WASTE MANAGEMENT AREA (WMA)

and

SUPPLEMENTAL WELL (SPW)

GUIDANCE

United States Environmental Protection Agency
Office of Solid Waste
401 M Street, S.W.
Washington, D.C. 20460

FINAL

June 1993

Hugh FYI

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUL 20 1993

OFFICE OF
SOLID WASTE AND EMERGENCY RESPONSE

MEMORANDUM

SUBJECT: Waste Management Area and Supplemental Well Guidance

FROM: Dev Barnes, Director
Permits and State Programs Division, OSW

Susan Bromm, Director Susan Bromm
RCRA Enforcement Division, OWPE

TO: RCRA Branch Chiefs,
Regions I-X

Attached is the June, 1993 "Waste Management Area (WMA) and Supplemental Well (SPW) Guidance." This document is intended to provide guidance to regulators regarding the implementation of the WMA and SPW approaches of the proposed Ground-Water Amendments Rule (53 FR 28160, July 26, 1988) prior to promulgation of the final rule. We appreciate your earlier thoughtful reviews of this document.

The proposed Amendments Rule is designed to increase flexibility in the RCRA ground-water monitoring program so that monitoring systems may be tailored to site-specific conditions and designed to foster the early detection of contaminant releases. We believe that the WMA and SPW approaches will provide greater protection of human health and the environment, and that EPA can immediately implement the approaches in individual facility permits and orders under the authority of the RCRA omnibus provision (RCRA §3005(c)(3) and 40 CFR 270.32(b)(2)).

We have also included an unbound copy of the guidance so that you can easily make additional copies. If you have any questions about this guidance or the Amendment's Rule, please contact Hugh Davis at (703) 308-8633.

Attachment

cc: Dave Fagan, OSW
Ken Gigliello, OWPE
Mimi Newton, OE
Larry Starfield, OGC

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OVERVIEW

EPA proposed Amendments to the RCRA Subtitle C ground-water monitoring regulations on July 26, 1988. The Agency presently is evaluating comments received from the public on the proposed rule and is developing the final rule. The proposed rule contains several provisions, including the waste management area (WMA) and the supplemental well (SPW) provisions, that are intended to increase flexibility in the RCRA ground-water monitoring program so that monitoring systems may be better tailored to site-specific conditions and designed to foster the early detection of contaminant releases. EPA believes that the WMA and SPW provisions of the proposed rule would provide greater protection of human health and the environment, and that EPA can immediately implement the WMA and SPW approaches in individual facility permits under the authority of the RCRA omnibus provision (RCRA §3005 (c)(3); 40 CFR 270.32(b)(2)). The purpose of this document is to provide guidance to RCRA permit writers and other interested parties regarding the implementation of these approaches prior to promulgation of the final rule.[1]

[1] The policies and procedures established in this document are intended solely as guidance and are not intended and cannot be relied upon to create any rights, substantive or procedural, that are enforceable by any party in litigation with the United States. EPA reserves the right to act at variance with these policies and procedures and to change them at any time without public notice.

CHAPTER 1

INTRODUCTION

1.1 Background and History of the Ground-Water Amendments Rule

The Environmental Protection Agency (EPA) first promulgated regulations governing ground-water monitoring at hazardous waste management units on July 26, 1982, under Subtitle C of the Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act of 1976 (RCRA), and the Hazardous and Solid Waste Amendments of 1984 (HSWA). Under these regulations (40 CFR Part 264, Subpart F), facility owners or operators are required to install ground-water monitoring systems and to sample ground water to determine whether there is a release of hazardous constituents from the facility and contamination of ground water. If contamination exceeds statistically significant levels, the owner or operator must perform compliance monitoring or implement a corrective action program in accordance with §§264.99 and 264.100.

EPA proposed Amendments to the Subpart F regulations (hereafter referred to as the "proposed rule" or "proposed Amendments Rule") on July 26, 1988. The Agency presently is evaluating comments received from the public on the proposed rule and is developing the final rule. The proposed rule is intended to increase flexibility in the RCRA ground-water monitoring program so that monitoring systems may be tailored to site-specific conditions and designed to foster the early detection of contaminant releases. The proposed Amendments Rule contains a number of provisions, including the waste management area (WMA), the supplemental well (SPW), and the unsaturated zone (USZ) provisions. The SPW and WMA provisions are the subjects of this guidance document. The Agency plans to implement these provisions in the context of individual permit decisions pursuant to the authority of the RCRA omnibus provision (RCRA §3005 (c)(3) and 40 CFR 270.32(b)(2)) prior to promulgation of the final Amendments Rule. The Office of Solid Waste currently is developing a companion guidance document for the implementation of the USZ provision.

1.2 Summary of the Multiple Waste Management Area (WMA) and Supplemental Well (SPW) Approaches

The proposed Amendments Rule contains a provision that allows for the establishment of multiple WMAs at a facility. The intent of this provision is to provide for protective point of compliance (POC) ground-water monitoring systems that can detect releases earlier, or in some cases, detect releases that may otherwise bypass a single POC monitoring system. This provision also would allow for a separate monitoring program or corrective action for each WMA at a site, thereby more efficiently focusing resources on areas with releases. The designation of a specific area within a facility as a WMA for purposes of a ground-water monitoring or corrective action program does not limit or otherwise affect EPA's corrective action authority under RCRA §§3004(u) and 3008(h), which extends to all contiguous property under the owner or operator's control.

The proposed Amendments Rule also contains the SPW provision that would allow the Regional Administrator (RA) to require the installation of wells to supplement the POC system. The intent of this provision is to allow installation of additional wells where complicated site conditions caused by hydrogeologic or contaminant characteristics could allow contaminants to migrate past or away from the POC without being detected. SPWs may function as standard ground-water monitoring wells, piezometers, or as monitoring wells designed to monitor specific hydrogeologic or contaminant conditions such as perched water tables, fractured bedrock, or nonaqueous phase liquids (NAPLs). SPWs may be necessary to improve the performance of the facility's POC ground-water monitoring system.

1.3 Overlap of the Waste Management Area and Supplemental Well Approaches

The authorities of the proposed SPW and WMA provisions may overlap in certain site-specific cases. This overlap may occur because both proposed provisions allow for extra wells in cases where releases might not be detected by conventional POC monitoring systems that are required under §264.91. [The proposed WMA provision also is intended to promote earlier detection of releases that would be detected otherwise]. In general, however, there are several distinctions between the use of the two approaches. Where only a few additional wells are necessary, or where conditions that warrant additional wells (e.g., reversal of ground-water flow caused by extreme storm surges) are infrequent, SPWs may be more appropriate. SPWs may include wells, such as piezometers, that perform functions other than standard ground-water monitoring, as would be conducted at the POC of a WMA. In cases where a large number of additional wells are needed to detect a potential release, such as from a multi-acre unit overlying complex hydrogeology, forming a WMA with an individualized monitoring program around the unit would be preferred over designating multiple SPWs. Chapters 2 and 3 of this document give additional examples of the uses of the two approaches.

1.4 Purpose of this Document

The purpose of this document is to provide guidance to RCRA permit writers and other interested parties regarding the implementation of the WMA and SPW approaches of the proposed Amendments Rule. This document will assist permit writers in defining single or multiple WMAs, and includes a description of the proposed criteria to be considered when defining WMAs. The document also provides guidance for identifying the need for SPWs, describes the difference between SPWs and POC wells, and explains the use of SPWs for corrective action. Throughout the document, real and hypothetical sites are presented as examples.

