



Groundwater Monitoring at Landfill Sites

Selected Idiosyncratic Topics

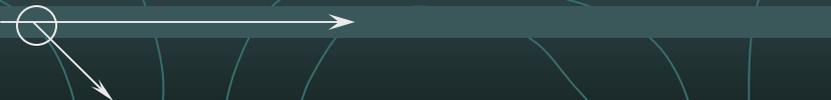


Topics of Discussion

- Conceptual site model development at landfill sites
- Landfill gas/Groundwater interaction
- Differential recharge?
- Regulatory point of compliance with regard to groundwater monitoring at landfill sites



Conceptual Site Model Development at Landfill Sites



Often Underutilized and Difficult to
Develop



Conceptual Site Model (CSM) Defined

- The primary tool used to predict the degree of heterogeneity and the nature of spatial patterning of data and contaminant migration pathways.(USGS)
- The conceptual site model synthesizes and crystallizes what is already known about a site that is pertinent to decision-making requirements.



Conceptual Site Model Evolution

- Initial CSM is based on available site data
- As more data is collected, the CSM is refined



Inherent Difficulties in CSM Development for a Landfill Site

- Often historical data gaps for waste volume, waste type and landfill construction
- Source heterogeneity
- ‘Infinite’ nature of source
- Complex chemical and biological processes occurring simultaneously
- Multimedia concerns
- Ambiguity in the applicability of regulations

Different Landfill Constructions



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Landfill Gas/Groundwater Interaction

