Passive Aquifer Mining for Landfill Expansion

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Background
- Waste Industries – Sampson County Disposal MSW Landfill (205 AC)
- Site has an overall soil deficit of almost 5 MCY
- Soil is imported from over 5 miles away
- Desire to bring the site into soil balance
- Desire to increase landfill airspace

Challenges
- Maintain four (4) foot separation from groundwater
- Maintain under gravity flow conditions (no long term pumping)

Project Concept
- Interior interceptor trenches
- Perimeter gravity groundwater main header
- Receiving collection manholes
- Potential to lower landfill base grades by 20 feet
- The Gravity Groundwater Intercept (GGI)
Proposed Site Layout

Keys to Design
- Hydraulic Conductivity
- Minimize Groundwater Rebound
- Radius of Influence

Considerations
- Decomposition of system
  - Pipe flow vs. Stone Flow
- Recharge
  - Reduced with landfill
  - Flow intercepted at headwater

Site Location
Site Topography and Hydrogeology

Site Geology
- Site geology primarily silty to clayey sands.
- Black Creek Aquitard found between 25 and 35 feet below grade over most of the site.
- Black Creek Aquitard hydraulic conductivity of \( \sim 5 \times 10^{-7} \) cm/sec.

Program Outline
- Phased approach with frequent cost/benefit analyses.
- Regulatory involvement – nearly constant!
- Each step reviewed for predictability/reliability of data.

Regulatory Requirements
- Four-foot separation to groundwater maintained through post-closure and beyond
- Gravity system only
- Black Creek Aquitard to remain untouched
- Initial model and ground truthing
Starting Point
- Original site design with large soil deficit
- Soil boring and groundwater data from 66 piezometers from 1994 forward
- Grain size analyses
- Initial conceptual (2-D) model based on Leonards (1962) as a partially penetrating slot
- Slug test data – questionable (0.01 to 10 ft/day)

Pump Test Results
- Pump tests conducted between 6 and 26 gpm – pumping well size a factor
- Hydraulic conductivities ranged from 115 to 284 ft/day
- Model utilized 135 ft/day
- Bradbury & Muldoon (1990)
Cell 5 & 6 Construction Model

Partial Construction Model

Final Construction Model

Ground Truthing

- Piezometer installation
- Water levels
- Rainfall data
- Target elevations
Field Demonstration

- Regulatory "Prove It!"
- Initial installation over 22 acre cell area
- 7 piezometers installed
- Rebound anticipated ~0.5 feet
- Trench inverts set at 5' below cell subgrade

Site Plan

Initial Trenching

Well Point System
Gravity Sump
- Centralized Sump
- Simulating gravity drainage
- 800 GPM pump

Intercept Trench Construction

Demonstration Performance
- 1 year seasonal high groundwater surface
  - most targets achieved within 4 months
- Average recharge on the system = 65 GPM < 300 GPM
  - Factor of Safety of 4.6
  - 65 GPM/600 feet = 0.1 GPM/FT (actual) after 5 months
  - Simplest analysis yielded the best results
- Black Creek required system to be adjusted by 7 feet in the sump area
Final Construction Phase

- Go ahead!
- Pipe to creek
  - Horizontal directional bore
    - Installed in three sections (cell, creek, future) to manhole
    - Installed at minimum 0.1% slope
    - Surveys performed every 25 feet along alignment

Keys to Design

- Must be dewatered for minimal reinforcement
- Pipe inverts 22 feet below groundwater
- Designed as soldier with embedment
- What went wrong?
Reinforcement

Horizontal Boring Equipment

Horizontal Boring Bits

Horizontal Bore Results

- All end targets were achieved within 0.5 feet
- Longest run was approximately 1500 LF
- Average depth of 25 feet
- 18" maximum pipe size
- 0.1% pipe slope maintained; maximum deviation was approximately 1.5 feet but below proposed alignment
Survey Results

Outlet Structure

Benefit to the Site

- Net change of ~18,000 CY/AC in soil need
- Close proximity of operational cover soil
- Increase of ~2.5 MCY in landfill airspace
- Increase in overall stability of the landfill
- Benefit Cost Ratio ~ 5:1
- Site intends to continue plan over the remaining 120 acres

End Result
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