Although EPA has not yet finalized the proposed Amendments Rule, the WMA and SPW provisions of the proposed rule ensure greater protection of human health and the environment, and EPA will immediately implement these approaches in the context of individual permit decisions under the authority of the RCRA omnibus provision (§3005(c)(3) and 40 CFR 270.32(b)(2)). The final Amendments Rule, if adopted in a form similar to that proposed, would make the multiple WMA and SPW requirements more explicit and the provisions more readily implementable.

1.5 Organization of this Document

The remainder of this guidance document is organized as follows:

- Chapter 2 provides a detailed discussion of the multiple WMA approach and discusses each of the factors that should be considered when designating WMAs. Chapter 2 also describes those situations where a single WMA might be appropriate.

- Chapter 3 provides a detailed discussion of the SPW approach and describes some of the hydrogeologic settings and waste characteristics that may warrant implementation of the SPW approach. Chapter 3 also discusses the relationship between SPWs and POC wells, and discusses the use of SPWs for interim measures and corrective action.

- Chapter 4 concludes this guidance document by describing how to implement the WMA and SPW approaches.

Appendix I to this guidance document contains proposed modifications to the model permit language to be used in implementing the WMA and SPW approaches. Appendix II compares and contrasts the objectives and uses of WMAs and corrective action management units (CAMUs).

CHAPTER 2

THE MULTIPLE WASTE MANAGEMENT AREA APPROACH

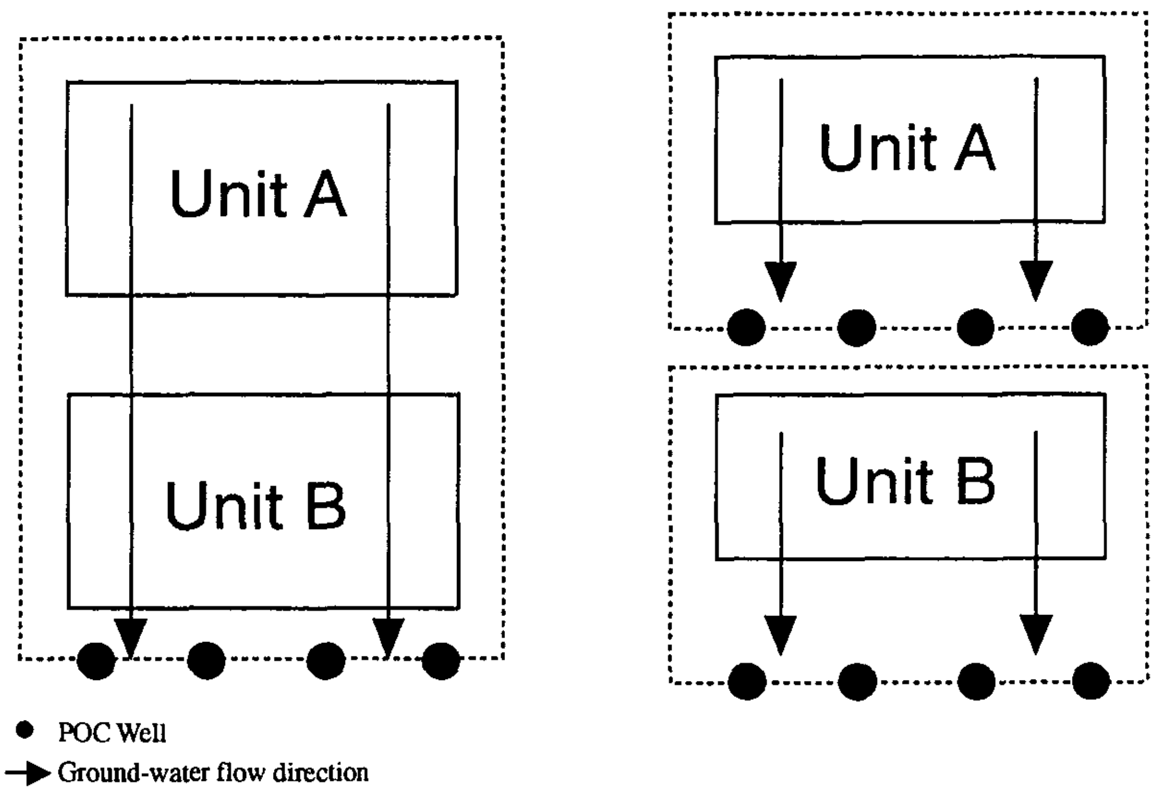
2.1 Description and Intent of the Multiple Waste Management Area Approach

For facilities that contain more than one regulated hazardous waste management unit, §264.95(b)(2) currently states that the WMA is described by an imaginary line circumscribing all of the regulated units. A point of compliance (POC) ground-water monitoring system is located at the downgradient margin of the WMA. The POC is the point at which both the ground-water protection standard must be met and monitoring must be conducted. [The POC is defined as a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated units.] However, the current regulations establishing a single WMA for the entire facility may prevent the early detection of ground-water contamination in certain circumstances. For example, if a contaminant release occurred at the upgradient edge of a WMA, ground-water contamination would not be detected until the release migrated to a POC well. Such a scenario could result in extensive contamination of the uppermost aquifer prior to detection of the release. The WMA provision of the proposed Amendments Rule (§264.95(b)(3)) and its implementation in individual permits through the omnibus provision, is intended to provide an additional margin of safety above that provided by the existing regulations in such cases.

As depicted schematically in the following diagram, §264.95(b)(3) of the proposed Amendments Rule would allow the Regional Administrator (RA) to designate the WMA in individual permits as: (1) an imaginary line circumscribing a number of waste management units, and/or (2) imaginary lines circumscribing individual waste management units. Similarly, permit writers may require such provisions in individual permits where deemed necessary to protect human health and environment based on the omnibus authority. The multiple WMA approach would allow individual monitoring requirements to be defined at each WMA to: (1) promote ground-water monitoring and phased corrective action strategies that correspond to the magnitude of the contamination in each waste management area (e.g., one portion of the facility could be in corrective action while another portion is in detection monitoring), (2) eliminate the potential for a required response action at one unit to unnecessarily trigger a response action for all units, (3) minimize the time from when a release occurs to when it is detected, and (4) minimize the volume of aquifer potentially contaminated prior to detection of a release. The multiple WMA approach will ensure greater protection of human health and the environment and eliminate unnecessary monitoring programs or remediation measures.

Case 1: WMA is designated by an imaginary line circumscribing more than one waste management unit.

Case 2: WMAs are designated by imaginary lines circumscribing individual waste management units.



Waste management areas (WMAs) and corrective action management units (CAMUs) which are authorized by §264.552 of Subpart S, both circumscribe areas or units containing hazardous wastes or constituents. The two designations are made for different purposes, however, and are independent of one another from a regulatory standpoint. A comparison of WMAs and CAMUs is given in Appendix II of this document.

2.2 Criteria for Defining Waste Management Areas

To determine whether it is appropriate to define single or multiple WMAs, the permit writer should consider the following five factors:

1) number, spacing, and orientation of units;

2) waste types handled;

3) hydrogeologic setting;

4) site history; and

5) engineering design of units.

These criteria are summarized in Table 2-1 and are discussed in the following sections.