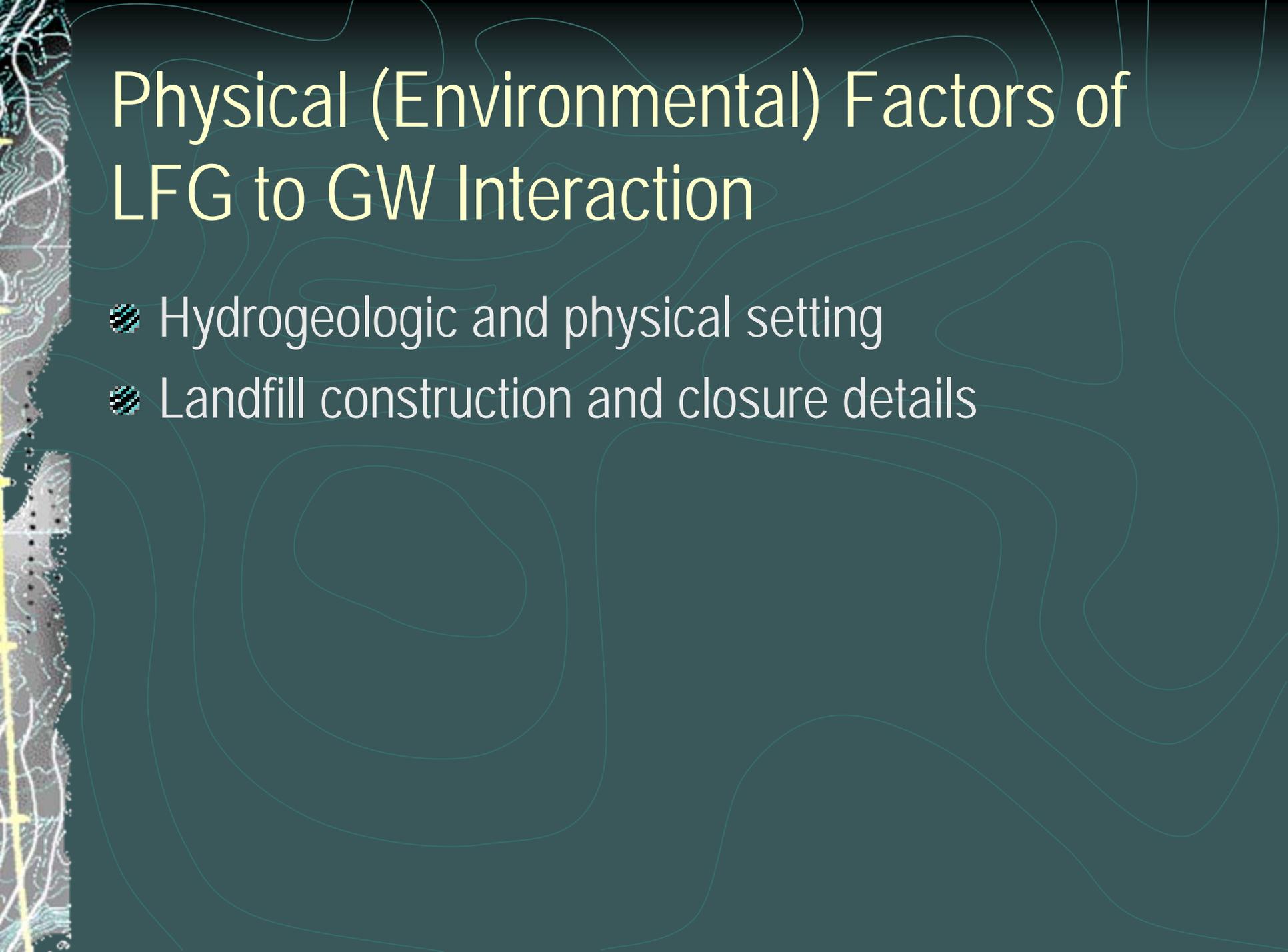


Watch out for the **X** Factor



Landfill Gas Basics

- Landfill Gas (LFG) is produced by the anaerobic decomposition of organic matter within waste.
- Landfill Gas is typically comprised of approximately 50-60% CH₄ and 40-50% CO₂ with VOCs and other component gases making up 0-3%
- A build-up of pressure within the landfill in excess of atmospheric pressure causes LFG to migrate
- LFG heterogeneity



Physical (Environmental) Factors of LFG to GW Interaction

- Hydrogeologic and physical setting
- Landfill construction and closure details



LFG Impacts to GW (Basic Mechanisms)

- Direct contact between LFG and GW
- Formation of LFG condensate in the soil adjacent to the landfill
- LFG contamination of the vadose zone and infiltration water carrying the contaminants to GW



LFG Impacts to GW (Effects)

- Primary or direct effects
- Secondary or indirect effects

VOC Phase Transfer (Direct Effect)

- VOC absorption process governed by Henry's Law

where;

X_{AQ} = Aqueous Concentration of the gas

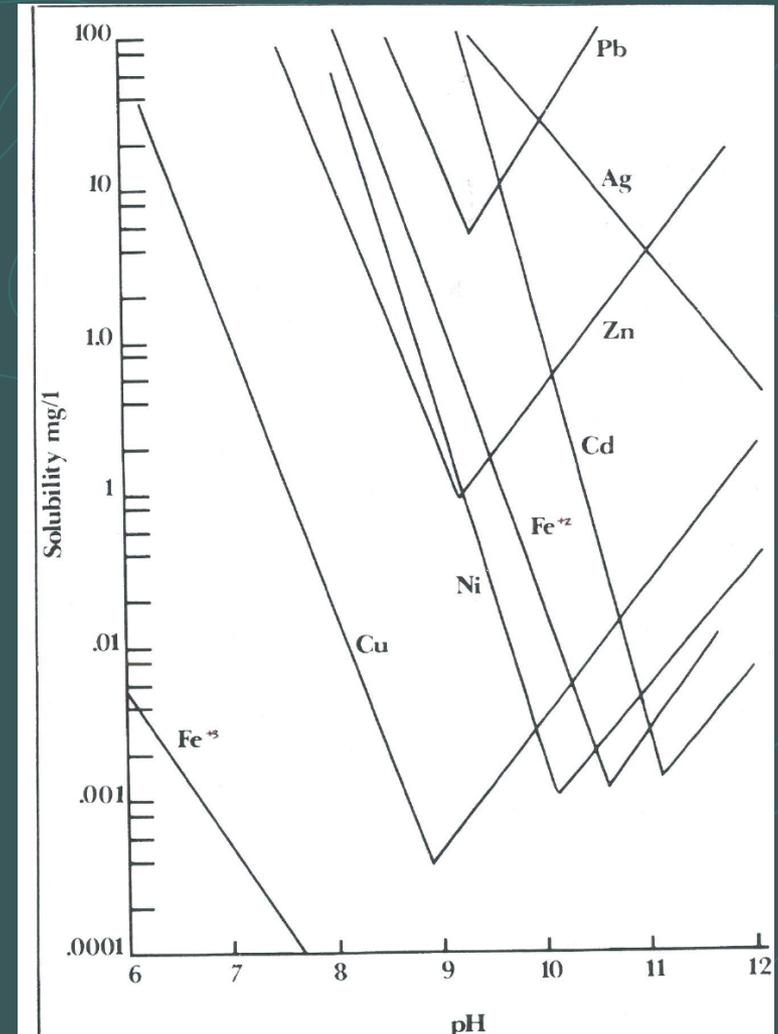
K = Henry's Law constant at specified temperature

