator to the insurer (in this case, the captive insurer).
- e. The author suggests that captive insurers “pay the claims” of the parent corporation. However, the Board has received direct testimony on numerous occasions that the captive insurer has never and will never be called upon to pay a claim, because the parent corporation will pay the expense directly without filing any claim against the captive for an “insured event” such as closure or PCC.
- f. CA has been made aware, by direct testimony from representatives of a parent corporation and of their captive insurer, that there are no reserves held by the captive insurer to pay for losses. The author’s statement also omits any reference to setting aside funds other than for legal expenses, operating expenses and dividends. The omission of closure, PCC, and corrective action claims is striking.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

176. Section 7.1.5, p. 68: The subset of Commercial Insurance Policy inappropriately “elevates” the previous discussion of Captive Insurance Policy. There is no federal FA demonstration identified as “captive insurance” for either hazardous or solid waste landfills. The only identification in the federal requirements is for “Insurance.” In CA, the regulations identify captive insurance, within the insurance requirements, specifically to clarify that any captive insurer will be treated in an equal manner to all other insurers. The ongoing inclusion of captive insurance as a distinct FA demonstration unfairly attempts to legitimize such coverage under new and completely undefined standards.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

177. Section 7.1.6, p. 68: Additional State-Approved Mechanisms. There are two topics discussed within this paragraph. The first is the discussion of “all other” FA demonstrations, and the minimum standards such demonstrations must meet. The second is the placement of a very brief discussion of standby trust funds, which are secondary mechanisms to other FA demonstrations – but, having no bearing on “Additional State-Approved Mechanisms.” With all of the prior discussion regarding captive insurance, and the inability of the demonstration to meet the “insurance” requirements, it should also be noted that captive insurance, as presented to date in CA, is also incapable of meeting the general standards of “Additional State-Approved Mechanisms.” Specifically, it is undemonstrated that any captive so far identified to CA regulators is capable of meeting the requirement of ensuring that sufficient funds will be available in a timely fashion.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

178. Section 7.2, p. 69: As discussions regarding FA demonstrations continue, and additional costs are identified, the impact to the price of waste disposal rises because the true costs of disposal are being recognized, not because the regulations are unnecessarily causing a rise in the cost of compliance.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

179. Section 7.2.1, p. 69: The use of the phrase “30-year tail” is inappropriate in this discussion. There is currently a requirement for a financial demonstration of 30 years, and a requirement in CA that the owner/operator maintain the facility until it no longer poses a threat to the public health or the environment. A “tail” is a term used with “insurance” regarding a specified time beyond when coverage is purchased wherein a claim can be made against the coverage. The 30-year FA demonstration is the coverage in this instance, not the tail period after the coverage where claims may continue to be made.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

180. Section 7.2.1, p. 69: The discussions of perpetual care and protection for events which may or may not occur are two legitimate discussions, not one in the same. As it stands now, it has proven to be very difficult to define how long PCC should continue. Some have used the term perpetual care to suggest that the requirement might never realistically end. It is probably much more significant and important that the costs that can be calculated to care for a facility over the years be identified and calculated. All items associated with the ongoing care have a service-life, and a cost associated with repair and replacement of the item, whether it is within 30 years, or beyond. These should all be identified and calculated. There are also costs associated with items that “may” occur in the future due to accidents or natural events that will impact the ongoing care of the facility. These items are not known either for when they may occur, or for how much they may cost to correct.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

181. Section 7.2.1, p. 69: However, a reasonable estimate can be developed for these items, and an appropriate risk of occurrence can be assigned. With such a determination, a value can be placed on the exposure, and a FA demonstration can be presented to the regulatory authorities. With these costs identified, the true costs of care for the facility become known to a greater extent, and the users of the facility during its active life can be charged accordingly.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

182. Section 7.2.1, p. 69: The author redundantly states that the inability to place a time frame on a demonstration will make the demonstration unavailable, as if there are two points being expressed. It is the same point, made twice, and, while partially accurate, is not an excuse to abandon the process of determining the true costs associated with closure and PCC of a facility in the long-term.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

183. Section 7.2.1, p. 69: The author identifies a value statement that trusts are not a good use of cash. In reality, due to the extremely long time-frames understood to be associated with PCC at facilities, a specific value of money carried in a financial instrument creating a minimum return to provide funds for the ongoing care and maintenance

of a facility may be the most cost-effective FA demonstration available. This is a point of current discussion in CA regarding these types of FA demonstration issues.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