To select a WMA configuration that is protective of human health and the environment, the five factors should be assessed as to how they affect:

- Early detection or lack of detection of releases from the unit(s); and
- Ease or difficulty of corrective action.

2.2.1 Number, Spacing, and Orientation of Units

The number, spacing, and orientation of the waste management units may significantly affect the designation of WMAs and monitoring programs. The spatial relationship between units must be considered in conjunction with other factors such as hydrogeology and waste characteristics. The distance between regulated units may be sufficient such that releases go undetected, or are not detected promptly with a single WMA. Example 1 demonstrates how a release from an isolated waste management unit located within a larger WMA may not be detected until extensive contamination has taken place.

When the regulated units within a WMA are closely spaced, it usually will not be necessary to establish separate ground-water monitoring systems for each unit. However, in some cases, closely-spaced units should be designated as separate WMAs. For example, if the contaminants of concern are not highly mobile, the designation of separate WMAs for individual units will better provide for early detection of contaminant releases.

Table 2-1

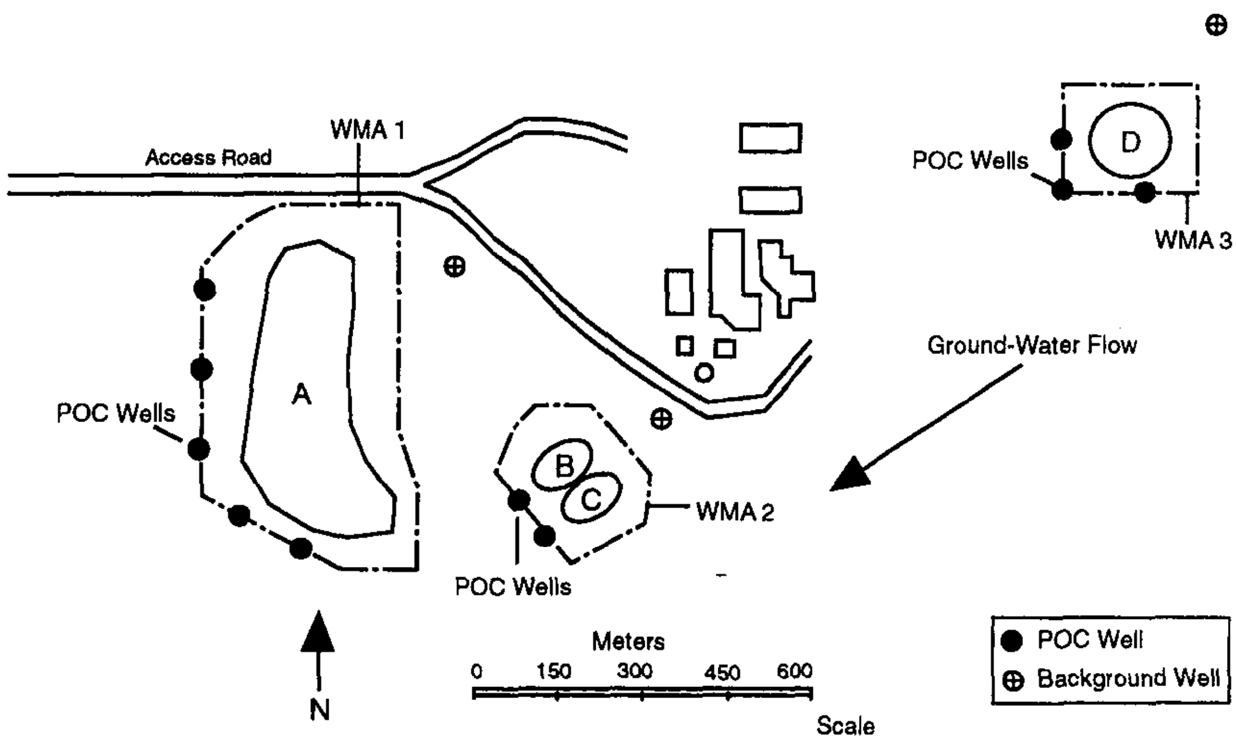
Criteria Influencing Designation of Multiple Waste Management Areas

Factor	Multiple WMAs may be appropriate if:
- Number - Spacing - Orientation of Units	• There is more than one regulated unit. • There are great distances between units. • Closely-spaced units are oriented such that a monitoring system for one unit may not detect releases from the other unit(s), or the source of a release cannot be distinguished.
Waste Type	• Wastes are not highly mobile. • Wastes managed in closely-spaced units are identical. • Nonaqueous Phase Liquids (NAPLs) are present.
Hydrogeologic Setting	• There is a ground-water divide between units. • There is a change in geology between units that influences ground-water flow (e.g., due to stratigraphy, structure, fractures, faults, solution channels, etc.). • A surface water body influences the hydrogeology (e.g., tidal influences, gaining/losing streams). • Perched water zones or other preferred contaminant migration pathways are present. • There are natural or human-induced fluctuations in ground-water flow direction
Site History	• Waste type has changed over time. • Regulated units are located near solid waste management units (SWMUs). • A unit has been subject to compliance monitoring or corrective action in the past.
Engineering Design	• There are buried pipes, utility trenches, etc., where a point source leak might occur. • Type of unit is different than adjacent units. • A unit is poorly constructed or has a high potential for failure or leakage.

WMA Example 1

Designation of Multiple Waste Management Areas Due to Significant Distance Between Units

An automotive parts assembly plant is located in the glaciated central region of the United States. The water table is approximately 30 feet below ground surface. A WMA comprised of three waste management units (Units A, B, and C) is located in the southwest portion of the site. An isolated waste management unit, Unit D, is located greater than 1,000 meters upgradient from Units A, B, and C. If all four units were included in one WMA, a release from Unit D would travel a significant distance beneath the WMA prior to detection at the POC wells. If the resulting contamination were to remain undetected for a substantial period of time, the potential for exposure to contaminants would be greater and the remediation more complex and expensive. Alternatively, the release might not migrate along a straight path towards the POC wells and might miss the POC wells and go undetected. A more protective strategy would be to designate three WMAs (WMA 1, WMA 2, and WMA 3), each with its own background well(s) to better differentiate sources of contamination, as shown in the figure below.



Finally, the orientation of the units may affect the designation of WMAs. Example 2 shows a large facility with a series of regulated units whose long axis is approximately parallel to the direction of ground-water flow. In this example, a release from the most upgradient unit would not be detected until it had migrated the entire length of the WMA. In this situation, it may be appropriate to break the WMA into two or more WMAs and to install additional POC wells to ensure more immediate detection of a release. Alternatively, supplemental monitoring wells (SPWs, discussed in Chapter 3) may be used to assure detection of a release from the upgradient regulated units. SPWs are intended to supplement POC systems that might not adequately detect releases. If only two or three wells are needed to assure the detection of a release, SPWs might be a better option than designating multiple WMAs. However, if larger numbers of wells are needed, or if corrective action of any unit is triggered, subdividing the WMA into multiple WMAs could direct resources more efficiently for monitoring and cleanup purposes.

2.2.2 Waste Type Handled

The type of waste that each unit contains or has contained in the past can affect chemical fate and transport or the likelihood of a release. These factors can influence whether units should be monitored as a single WMA, whether different types of waste require different monitoring systems or programs, or whether units or groups of units containing wastes with distinctive properties are appropriate candidates for multiple WMAs. Two of the most important factors to consider with regard to waste type include the physical state of the waste (liquid (including presence of light and dense nonaqueous phase liquids (LNAPLs and DNAPLs)), solid, sludge) and waste chemistry, including such factors as toxicity, mobility, solubility, and pH.