P_x = Partial pressure of the gas

$$X_{AQ} = \frac{P_x}{K}$$

Carbon Dioxide Dissolution (Indirect Effect)

- Higher solubility than CH₄
- Can cause reduction in pH, which can result in geochemical changes in aquifer materials





Differentiating Leachate and LFG Effects

- The genesis of impacts to GW can be difficult to discern
- New and evolving methods for differentiation
- Indicator parameters



Artificial/Differential Recharge at Landfill Sites



Differential Recharge: Did you guys just
make that up?



Artificial and Differential Recharge

- Artificial recharge is the practice of increasing by artificial means the amount of water that enters a groundwater reservoir (USGS, 1959)
- Differential recharge is the redistribution of recharge to an area or areas by blocking infiltration to another area (MES, 2009!?)

Effects of Artificial/Differential Recharge on Different Landfill Types

- Unlined, Uncapped ‘Dumps’
 - Potential for hydraulic mounding, depending on site conditions
- Unlined, Capped Landfills
 - Initial hydraulic mounding, decreases after capping
 - ‘Differential Recharge’
- Lined, Uncapped Landfills
 - Depressed water table under the landfill and immediately downgradient
- Lined, Capped Landfills
 - Differential recharge/Depressed water table



Limitations of Artificial/Differential Recharge

- Is there a perched leachate mound, or is there a hydraulic connection between GW and leachate?
- Does the ‘localized’ hydraulic mounding or water table depression overcome the natural GW gradient?

Case Studies



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Regulatory Point of Compliance With Regard to Groundwater Monitoring at Landfill Sites

Clear As 500 NTU Water

Regulations – Federal and State

● RCRA-federal regulations

- Facilities that accepted waste after October 9, 1991
- Other restrictions-size, etc