184. Section 7.2.2, p. 69: The initial paragraph could divert the reader's understanding of the costs of disposing of waste. As currently practiced, the entombment of solid waste will guarantee an ongoing requirement to maintain a facility. Such maintenance will have costs associated with it and these costs will likely be higher than currently required estimates. However, these higher costs are only reflective of the attempts of the regulatory agencies to bring cost estimates and FA demonstrations closer to the true costs of disposing.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

185. Section 7.2, p. 70: The author is repeating the incorrect statement mentioned earlier in the report that the FA demonstrations are only a secondary source of funds and not the primary source. The validity of this statement is entirely based on the FA demonstration presented by the owner/operator for the facility. In addition, it is unrecognizable what the intent of the statement regarding draws against existing instruments due to the inefficiency of the instrument is intended to mean. The emphasis of acceptable FA demonstrations should be to assure that funds are available for adequate amounts in a timely manner. If the demonstration is linked to the operator's capability to perform (financial test/guarantee), then scrutiny of the owner/operator's independent financial capability is the primary focus of the demonstration. If the demonstration is from a true third-party (letter of credit, surety bond, insurance, trust agreement, etc.), the regulatory scrutiny is directed at the third-party's capability to provide the funds in a timely manner for an adequate amount.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

186. Section 7.3, p. 70: As identified earlier, the FA demonstrations can also be the owner/operator's source of monies for the assured activities. This is the case when the owner/operator provides insurance or a trust fund (and, in the CA, an enterprise fund), as these demonstrations are developed with the intent of the operator accessing the funds to perform the assured event.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

187. Section 7.3, p. 70: While the author identifies that US EPA allows discounting in specified instances, the "conditions" that must be met are unlikely in virtually any situation in CA. Items (c) and (d) are unattainable, as has been discussed at numerous public workshops in CA, because the closure date of most any landfill in CA is not certain. In fact, there are many foreseeable factors that will change the estimate of site life, virtually up to the point that the owner/operator finally receives the last load of waste. Due to this reason, which is a crucial point in discounting the estimates, CA is not willing to transfer the risk of the financial obligation from the owner/operator to the public at large.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

188. Section 7.3, p. 70: This discussion becomes even more problematic when discussing the PCC requirements of the facility as the PCC FA demonstration is currently required for 30 years, but the owner/operator is obligated to care for the facility until there is no further threat to the public or the environment. And, the costs that will be

encountered over the initial 30 years of PCC are estimated, but in no aspects are these costs certain, which could conceivably compound a shortfall in funding, should these estimated costs also have been discounted.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

189. Section 7.3, p. 70: It should also be noted that the author acknowledges the difficulties encountered with discounting, but continues to advocate for the same. Without the ability to meet the requirements identified, discounting is an inappropriate option and unnecessarily exposes the general public funds to potentially bail-out under funded FA demonstrations.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

190. Section 7. 3, p. 71: The statement that “we know ... the money ... will be spent 30-years after closure, no sooner” is not accurate. Owner/operator’s utilizing insurance or trust funds will be spending money from these assurance demonstrations throughout the PCC of the facility. As stated previously, this is currently required to be financially assured for 30 years, but the owner/operator continues to be liable for care and maintenance until the facility no longer poses a threat.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

191. Section 7. 3, p. 71: CIWMB staff does not agree that discounting should be allowed without restriction. As identified earlier, the costs are not fixed for the PCC, and the period is not truly known. While the current requirement is for 30-years of funding availability, there is no certainty regarding when that 30-year period will begin. The ultimate exposure to this expense should be carried by the users of the facility, not the future generators of the waste. Allowing discounting of such potentially variable value (the costs of PCC) would be irresponsible on the part of the regulators of these facilities. For the author to suggest that this act also “be allowed without restriction to allow for flexibility of instruments” does not serve the interest of the public protection. The owner/operators currently have every financial instrument available in the market for their individual flexibility. Any financial instruments not specifically identified are also allowed, should the FA demonstration be capable of meeting the very basic and general requirements of the “State Approved Mechanism.”

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

192. Section 7. 4, p. 72: “Surety bonds, letters of credit and financial tests/corporate guarantees are similar in the aspect of providing the assurance that should the owner/operator fail to complete their obligations, a source of funds is identified that the regulator can draw upon to contract for the completion of the activities. In contrast, insurance and trust funds are direct sources of funds to the operator to perform the activities, and the remaining value of the insurance coverage and the trust fund is available to the regulator, should the owner/operator fail to complete their obligations. The author seems to imply that the uncertainty of the true length of PCC is used as justification to restrict the FA demonstrations available. In contrast to this implication, in CA all the current FA demonstration are expected to continue to be allowed and relied upon to allow the maximum flexibility of all owner/operators to meet the ongoing expenses of PCC until the facility no longer poses a threat to the public or the environment.”