The physical state of the waste may influence the likelihood of a release. For example, if the a liquid waste is managed in the unit, a leak or structural failure of the unit may result in an immediate release to ground water or the unsaturated zone. Structural failure of a unit containing solid wastes may not result in contamination of ground water until infiltrating rain water mobilizes the contaminants.

WMA Example 2

Designation of Multiple WMAs Due to Orientation of Waste Management Units

A large facility located in the Atlantic Coastal Plain operates a series of surface impoundments that have been designated as a single WMA, as shown below in Figure A. The long axis of this single WMA is parallel to the direction of ground-water flow. If a release from the most upgradient impoundment occurred, the release would not be detected until it had migrated the entire length of the WMA to the POC wells. In addition, small changes in the ground-water flow direction might cause a release to remain undetected as it migrated to the side of the POC wells. In this situation, dividing the existing WMA into two or more WMAs as indicated in Figure B would have been more protective of human health and the environment.

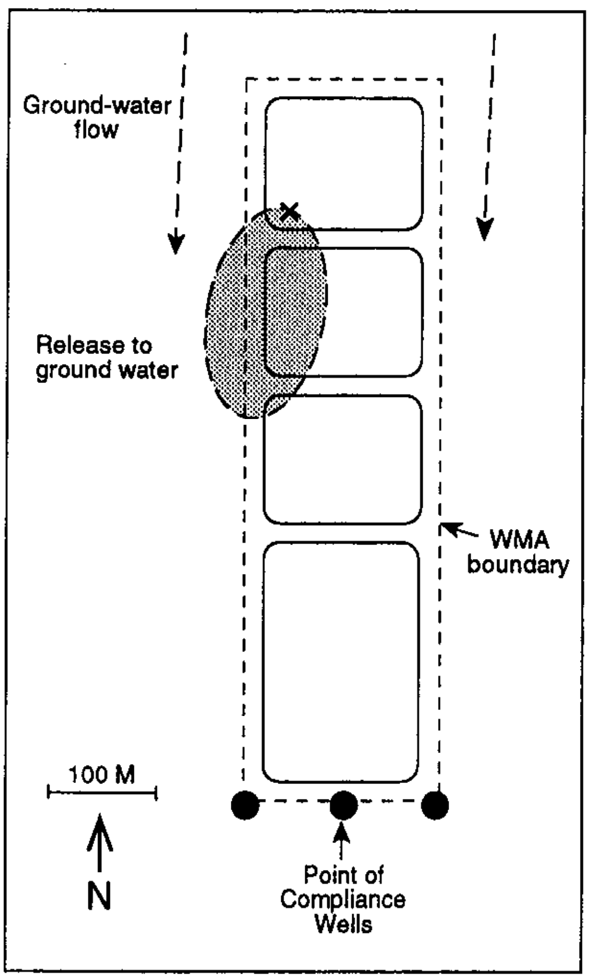


Figure A

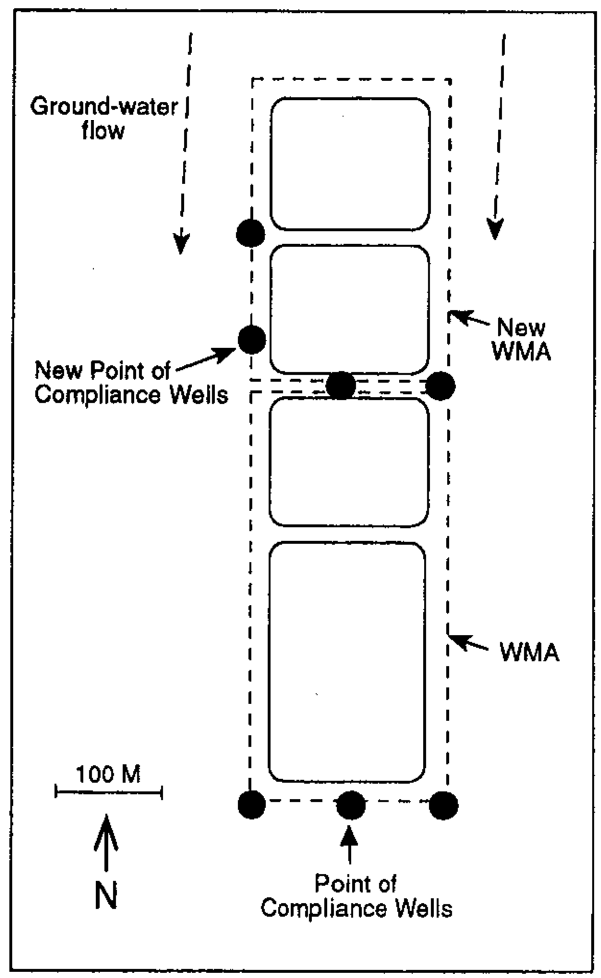


Figure B

Waste chemistry also should be considered in designating WMAs. For example, highly soluble or mobile contaminants might be readily detected with a single ground-water monitoring system monitoring a multi-unit WMA, whereas less mobile contaminants may be released into the subsurface for a long period of time before they are detected. Thus, at sites where there are multiple units containing relatively immobile constituents, a multiple WMA designation may facilitate the detection of a release prior to extensive subsurface contamination. Factors such as pH, hardness of ground water, and organic matter content can affect the mobility of certain metals. For example, at high pH and in oxidizing conditions, trivalent chromium can convert to hexavalent chromium, which is a more mobile and toxic form.

LNAPLs and DNAPLs are particularly difficult to remediate and may require unique monitoring systems. Units with the potential to release LNAPLs or DNAPLs should be considered candidates for designation as single WMAs so that a sufficiently protective ground-water monitoring program can be implemented. NAPLs are discussed further in Section 3.4 of this document.

It may be possible to differentiate between releases from multiple units within a single WMA if waste types differ significantly among units. In such a situation, multiple WMAs may not be needed, since a release may be readily attributable to the unit containing the constituents present in the release.

2.2.3 Hydrogeologic Setting

The hydrogeologic setting of a facility strongly influences the potential transport and migration of contaminants once a release has occurred. The permit writer should evaluate flow net and conceptual geologic/hydrogeologic models to determine if appropriate zones are being monitored and if the horizontal and vertical placement of the wells is sufficiently protective. If different or complex hydrogeologic settings exist at a facility, it might be more protective to establish multiple WMAs at the facility. Key elements of the hydrogeologic setting that may influence the need to designate multiple WMAs include:

- Depth to ground water;
- Perched water tables;
- Lateral and vertical changes in natural water chemistry;
- Geologic structures;
- Ground-water flow directions, gradients, and rates; and
- Waste management unit effects.

The SPW approach (discussed in Chapter 3 of this document) also may be applied at sites with varied or complex hydrogeologic settings. The SPW approach is intended to allow for the placement of additional wells when the existing POC wells might not detect releases. SPWs can be used for the same purposes as POC wells, or may be specialized wells (e.g., for monitoring intermittent perched water tables) or simple piezometers. If few additional wells are needed, SPWs may be an appropriate complement to the POC well system. However, if a large number of additional wells are needed, the designation of an additional WMA with its own monitoring program may be the most appropriate response.