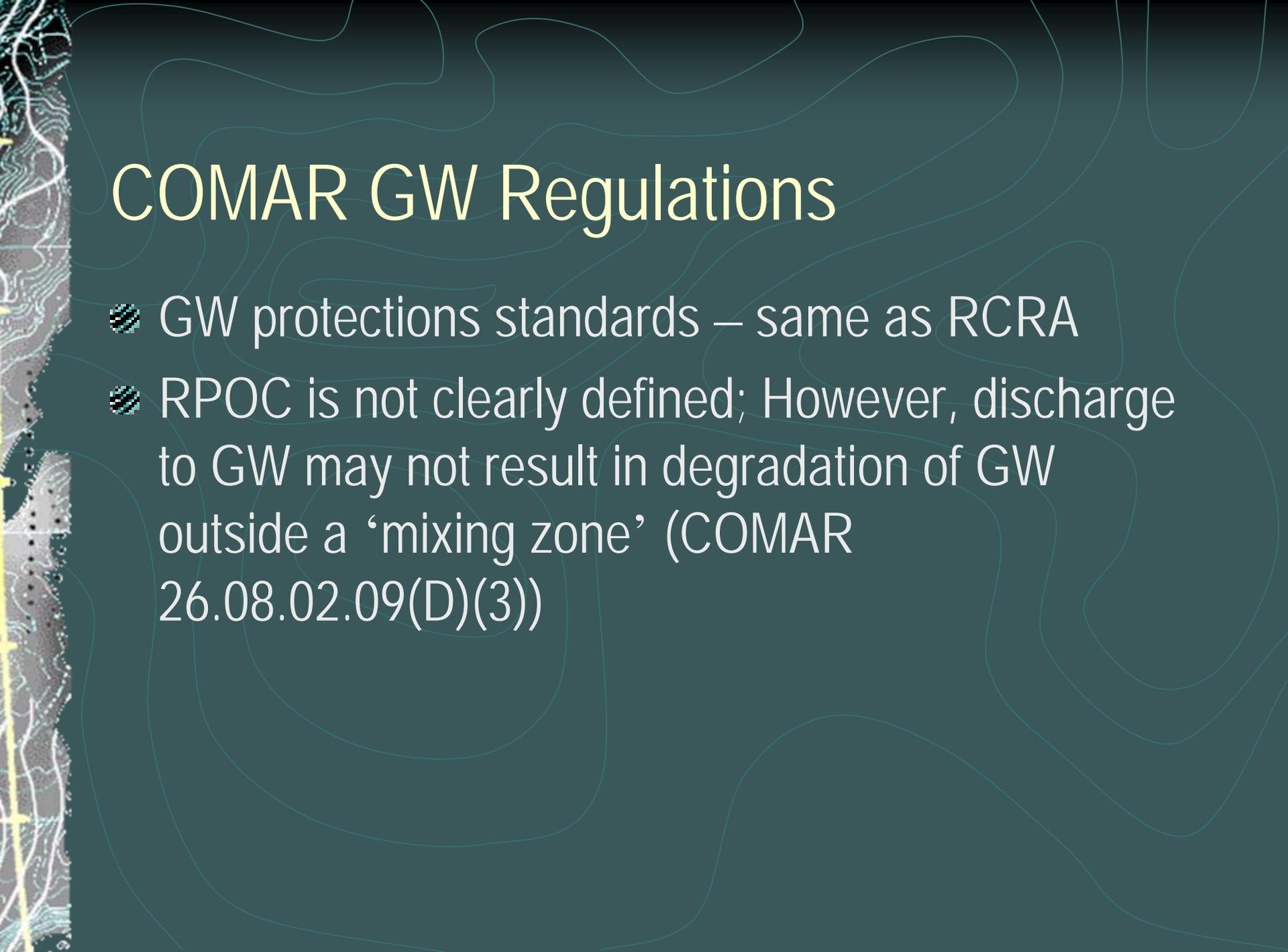
● COMAR-state regulations

- Facilities that ceased accepting waste before October 9, 1991
- Other qualifying aspects-size, waste type, etc.
- Applies to all facilities in which RCRA does not apply



RCRA Facility GW Regulations

- GW protection standards: drinking water standards (MCL) or background
- Regulatory point of compliance (RPOC): ≤ 150 m or 492 ft from waste management unit boundary and on land owned by the same entity (40 CFR 258.40(d))
- Compliance means that all points within the plume of contamination that lie beyond the RPOC meet the GW protection standards (40 CFR 258.58(4)(e)(1))

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COMAR GW Regulations

- GW protections standards – same as RCRA
- RPOC is not clearly defined; However, discharge to GW may not result in degradation of GW outside a ‘mixing zone’ (COMAR 26.08.02.09(D)(3))

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Regulatory Point of Compliance

- Clearly established in RCRA for GW
- Not so clear in COMAR
- Both sets of regulations establish the concept of ‘mixing zones’, outside of which is the RPOC



Mixing Zone Defined

- Contaminant transport mixing zone – area where contaminants impact ambient groundwater or surface water...an area contiguous to a discharge, where SW quality or GW quality does not have to meet all water quality criteria (COMAR 26.08.01.01)



What Does it all Mean?

- RPOC is relatively straight forward to RCRA regulated landfills
- RPOC for non-RCRA regulated landfills is open to some interpretation
 - Is this good or bad?



Why MDE Got It Right

- Unlike RCRA, COMAR does not apply an arbitrary distance (150m), current MDE *POLICY* is compliance with MCLs at the property boundary, which is a legally sensible, consistently applied policy, that is logical for the varying site conditions that are encountered throughout the state



Our Recommendation

- The current MDE policy on RPOC for COMAR regulated facilities should be clarified in the regulations