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

193. Section 7.4, p. 72: The report continues to extol the virtues of captive insurance policies, but fails to recognize that all current captive insurance policies presented in CA fail to meet the federal FA demonstration requirements for “insurance,” and also fail to meet the general basic requirements of all other FA demonstrations allowed under “state approved mechanisms.”

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

194. Section 7.4, p. 72: The financial means test/corporate guarantee is essentially the most flexible of FA demonstrations available to owner/operators capable of meeting the requirements on an annual basis. One of the biggest concerns of regulators regarding this demonstration is the speed by which an entity apparently otherwise financially sound can arrive at a point where they no longer are capable of meeting the financial requirements of the test. This is problematic for regulators in that the financial condition of such an entity raises concerns regarding their ability to be financially capable of securing an alternative FA demonstration for their obligations.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

195. Section 9.0, p. 77: CIWMB staff does not agree with the finding that FA should not be required during CC. As stated above if maintenance is required to protect HH&E then FA should also be required. (See Comments nos. 3, 4, 5, and 7.)

See response to Comment 157.

196. Section 9.0, p. 77: The finding and corresponding recommendation regarding land use control mechanisms appear incongruent. Although the report recognizes the ineffectiveness of these mechanisms, it still recommends that they be employed. Moreover, the report further recommends that States should develop a method to track the environmental effectiveness of these land use controls. The more effective response would be for the States to continue to oversee PCC and the sites and not to institute CC. (See Comments nos. 3, 4, 7, 14, 21, 24, and 26.)

See responses to Comments 157, 13, and 21.

California Department of Toxic Substance Control, May 19, 2005

198. Cover letter statement: The most critical oversight is how the Guidance is focused narrowly on the ending of post-closure care. DTSC envisions that post-closure care would, in essence, be required into perpetuity, while certain elements of such care may be limited over time. The far more important question is what elements of this care should be continued over the long term, what level of care is needed for all elements and that refurbishment of cover systems may be necessary in the very long term. Additionally, discussion of the parties responsible for this care should be included. There is strong need for regulatory agencies, owners of landfills, landfill neighbors, and developers to understand the long term needs at closed landfills. It is our experience that HWLs will need some level of PCC into the foreseeable future. Instead of drafting guidance which indicates that PCC will end, our experience in California certainly does not illustrate that this is case. We should focus our limited resources on addressing the most significant and widely applicable problems, which are identifying levels of long-term PCC and ensuring adequate funding.

We focused on MSW landfills, and the team recognized the potential usefulness of the concepts and approaches used in the guidance for HWL modified in accordance with state provisions. We are revising the title of the document and text to emphasize optimization rather than ending PCC. Our opinion is that the evaluation to optimize (reduce) PCC monitoring in any of the modules will be done repeatedly and the decisions to reduce PCC will be more frequent than ending PCC. The methodology should not be perceived as restricted to ending PCC. After repeated evaluations for optimizing PCC, ending PCC may not be the more difficult decision but nearly intuitive.

199. General: The Guidance is poorly thought out in a number of areas. The most critical oversight is how the Guidance is focused narrowly on the ending of post-closure care. The far more important question is how long should this care last and what level of care and refurbishment of cover systems may be necessary in the very long term and what parties will be responsible for this care. There is strong need for regulatory agencies, owners of landfills, landfill neighbors, and developers to understand the long term needs at closed landfills. It is our experience that HWLs will need some level of PCC into the foreseeable future. While it possible some sites may not need very long-term care, our experience in California indicates it will be rare. We should focus our limited resources on addressing the most significant and widely applicable problems, which are identifying levels long-term PCC and ensuring adequate funding.

See previous response.

200. This Guidance misrepresents federal law and California's authorized RCRA program. The intention of both federal and state the law has been to ensure the availability of sufficient financial resources, provided by the owner/operators, for use by regulatory agencies to complete PCC, protecting human health and the environment throughout the length of post closure. Post closure is the length of time operation and maintenance is required to ensure there is no risk from the waste material. Some level of maintenance and monitoring will be required as long as waste material remains in place without complete degradation.

The team considers that waste in place may pose a risk; however, with proper landfill controls, the landfill may not pose a threat at the point of exposure (See Section 1.1). By demonstrating that the landfill controls are effective in mitigating the potential threat at the POE, the facility may optimize PCC or transition into CC. Also see response to Comment 198.