Ground-Water Flow Directions, Gradients, and Rates

Ground-water flow directions, gradients, and rates may be the most significant hydrogeologic factors affecting the designation of multiple waste management units. The permit writer should evaluate flow nets and potentiometric surface maps submitted by the owner/operator to assess the presence of ground-water divides, the potential effects of nearby surface water bodies (e.g., ponds, lakes, gaining or losing streams, oceans), seasonal or tidal affects on the water table elevations and hydraulic gradients, effects of pumping of nearby water supply wells (e.g., local public, facility, or agricultural supply wells), and the presence of steep downward or upward hydraulic gradients, or other gradients, such as radial flow from human-made ponds. In certain cases, potentiometric surface maps must be constructed from measurements made during periods of potential change in ground-water flow direction, such as during seasonal agricultural pumping or during high or low tides, in order to detect complex or variable flow directions.

Example 3 shows how the presence of a ground-water divide at a facility may affect the designation of WMAs. Example 4 shows how the presence of a surface water body at a facility can affect the designation of WMAs. Example 5 demonstrates how the use of multiple WMAs may enhance detection of releases at a site with strong downward hydraulic gradients.

Depth to Ground Water

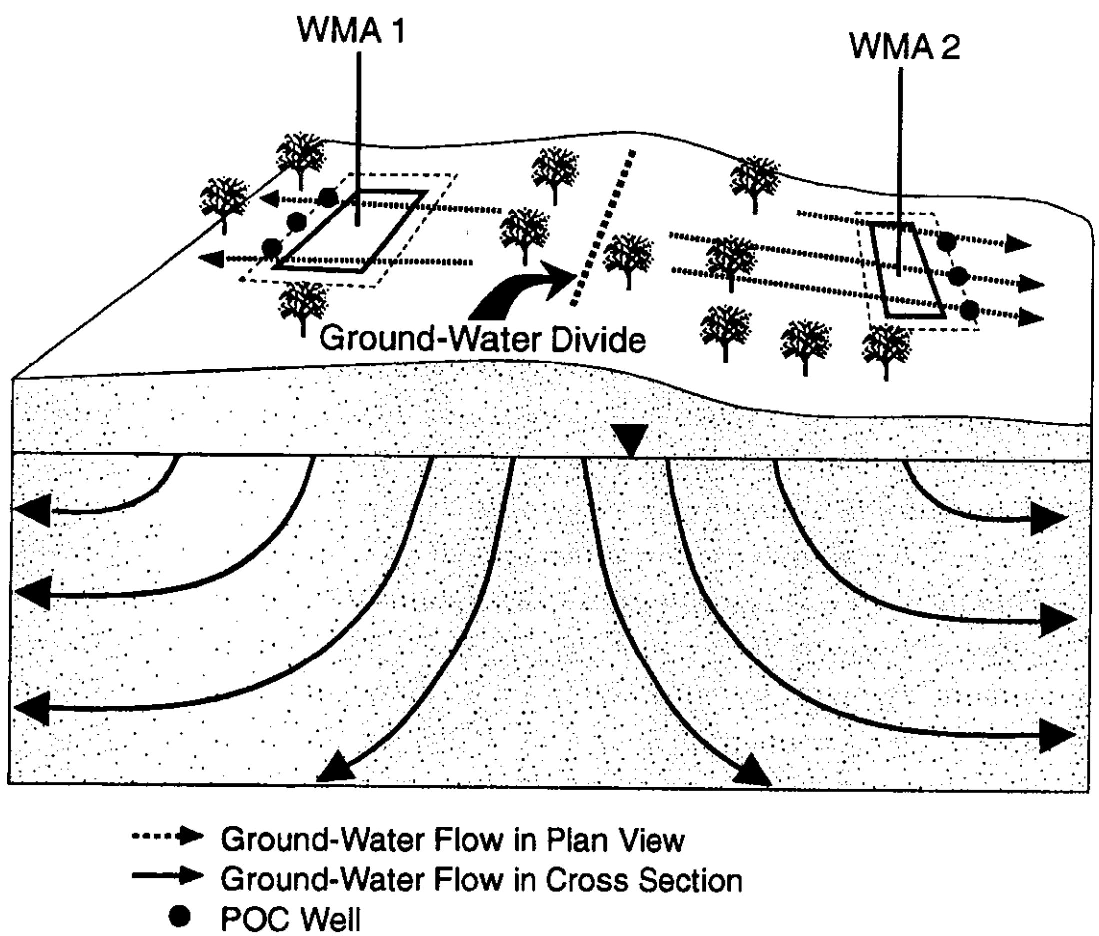
Depth to the saturated zone, when considered with the characteristics of the geologic material beneath the regulated units, can have a substantial influence on the potential migration of contaminants released to ground water. The thickness and transport characteristics of the unsaturated zone (used synonymously with "vadose zone" in this document), as well as the contaminant characteristics, influence the potential for contaminant migration to ground water. If depth to ground water is shallow, a release from the unit may result in an immediate release to ground water. However, even with great depths to the saturated zone, contaminants released in sufficient quantity also can migrate to the water table. In certain situations, such as when depth to the saturated zone is great, monitoring of the unsaturated zone may enable detection of releases prior to extensive contamination of the subsurface. The proposed Amendments Rule contains a provision to allow for unsaturated zone monitoring at hazardous waste sites. The Office of Solid Waste currently is developing a document to provide guidance on the design and implementation of unsaturated zone monitoring systems. Additional information and guidance on unsaturated zone characterization and monitoring can be found in Permit Guidance Manual on Unsaturated Zone Monitoring for Hazardous Waste Land Treatment Units (USEPA, 1986) and Monitoring In the Vadose Zone: A Review of Technical Elements and Methods (USEPA, 1980).

If depth to ground water is great, the permit writer should evaluate the potential for monitoring perched water tables. The importance of monitoring perched water is discussed in the following subsection.

WMA Example 3

Designation of WMAs in the Vicinity of a Ground-Water Divide

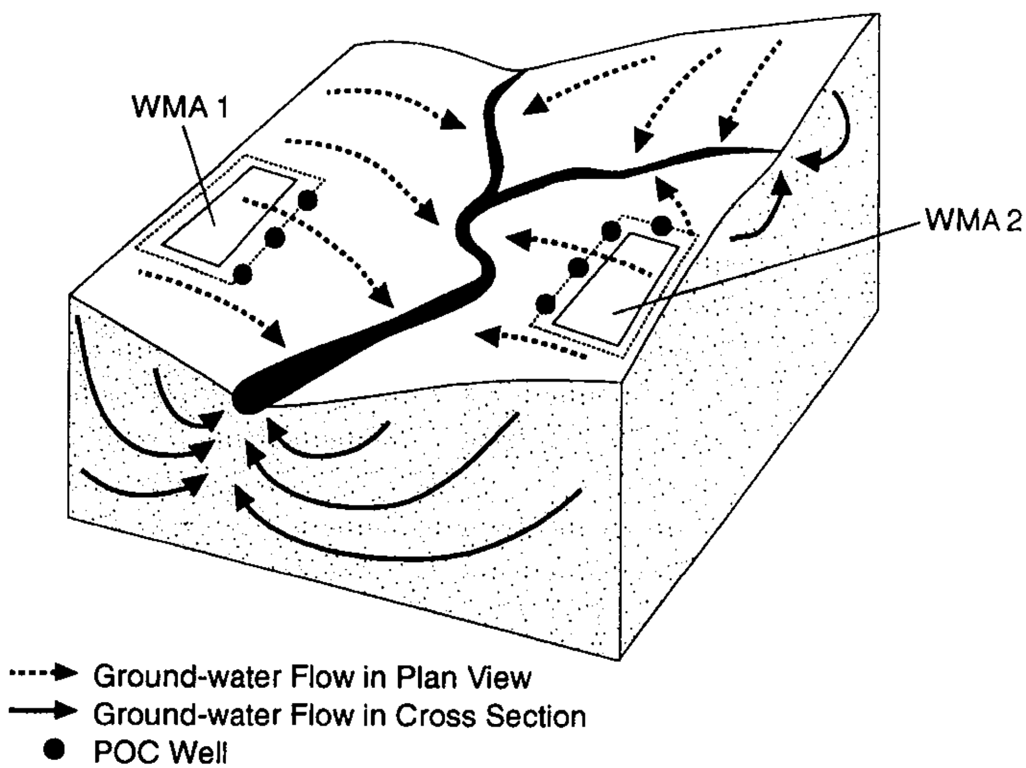
A facility located in the nonglaciated central region of the U.S. is positioned over a ground-water divide as shown in the figure below. In this example, the presence of the ground-water divide affects the appropriate designation of WMAs. Although closely-spaced, WMA 1 requires POC wells located on the west side of the WMA, while WMA 2 requires POC wells located on the east side of the WMA.