201. The Guidance has a lengthy section on financial assurance that does little more than describe various mechanisms in ways that are inconsistent with laws and regulations in California. The section should be removed as it is unnecessary and inaccurate. The inaccuracies are described in detail by another California Agency the Integrated Waste Management Board.

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

202. The stated rationale for creation of this Guidance is to assist in re-use of closed landfills. Removing oversight of landfills from agencies that have expertise and experience in working with potential risks places this responsibility on local agencies that often lack the expertise and resources to adequately oversee long term requirements at these sites. Furthermore, operation and maintenance without oversight from any government agency is very significant change in current regulation of landfills that would require a great deal of input from the public, states and other interested parties.

See response to Comment 138.

203. The recommendation of this Guidance is to push for closed landfills to exit PCC and move into unregulated Custodial Care (CC). The Guidance does not consistently define CC; in some cases it is defined as activities that are required of any type of property, in others it can include cover maintenance, leachate monitoring and maintenance, and groundwater monitoring. CC implies that maintenance activities are not particularly important, or the failure to perform these activities is similar to the mowing of weeds and paying property taxes. Landfill maintenance activities at a hazardous waste landfill are critical to its stability, if the cover and other systems are not properly maintained; it is no longer stable and may degrade groundwater, surface water and the air. Hazardous waste landfills, even in a stable condition, require critical maintenance and monitoring that is well beyond what is needed at any other type of property.

See responses to Comments 157, 13, and 21, but be aware that this document focuses on MSW landfills, not HWL.

204. While the Guidance does not state it explicitly, it appears to promote the self regulation of operation and maintenance at closed landfills. If these activities are critical to public health and safety, they should be done under the regulation of a responsible agency. Hazardous waste landfills require ongoing operation and maintenance to ensure that essential engineering controls and systems keep the waste and its residuals entombed. This includes repairing erosion and damage to the cover and drainage system. It often includes operation of leachate or contaminated groundwater extraction and treatment for groundwater protection. Groundwater monitoring is also required to ensure the protectiveness of the closure system and assure the local community and other stakeholders that the landfill is not leaching contaminants into the groundwater and subsurface.

See responses to Comments 157, 13, and 21, but be aware that this document focuses on MSW landfills, not HWL.

205. The Stakeholder Considerations Section is completely devoid of legitimate input from those communities that surround landfills, focusing exclusively on potential re-use. These communities generally prefer stringent oversight and a high level of maintenance and monitoring to ensure that the people, environment and resources in their community are not degraded nor at risk.

We recognize the comment as one agency's opinion, which does not comport with this team's findings. This is very apparent in many communities' vested interests in beneficial redevelopment of landfill properties. Our community stakeholder put a great deal of time into preparing the stakeholder section and continues to be involved in many aspects of environmental protection. What SEEMS illegitimate might in fact portray a legitimate effort of a community leader to solve environmental problems, not stall the efforts of legitimate regulators and businessmen. Offering the community a description of the existing threat and the management systems used to manage that threat will provide an improved understanding of landfills.

206. The guidance does not adequately address the need for very long-term refurbishment of landfill structures such as drainage and cover system. The stability of landfills is dependant these structures and without their integrity material inside will be released into the environment.

See module on caps. Those functions may also be maintained during CC using covenants or deed restriction. See responses to Comments 13, 21, and 157.

207. The Guidance does not address the critical issue of who will pay for long-term PCC, whether it is called PCC or CC. This includes the annual maintenance and monitoring, but also periodic refurbishment of landfill structures such as the cover system. Transferring the burden of these costs to taxpayers at the state or local level is not an appropriate strategy.

There are no proposed changes in Financial Assurance requirements in PCC. Financial responsibility for custodial care activities are a key element in the administrative mechanisms attached to the property. See responses to Comments 157, 13 and 21.

208. A major point of the guidance is to change how risk is assessed at landfills. Measuring risk at the point of exposure is proposed as an alternative to measuring risk at the waste material itself. While that concept itself is one critical part of risk assessment, the guidance omits the other critical parts of assessing future risk. Future exposures are not addressed, nor are natural processes of erosion, waste degradation, or infiltration to groundwater addressed. The most egregious error here is the assumption that if there is no significant exposure at this time, there never will be one regardless of the condition of landfill structures. If there are no financial assurances or party to ensure the condition of the landfill cover system, the cover system will degrade and future exposure will change. It is ironic that lack of exposure based on an adequately monitored and maintained landfill is used as a rationale for ending the very activities preventing exposure.