WMA Example 4

Effect of Surface Water Body and Ground-Water Flow Direction on Designation of WMAs

A pesticide manufacturing facility manages sludge in two waste management units. Ground-water flow in the uppermost aquifer at the facility is towards a stream, which bisects the site. The waste management units are located on either side of the stream. In this situation, it is appropriate to designate two WMAs as shown in the figure below to detect releases from each waste management unit.

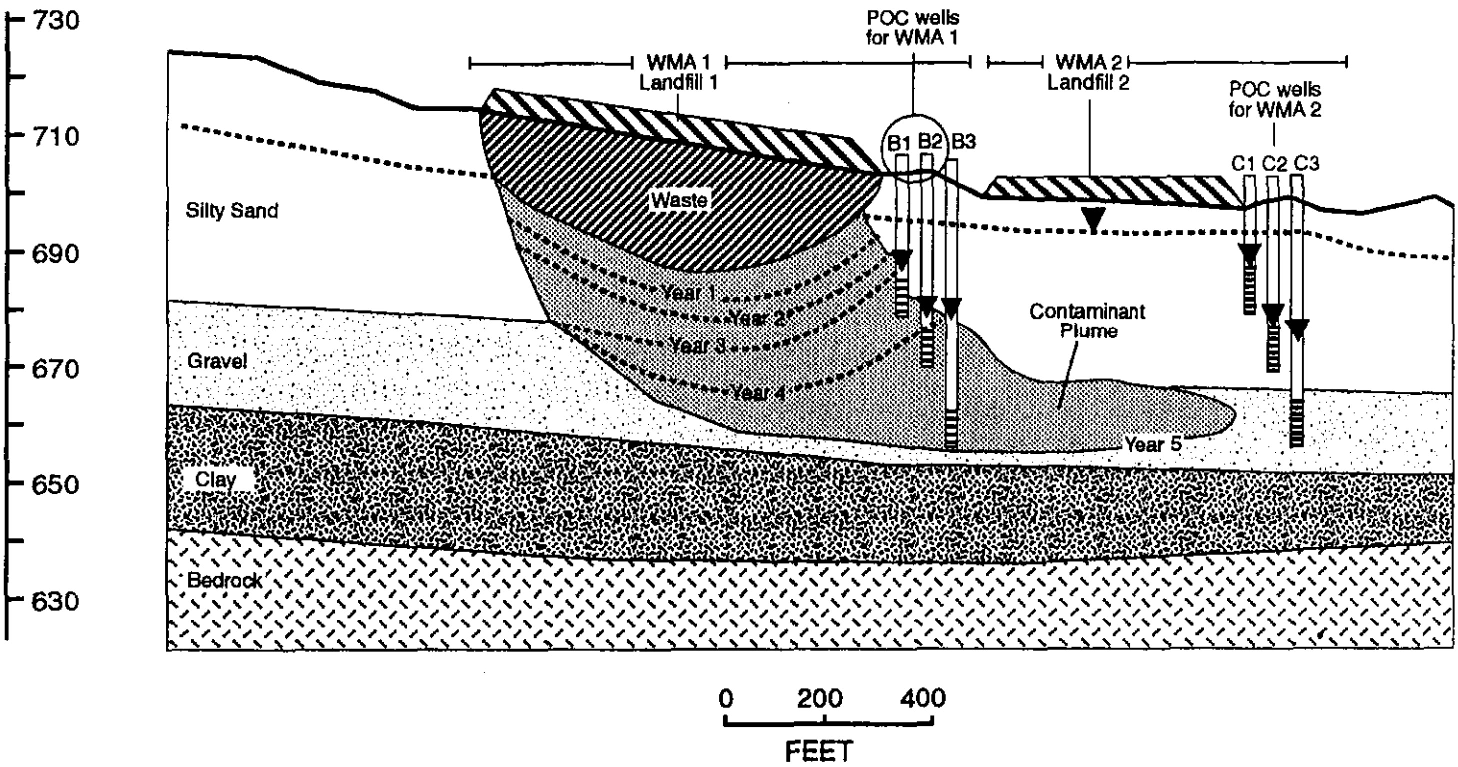


(Modified from Heath, 1982)

WMA Example 5

Effect of High Downward Gradients on Designation of WMAs

A pharmaceutical manufacturing facility manages fly ash in two landfills. A hydrogeologic investigation of the facility indicated that a strong downward hydraulic gradient is present in a silty sand unit with a relatively low horizontal hydraulic conductivity that underlies the landfills. In this scenario, monitoring the uppermost aquifer at wells C1, C2, and C3 would not detect a release from Landfill 1 for many years, and thus would not be protective of human health and the environment. The hydrogeologic conditions at this facility make it necessary to designate two WMAs as shown in the figure and to install POC wells at the downgradient margin of each WMA.



(Modified from Sara, 1991)

Perched Water Tables

In more complex unsaturated zone environments, perched water tables may be present. These discontinuous saturated lenses may act as conduits or migration pathways for contaminants released from a waste management unit. A perched zone may develop on lower hydraulic conductivity lenses or within lenses or layers of higher hydraulic conductivity. A perched zone can be seasonal as it is recharged by precipitation events or by a fluctuating water table. Ground-water flow in a perched zone might not follow the local ground-water flow direction. Because of these complexities, separate ground-water monitoring strategies are often needed for perched water tables. A waste management unit or group of units overlying zones of perched water may be designated as a single WMA.

Lateral and Vertical Changes in Natural Water Chemistry

Lateral and vertical changes in sediment and rock type across a facility can influence the natural ground-water chemistry and consequently are important factors that must be considered in the designation of WMAs. Current EPA guidance (RCRA Ground-Water Monitoring: Draft Technical Guidance, 1992) suggests that the owner/operator screen background and POC monitoring wells in equivalent stratigraphic horizons to obtain comparable ground-water quality data. In cases where the geology is complex, it may be necessary to designate multiple WMAs so that background and POC wells are hydraulically connected.