The intent of the guidance is not to change how risk is assessed at landfills, but to identify how threat may be evaluated and managed at the POE associated with landfills (EPA 1998, revised from 1993). See Section 1.1 as follows: This simple definition provides a framework that identifies landfills as engineered structures designed, constructed, and monitored to manage threat (HH&E) and eliminate (where possible) receptor exposure to waste materials, landfill gas and leachate. The Team, when assessing threat (HH&E) at the

points of exposure, considers that: Wastes contained within the landfill structure may represent a potential risk, however, exposure to the wastes can be managed and evaluated on a site-by-site basis to determine if such a condition represents a threat to human health and the environment based upon specific State's statute and regulation. This text supports the position that a solid waste landfill is a performance-based system that is constructed and/or managed to minimize potential impacts from site-specific leachate, landfill gas, and/or groundwater.

209. Some Subtitle D landfills have wastes with high levels of volatile organic compounds in shallow ground water environments where biodegradation functions slowly, high longevity organic contaminants, pesticides, metallic contamination, and others. Many Subtitle D landfills received substantial quantities of hazardous waste before the advent of RCRA; these landfills were generally not sited, constructed, or engineered to post RCRA standards. They will require special analysis and care rather less regulatory oversight. In addition, Subtitle D landfills contain significant quantities of metals that do not biodegrade and can be released into the environment without the benefit of an adequately maintained cover system.

A very good point that must be taken into account during the leachate module evaluation.

210. This guidance as written has no applicability to HWLs. Unless or until the waste material degrades into a material that will not pose a risk as unrestricted use, some level of post closure maintenance and monitoring is required. HWLs pose particular challenges. Based on the type of waste that has and continues to be placed in land disposal units, the material will remain a risk for hundreds or thousands of years without maintenance of containment structures and engineering controls. In addition, the monitoring programs associated with these units are critical components of evaluating the continuing effectiveness of the containment structures and providing critical data to nearby communities.

HWLs certainly pose different threat scenarios. Also see response to Comment 198.

EPA HQ Office of Solid Waste, Comments by Paul Cassidy and Craig Dufficy 5/8/2006

212. Major comments: The draft document needs to make it clear that States are the lead Agencies when it comes to implementing and permitting municipal solid waste landfills. The document also needs to make it clear that the approach discussed in the document is one approach that State Agencies could use in evaluating when post-closure care should be terminated. Lastly, the document also needs to make a statement that the EPA doesn't endorse the approach presented in the document or any other approach that a State Agency may elect to use as a method for determining when post-closure care should be terminated or potentially extended.

Clarifying language has been added to the first paragraph of the introduction regarding the states' lead status. We do point out that this is an approach, not necessarily the only approach. We have added an EPA disclaimer in a footnote in the acknowledgments section.

213. Overall general comments: This document is too long and needs shortening to make it more usable for readers. In addition, certain sections of the document that are mentioned in our specific comments, could be eliminated in order to help shorten the document. To the extent that the document can quickly get into a discussion of the four components of PCC (i.e., leachate quality, gas generation, ground water monitoring/quality, and cover maintenance) and then provide the guidance on how to evaluate the data that applies to each component, you would have a more readable and useable document.

We will consider this during our final rewrite.

214. Executive Summary, first sentence: "PCC . . . assures that a solid waste facility . . . does not, or ever, pose a threat to HH&E." This sentence seems to promise no problems after closure. I think slightly better wording would be that the goal of PCC is to minimize potential problems in order to protect HH&E.

"or ever" has been removed.

215. Executive Summary, 4th para.: “Even though PCC ends, an obligation for continued monitoring is required to maintain the property according to planned land use.” Under the 40 CFR Part 258 rules, after completion of the PCC, the owner notifies the State Director that closure has been completed. Once completed there are no Federal requirements. I am not sure if the document is referring to State requirements or what. The use of the term “CUSTODIAL CARE” is not a Federal term—again—this must be in reference to State/local rules/ requirements.

The term “custodial care” is not a state term either. It is a description of a process as described on page 3 in the introduction and highlighted box.

216. Intro, p. 1: “While 40 CFR 256.61 (a)(2). . .” Should be 40 CFR 258.61(a)(2).

Previously changed.

217. Intro, p. 1: The language for 258.61 (a)(2) is not exactly the language in the regulations.

The direct quote has been incorporated.

218. Intro, near bottom, p. 1: A definition of “point of exposure” is provided. Where does this definition come from?

Check the consistency with EPA 1993 and check for a proper definition in RAGs.

219. Intro, second insert, p. 1: The words in italics are from the guidance document (USEPA, 1998) and are NOT contained in 258.61 (a)(2).

Agreed.

220. p. 2: It needs to be made clear that any requirement beyond post-closure care (what you refer to as CUSTODIAL CARE) is NOT a FEDERAL requirement that applies anywhere within the municipal solid waste Criteria.

It is never implied that is a federal requirement, and the states who have commented on the same document have not revealed such confusion.

221. p. 3: The regulatory cite to Section 258.61 contains a reference to the guidance (EPA 1998, Section 6.6.2). The cite to the guidance should be deleted.

We have since corrected the citation.

222. p. 3: Text states that any modification to the PCC term should be based upon “relevant environmental factors.” Where is this term pulled from? I can’t find it in the regulations (258) or the guidance (in Sections 6.62 or 6.6.3). Also the document states that any determination as to how to modify the length of the PCC period has not been clearly or consistently established. Clearly, EPA’s guidance address the issue of leachate quality and how it can be used to evaluate the length of the PCC period (see page 345 of EPA guidance). In addition, the fact that States have flexibility to address issues is the basis of the Federal Criteria and has been endorsed by the States.

Some clarification on this issue as included in the October 1991 preamble to the Subtitle D rule (56 Fed. Reg. at 51101):

“The Agency considered all comments and determined to require a 30-year PCC period with reductions permitted only ‘if the owner or operator demonstrates that a shorter period is sufficient to protect human health and the environment’ and lengthened on the same standards.

“Some commenters suggested a 15 year minimum, but ‘no leachate data were submitted’ although the commenters did submit some gas generation rates.

“The Agency’s evaluation of the comments submitted in the rulemaking reflected its demand for data on relevant environmental factors. In the absence of such data, EPA retained the Subtitle C standard, including the reference to ‘relevant environmental factors’ from the 1981 Subtitle C rulemaking. The

Subtitle D preamble concludes: ‘Therefore, the Agency does not have data at this time to support a requirement that is either more or less stringent than subtitle C requirements.’ (56 Fed Reg. at 51101). The preamble concludes: ‘Providing for variances in the post-closure care period in approved States allows the flexibility to accommodate differences in geology, climate, topography, resources, demographics, etc. In all cases, however, the Agency is convinced that these decisions must be reviewed carefully and be subject to State review to ensure that units are monitored and maintained for as long as is necessary to protect human health and the environment.’” (56 Fed. Reg. at 51101).

223. Para. 1, p. 4: EPA has no decision on what will be the end use. The approved state director has the power in determining what will be the best end use.

Language has been modified, and a reference to Section 2.1.1 has been provided.

224. p. 4: Instead of using a definition of landfill from some publication, why not use the regulatory definition of municipal solid waste landfill provided in the Federal Criteria since that is what you are referring to.

USEPA, 2002 is a valid reference.

225. Para. 4, p. 4: The EREF Post Closure Care document has not been released yet and therefore it seems to make this ITRC document more difficult to review since it uses the EREF unpublished document as the basis of its work.

Agreed. This document has been delayed while waiting for the reference to be published and released.

226. p. 5: 40 CFR Part 258 adopted this PCC term (i.e., relevant environmental factors). Where in the Part 258 rule is this term provided?

See response to Comment 222.

227. Para. 2, p. 6: The duration of PCC can be decreased by the approved state director, who is the best position to decide this on a case-by-case basis.

See Section 1.0 of the document:

Relative to permitted solid waste disposal facilities, EPA’s Code of Federal Regulations, Section 258.61 Post-closure care requirements states:

(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)....

(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 (EPA 1998, Section 6.6.2).

Approval for such a request resides with the Director of an authorized State regulatory agency. The USEPA further stated that any modification to the PCC term should be based upon “relevant environmental factors.” However, details of how such a determination is made have not been clearly or consistently established.

228. p. 7: There is a statement that reads “. . . States and local agencies may conclude incorrectly that the most appropriate course of action for long-term landfill management would be to arbitrarily extend the PCC.” It seems hard for me to believe that a State lead organization, such as ITRC, would make such a conclusion and statement. I believe that would States decide to extend or reduce the length of time for PCC that it is based on site-specific information.

The paragraph has been modified to more positively reflect methodology in the guidance.

229. pp. 9–11: This material can be shortened substantially since if a State decides to use the approach for MSWLFs it can decide to use the same approach for industrial waste facilities if they elect to—it is not necessary for this document to highlight the obvious to State agencies.

Abbreviate and combine industrial waste and hazardous waste section into other applications.