Geologic Structures

Geologic structures can have a significant impact on ground-water movement by acting as preferential flow paths or by acting as barriers or conduits for ground-water flow. Examples of structures that may influence ground-water movement and direction include faults, fractures, and folded or dipping formations.

Steeply dipping alternating formations of differing hydraulic conductivities can cause preferential movement of ground water along the strike of the geologic units with higher hydraulic conductivities. Changes in structural characteristics can result in variations in the direction of ground-water movement at a single site.

Faults may serve as either conduits or as barriers to ground-water movement. If the fault zone consists of finely ground rock and clay, the material may have a very low hydraulic conductivity (e.g., less than 1 x 10^{-6}cm/s) resulting in significant differences in water level across the fault. If a fault that acts as a barrier to ground-water movement transects a multi-unit WMA, it may be appropriate to designate separate WMAs for the hydrogeologically distinct areas on each side of the fault.

Waste Management Unit Effects

The presence of a waste management unit (e.g., a landfill) can affect ground-water flow under and adjacent to the unit. For example, the compaction of the clay subgrade and any overlying clay liners during landfill construction can have a temporary effect (estimated six months to five or more years) on the potentiometric surface, producing a depression in the water table. In other materials, such as silts, surface loading caused by the landfill, especially the embankments, produces consolidation of the underlying sediment. This consolidation may increase the capillarity of the sediment and result in mounding of the ground water beneath the unit.

Because the owner/operator is required to make an annual determination of ground-water flow direction and rate (including construction of potentiometric surface maps), the permit writer should assess on an ongoing basis whether the effects of waste management units on ground-water flow are sufficient to require a modification of WMAs.

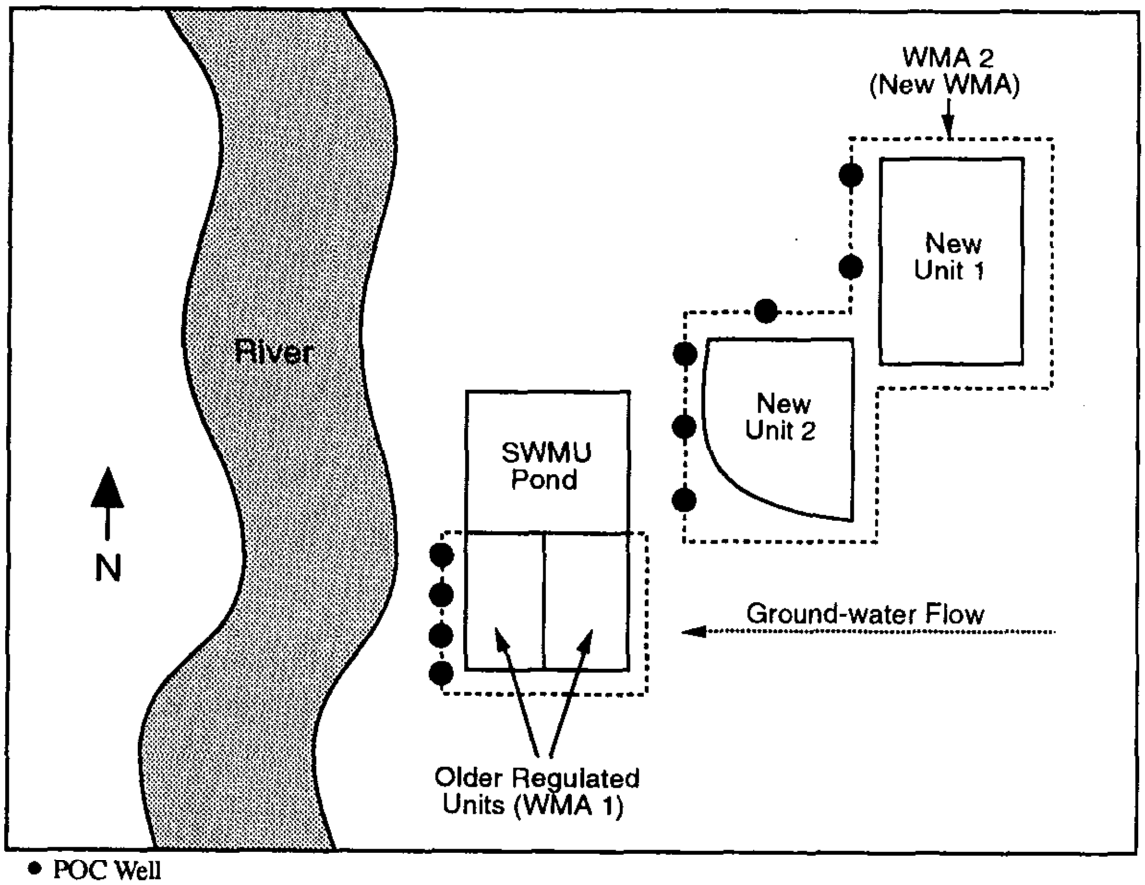
2.2.4 Site History

Historical operating practices at a facility may influence the present-day ground-water monitoring regime. Changes in waste management activities and in waste types handled, the historical or current presence of other solid waste management units (SWMUs), and any associated remedial actions taking place may influence the need for designating multiple WMAs. Example 6 provides an illustration of a facility at which site history influenced the designation of a new WMA.

WMA Example 6

Influence of Site History on the Designation of Multiple WMAs

A facility located in the Blue Ridge Region of the eastern United States is located on thick, layered river deposits. Ground-water flow is to the west, towards a river. The site includes an older SWMU that has contributed to ground-water contamination and is adjacent to two regulated waste management units (currently managed as a single WMA, WMA 1). The two regulated units are in compliance monitoring. Two new state-of-the-art regulated units (New Unit 1 and New Unit 2) are to be constructed upgradient of the older units. In this example, it is appropriate to delineate a new WMA, WMA 2, solely to monitor the new waste management units. If all four regulated units were designated as one WMA with the same POC wells, all the units would be in compliance monitoring, as Subpart F regulations require all regulated units in a WMA to be under the same monitoring program.



2.2.5 Engineering Design of Units

The nature and design of each unit, including any associated engineered structures and ancillary equipment, should be considered in the designation of WMAs. For example, if a unit is poorly constructed or has a high potential for failure or leakage, the permit writer should consider monitoring the unit as a single WMA. Key factors to consider when evaluating engineering design aspects of waste management units are:

- Type of unit (e.g., landfill, surface impoundment, or waste pile);
- Size of units or WMAs; and
- Potential point sources of contaminant releases.

The type of unit and its design can affect its potential for release and the appropriateness of its designation as a WMA. For example, construction materials for liners of surface impoundments can vary from clay to state-of-the-art double liners with leachate collection systems.

The size of a waste management unit also may be a significant factor when considered along with the geology and hydrogeology beneath the unit. If the hydrogeologic setting changes beneath a unit, the most protective strategy for the unit may be designating it as a single WMA with an individual ground-water monitoring system. See Section 2.2.3 of this guidance for a discussion of hydrogeologic factors influencing the designation of WMAs.

Point source contaminant releases can occur where ancillary equipment such as buried pipes and utility trenches are located. Failure of a waste management unit can occur due to age of the unit, poor design, proximity to a hill or slope, or excessive liquid pressure in a pipe or containment vessel. The potential for point source contaminant releases or unit failure should be considered during the designation of WMAs.