230. Para. 2, p. 10: Replace SIC codes with the updated codes.

This paragraph is deleted See previous response.

231. Discussion of what the POC is can be eliminated in that the POC will have been established years ago by a State Agency.

Thank you.

232. pp. 12–13: This information seems to be information that solid waste directors and staff, along with owners/operators of MSWLFs already are familiar with and doesn't need to be discussed.

Some are not so well informed, and it sets the context of the methodology which is explained later in the text.

233. pp. 24–26: These pages seem to discuss different performance approaches but the content of this document is supposed to be the EREF approach.

The team used EREF only as a reference and changed language where they felt appropriate and necessary. Language was added to the introduction that this is an approach and not the approach. State shave the flexibility to tailor it to their regulatory authority.

234. p. 24: Waste Stabilization: Earlier in the document it seemed to argue that the EPA did not have any guidance concerning the length of the PCC period. Yet in this paragraph it states that “stabilization” is when waste can no longer harm the environment, implying that there is some guidance from EPA. However, this paragraph then argues that stabilization is not the answer and that may be difficult to achieve in full-scale MSWLFs. This seems to argue against any shortening of the PCC period.

Language has been modified.

235. p. 27: Has a discussion and cite for hazardous waste rules—this seems to be completely out of place.

The regulatory citation and language is included to demonstrate flexibility in other programs.

236. Last para., p. 27: Replace obligation with requirement.

Done.

237. p. 28: The document states that only 55% of States have regulations for post closure care. The EPA has approved all States for the Part 258 Criteria—this means that all States have some sort of PCC requirements that are at a minimum equal to the Federal EPA PCC requirements. In addition, the document highlights that States normally and intentionally only provide broad performance standards and leave the interpretation up to the State for PCC. This is generally how States address the issue of flexibility—it may not be liked by industry but I believe that the States have selected this approach for a reason.

The language has been revised.

238. pp. 29–31: This section goes into to much detail about State programs.

Conduct an edit but retain the substance of the survey results.

239. p. 32: “In reality, 22 States in the USA have adopted the Subtitle D regulations. . .” This is WRONG.

The language has been clarified to state that 22 states simply adopted the federal rules with no adjustments or no additional stringency. All 50 states have adopted Subtitle D.

240. p. 32: The reference to Appendix D that contains a summary of all of the States PCC requirements doesn’t add anything to the document, in my opinion, in that, individual States have created their PCC requirements based on their reasons. Individuals in NY don’t need to know what the PCC requirements are in SD or Wash. because they are not relevant to their permit requirements.

It does seem important to states who might pursue better or innovative ways to do business.

241. p. 33: This begins the discussion of the EREF approach. This needs to be much sooner.

See Section 1.4: “This guidance applies an approach developed by the Environmental Research and Education Foundation (EREF 2006) to evaluate data collected during the active life of a landfill and/or following its closure, and provides the basis for decisions related to enhancing, extending, shortening, or ending post-closure care. The EREF approach referenced herein as an example of one approach to evaluate the data and facilitate post-closure care decisions. While the EREF approach may not be the only approach for evaluating PCC data, it is certainly a model for data collection and evaluation and integrates the key PCC elements.”

242–53. pp. 33–52: This is the heart of the document. These pages talk about the four components—leachate management, gas management, ground water monitoring, and cap maintenance. Each of the four components is divided into five sections: 1) Satisfy Prerequisites, 2) Evaluate change, 3) Implement change, 4) Monitor change, and 5) Module completed. These 21 pages seem to be redundant and could be shortened substantially to basically discuss for any component of PCC that the first section is to determine if you have sufficient data to review in the second section (evaluate change) such that after an evaluation you could then make a change (implement change) and after some period of time (monitor change) you decide whether that specific module is completed or not. The key to the document is what is provided as guidance for how an owner/operator or a State official makes an evaluation.

The team believes that the apparent redundancies are important to convey the hierarchical evaluation that must be conducted. We will consider describing the general steps similarly in each process.

254. p. 56: This document seems to start to drift into a discussion of bioreactors. Not sure that is necessary. Facility manager will need to prove to State that leachate quality is acceptable, gas generation is at an acceptable level, no ground water contamination exists and the potential doesn’t exist for any later—all of these results are independent of how a facility manager elects to operate the facility.

Others on the team and through state’s comments agree that bioreactor landfills have a significant place in the accelerating of PCC.

255. p. 57: Clean closure—is this really happening—not sure it is a legal option under the federal Criteria.

It may be the exception rather than the rule, but even though clean closure is not an option under 258, waste removal and removal of any residual problem thereby eliminating the threat can be conducted at a landfill.