2.3 New, Replacement, or Expansion Units

If a new, replacement, or expansion unit is built adjacent to an existing unit, it may be appropriate to incorporate the additional unit into the WMA of the existing unit, thus expanding the WMA overall. If the additional unit is downgradient of the existing unit, the POC for a new combined WMA could be at the hydraulically downgradient limit of the additional unit. The original POC wells at the existing unit could become informational wells and would no longer be subject to POC well monitoring requirements. If old POC wells must be decommissioned, as in the case of expansion of an existing unit, they must be decommissioned properly (American Water Works Association, 1988). If the new unit is upgradient of the existing unit, either the POC for the new combined WMA would remain the same, or it would be necessary to create a new WMA. In both cases, it might be necessary to install new upgradient wells.

2.4 Situations Where A Single WMA Is Appropriate

Many facilities will not require the designation of multiple WMAs to ensure adequate protection of human health and the environment. Four examples of where the designation of a single WMA generally is appropriate include:

1. When units are closely spaced and designating multiple WMAs offers neither significant increase in protection to human health and the environment, nor earlier detection of a release;

2. When units contain unique types of waste. It is easy to identify the source of release by correlating the type of contamination with the waste contained in each unit;

3. When several units are located over materials with high hydraulic conductivity, such as unconsolidated beach sand, and detection of a release would not be subject to an unacceptable delay; and

4. When a small number of wells is needed for additional protection, or the event that necessitates additional wells is infrequent, and SPWs are added (for further discussion, see Section 1.3).

CHAPTER 3

THE SUPPLEMENTAL MONITORING WELL APPROACH

3.1 Description and Intent of the Supplemental Well Approach

The proposed Amendments Rule would modify §264.95(a)(2) to allow the Regional Administrator (RA) to require installation of supplemental wells (SPWs) where complicated site conditions caused by hydrogeology or contaminant characteristics could allow contaminants to move past or away from the point of compliance (POC) without detection. Similarly, under the authority of the omnibus provision (RCRA §3005(c)(3) and 40 CFR 270.32(b)(2)), the RA may require such provisions in permits or orders where deemed necessary to protect human health and the environment. Monitoring the uppermost aquifer at the POC will continue to be the primary component of the Subpart F ground-water monitoring program. However, in certain cases, SPWs may be necessary to improve the performance of the facility's POC ground-water monitoring system to protect human health and the environment.

SPWs are intended to serve multiple purposes and, by definition, are supplemental to the wells required by the RA at the POC. SPWs may function as standard ground-water monitoring wells, piezometers, or monitoring wells designed to monitor specific hydrogeologic or contaminant conditions such as perched water tables, fractured bedrock, or nonaqueous phase liquids (NAPLs). In addition, it may be necessary in some cases for the RA to modify the location, number, and depth of monitoring wells at the POC. For example, if SPWs are needed where contamination could bypass POC wells without detection, the RA may remove the POC well(s) from the monitoring program.

3.2 Defining the Need for Supplemental Monitoring Wells

SPWs may be designated by the RA in cases where site conditions might allow contaminants to migrate past or away from the POC without being detected. The need for SPWs must be determined after considering the site hydrogeology, waste and contaminant characteristics, and the POC monitoring well system. The information used to determine whether SPWs are necessary and to designate SPWs will include existing site characterization data and any other available hydrogeologic studies. The need for SPWs can be evaluated during the permitting process or following subsequent ground-water monitoring (Chapter 4).

In general, as site hydrogeology increases in complexity, and as sites increase in size or number of units, the need for SPWs will be greater. The following sections (3.3 and 3.4) describe several hydrogeologic settings and waste characteristics which may warrant the use of SPWs. Each section includes real and hypothetical case studies. These case studies do not include all possible uses of SPWs, but provide examples of likely scenarios that would result in contaminant releases going undetected without the use of SPWs.

3.3 Hydrogeologic Site Conditions That Might Require Supplemental Monitoring Wells

The hydrogeologic characteristics of a site control the movement of ground water and contaminants. Consequently, the design of the monitoring system and the need for SPWs should take into consideration the hydrogeologic characteristics of a site, such as:

- The subsurface materials below the owner/operator's hazardous waste facility, including:
  - The lateral and vertical extent of the uppermost aquifer;
  - The lateral and vertical extent of upper and lower confining units/layers;
  - The geology at the owner/operator's facility (e.g., stratigraphy, lithology, structural setting); and
  - The chemical properties of the uppermost aquifer and its confining layers relative to local ground-water chemistry and hazardous waste managed at the facility;
- Ground-water flow below the owner/operator's hazardous waste facility, including:
  - The vertical and horizontal directions of ground-water flow in the uppermost aquifer;
  - The vertical and horizontal hydraulic gradient(s) in the uppermost aquifer;

- The hydraulic conductivities of the materials that comprise the uppermost aquifer and its confining units/layers; and

- The average linear horizontal velocity of ground-water flow in the uppermost aquifer.

If geologic units beneath a site are discontinuous, exhibit variations in thickness and/or dip, are highly fractured, or contain conduits, hydraulic conductivity and hydraulic gradients may exhibit frequent and significant variations across a site. Natural and human-induced factors such as fluctuating water levels in nearby surface water bodies and on- or off-site pumping wells also may influence hydraulic gradients and ground-water flow directions.

If a hydrogeologic investigation indicates the existence of such complex hydrogeologic conditions, careful consideration must be given to the need for SPWs to assure the detection of contaminant releases that might not be intercepted by POC wells. The more common types of complex hydrogeologic settings that may require SPWs include:

- Zones of high hydraulic conductivity;
- Presence of fractures and fracture flow;
- Perched water tables;
- Presence of conduits and conduit flow in karst terrains;
- Dipping geologic units;
- Strong vertical gradients;
- Natural fluctuations in ground-water flow direction; and
- Human-induced fluctuations in ground-water flow direction.

The following sections provide a discussion of each of these complex hydrogeologic settings.

3.3.1 Zones of High Hydraulic Conductivity

In geologic formations consisting of units or zones of largely different hydraulic conductivities, ground water generally flows toward, and preferentially migrates in, the zones with higher hydraulic conductivity. Examples of higher hydraulic conductivity zones contained within lower hydraulic conductivity formations include:

- Buried river or stream channels;
- Buried bedrock valleys;
- Fill materials; and
- Buried glacial deposits (e.g., eskers, kames, outwash).

Zones of high hydraulic conductivity located in lower hydraulic conductivity materials may effectively direct contaminant migration away from POC wells, causing a release to go undetected. As shown in Example 1, SPWs can be located in zones of higher hydraulic conductivity to ensure that a contaminant release will be detected.

3.3.2 Fractures and Fracture Flow

The migration of contaminants in ground water can be controlled by the orientation, density, and connectivity of fractures or faults in bedrock (e.g., shale, limestone, granite). Fractures can increase the hydraulic conductivity of otherwise "impermeable" bedrock and may provide a conduit or preferential pathway for contaminant migration. If monitoring wells have been installed without consideration of the location of fractures and the direction of fracture flow, contaminants might migrate past the POC without being detected. Although regional flow patterns are generally established during site investigations, flow through fractures is often difficult to predict. Facilities overlying fractured bedrock require additional investigative techniques (e.g., fracture trace analysis, detailed geologic mapping, geophysical investigations, fracture analysis of cores, pump tests to assess anisotropy) to adequately determine ground-water flow pathways and to design a protective ground-water monitoring system. Example 2 illustrates the use of SPWs in areas where contaminants might migrate within bedrock fractures.