256. p. 57: Active Strategy—Inward gradient—the cons seem to far outweigh the pros for this approach. Why mention it?

The team disagrees. It has been used in several states.

257. Section 7.0, p. 64: Financial Assurance—The information on pp. 64–73 seems to be unnecessary. We understand that financial responsibility and closure go hand in hand; however, five pages that discuss financial assurance mechanisms seem out of place. In addition, on pp. 68–72, information seems to be presented that sounds a lot like comments on the financial assurance requirements. This document should not be a place to comment on financial assurance requirements. “Stakeholders have expressed concerns...” An additional concern is the need to extend financial assurance requirements to a wider variety of facilities (i.e., beyond Subtitle D).

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

258. Not sure what this statement means since there are financial assurance requirements for Subtitle C facilities. “Any discussion of changing the financial assurance system must consider the impact of tying up liquidity of capital resources in fixed instruments. . . .”

This section is meant to be a list of mechanisms available. It appears that the mechanism is a critical issue between the regulating authority and the owner/operator. To avoid any confusion that we are endorsing or encouraging particular mechanisms, we have chosen to remove the section.

259. p. 73: Stakeholder Considerations - This section implies that State programs do not have public participation requirements in their State rules. I would argue that States already take stakeholder considerations into account.

The administrative process is often restricted to the evaluation of decisions not proactively soliciting communities desire for an end use of a property.

Navy (Mach)

261. I review the document yesterday. It is about optimization and ending the post-closure care of municipal landfills. Based on the document’s contents and my experience with NFECSW’s landfill sites moving through the CERCLA process, I saw little practical benefit to our program. It does not explain this is done through the CERCLA process and is big picture in nature. Navy and other guidance documents do a better job. Additionally, half of the topic areas have no (leachate collection systems—no NFECSW sites) or little (gas monitoring system—I NFECSW site) applicability.

DoD representatives were part of the primary authors of the document preparation. We understand that leachate collection and gas management systems are not components of many DoD landfills. One must rely on the modules that do exist to evaluate the performance of the landfill in those cases.

262. While there is little practical benefit from the document, there is benefit in supporting the document for state buy-in to optimization and the concept of ending post-closure care. I was not able to identify a reason to non-concur on the document.

We will accept the concurrence

263. If the purpose of this document is to formulate some guidance and methodology to reduce or end post-closure care, then the purpose has been satisfied. Further, we support the concept of Custodial Care and transfer of such care to future owners, but are cautious about controls that would be in place to ensure that their care would not fail and come back to the Navy.

You are correct to point this out, and it is consistent with the team findings and recommendation. **Finding:** Financial Assurance (FA) is not required during Custodial Care. Covenants, deed restrictions, or other land use control mechanisms may assure that the land is only used accordingly, and that appropriate custodial care is provided. For the purpose of Custodial Care covenants, deed restriction, or other land use control mechanisms are only as effective as the government’s ability and resources to enforce them. These mechanisms may be tied to the land and ultimately are the owner’s responsibility. State environmental

agencies should have a legal mechanism for notification when a land use control has been violated. This allows the state agency an opportunity to investigate any environmental or health consequences of a land use control violation. **Recommendation:** The team recommends that states should develop a template they can use, and adjust to their own use, to track and evaluate the environmental effectiveness of land use controls placed on a landfill site. This might be best accomplished through a national organization that represents the states (see Section 4.8.2).

264. In the findings and recommendations in Section 9, the document states: “Covenants, deed restrictions, or other land use control mechanisms may assure that the land is only used accordingly, and that appropriate custodial care is provided. For the purpose of Custodial Care covenants, deed restriction, or other land use control mechanisms are only as effective as the government’s ability and resources to enforce them. These mechanisms may be tied to the land and ultimately are the owner’s responsibility. State environmental agencies should have a legal mechanism for notification when a land use control has been violated.” This is basically the bottom-line extent of this document’s discussion on Custodial Care, meaning that we all should recognize that the Custodial Care steps are not fully lined out. We realize that this may not really be the purpose of this document. Therefore, the unresolved question in our minds remains: what’s the follow-up to this guidance document and where do we go from here? We continue to be cautious about putting the management of our liability in someone else’s hands, without transferring the liability.

We agree and have been in contact with ASTWMO about organizing a group of states to develop a consistent approach to covenant and deed restrictions. It seems more appropriately conducted by ASTWMO with and ITRC representative.

Appendix H

ITRC Contacts, Fact Sheet, and Product List

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