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Effectiveness of a Slurry Cutoff Wall at Loeffel Site

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SYNOPSIS In recent years slurry cutoff walls have been successfully employed to mitigate seepage and isolate liquid waste and leachate in the groundwater environment. However, a success of the slurry cutoff wall depends on the hydrological condition of the site. A post construction and pre-construction groundwater budget analysis can demonstrate the effectiveness of a slurry cutoff wall.

In this paper, a detailed groundwater budget analysis of Loeffel site in the Southwestern Rensselaer County of New York is discussed. The analysis shows that the use of a slurry cutoff wall effectively mitigates the release of contaminated groundwater from the site.

INTRODUCTION

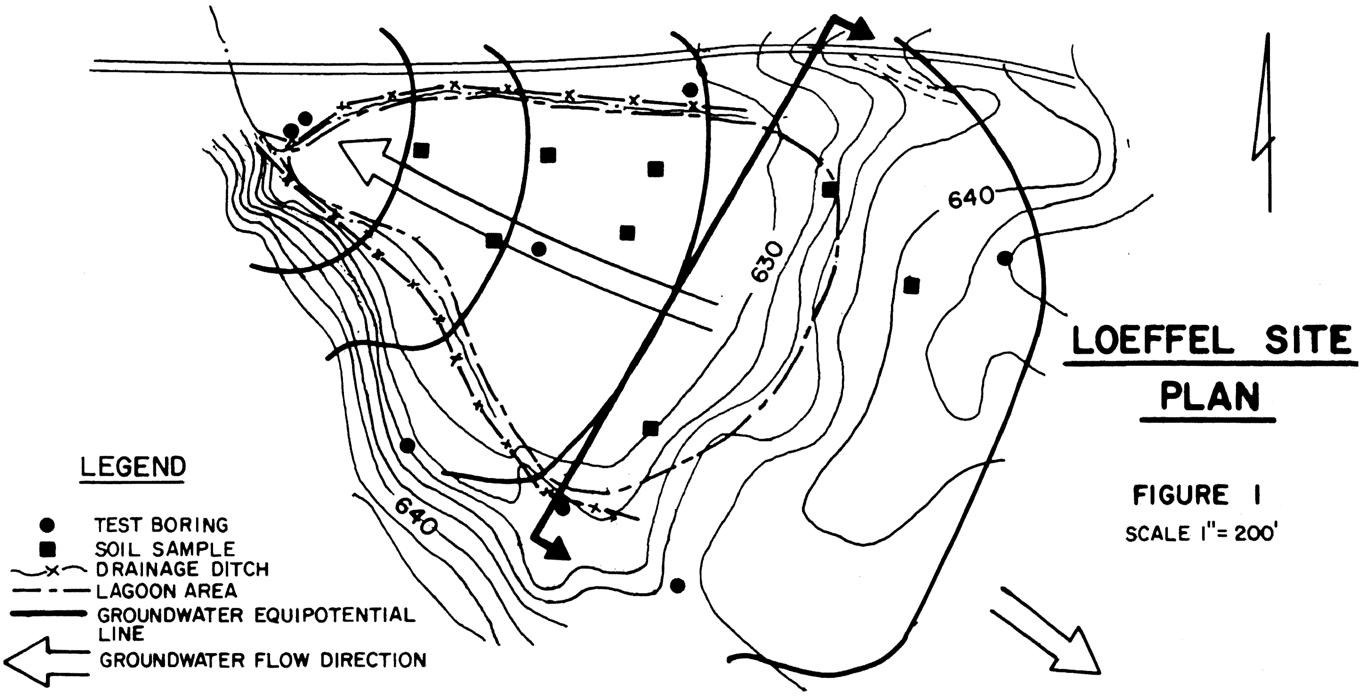
In recent years slurry groundwater cutoff walls have been successfully employed to mitigate seepage and isolate wastes in the groundwater environment. The Loeffel site is a case in which the hydrogeological conditions were determined suitable for the use of a groundwater cutoff wall as an appropriate remedial measure. An analysis of the projected post-construction groundwater hydraulics demonstrated that the use of a slurry cutoff wall would effectively mitigate the release of contaminated groundwater from the site.

BACKGROUND

The Loeffel site encompasses an area of approximately eleven acres in southwestern Rensselaer County, New York. This site was reportedly operated between 1952 and 1970 as a disposal facility for industrial waste materials. It is estimated that 38,000 tons of waste materials were disposed of at the site (see Figure 1).

The site geology consists of glacial deposits over shale bedrock. (Figure 2). The glacial deposits consist of till and outwash sand and gravel. Neither the outwash deposits or the till is continuous beneath the entire site. Within the boundary of the site, fill overlies the till and outwash deposits.

The site investigation documented that groundwater occurs in the bedrock, till and outwash deposits, however, the predominant groundwater flow, occurs at a very slow rate



LOEFFEL SITE PLAN

FIGURE I
SCALE 1"= 200'

due to the low hydraulic conductivity of these units, about 1.968 x 10^{-6} feet/min. for the shale and 9.842 x 10^{-8} feet/min. for the till. Groundwater flow in the sand and gravel deposits was estimated to be 23,000 gpd. (Ref. 1).

Chemical analyses of the groundwater in the immediate vicinity of the site indicated that small but measurable quantities of contaminants were being released from the Loeffel Site. Identified contaminants (such as benzene, toluene, xylene, and methylene chloride) were found predominantly in the outwash sand and gravel deposits.

REMEDIAL DESIGN

In order to mitigate future contaminant releases, a remedial construction design was proposed that would consist of a bentonite slurry groundwater cutoff wall and a site cover with a saturated hydraulic conductivity of 1 x 10^{-7} cm/sec. A principal element required for the successful use of a groundwater cutoff wall is a continuous base unit of an acceptably low hydraulic conductivity that the cutoff wall can be keyed into (Figure 2). At the Loeffel site it was demonstrated that the shale bedrock unit is continuous and has an acceptably low hydraulic conductivity, about 1 x 10^{-6} cm/sec.

HYDRAULICS EVALUATION

An analysis of the projected post-construction groundwater hydraulics was performed to demonstrate to the state regulatory agency that the proposed remedial design would effectively mitigate the release of contaminated groundwater from the site.

The analysis of the projected post-construction hydraulics for this site utilized basic equations for steady-state groundwater flow and a simplified model of the site groundwater budget. This simplified model of the site recognized that groundwater could flow into and/or out of the site through three potential paths:

(1) the site cap;
(2) the groundwater cutoff wall;
(3) the confining unit at the base of the site.

The potential groundwater flow into and/or out of the site through each of these three paths was evaluated independently under steady-state conditions. Following these independent calculations, the values of inflow and outflow were summed in a site groundwater budget. To more accurately approximate the site conditions, the site was segmented for the individual calculations. The analysis was conducted for the worst-case conditions as a conservative method of accounting for the approximate nature of the calculations.

This analysis of the projected post-construction groundwater hydraulics was performed manually using analytical steady-state groundwater flow equations to demonstrate that the equations and techniques for such an analysis are readily available to consultants. Computer models of varying degrees of sophistication may be used in similar analyses; however, their availability is more restricted and the sophistication and expense involved with computer modeling may exceed that which the site groundwater hydraulics or client requires.

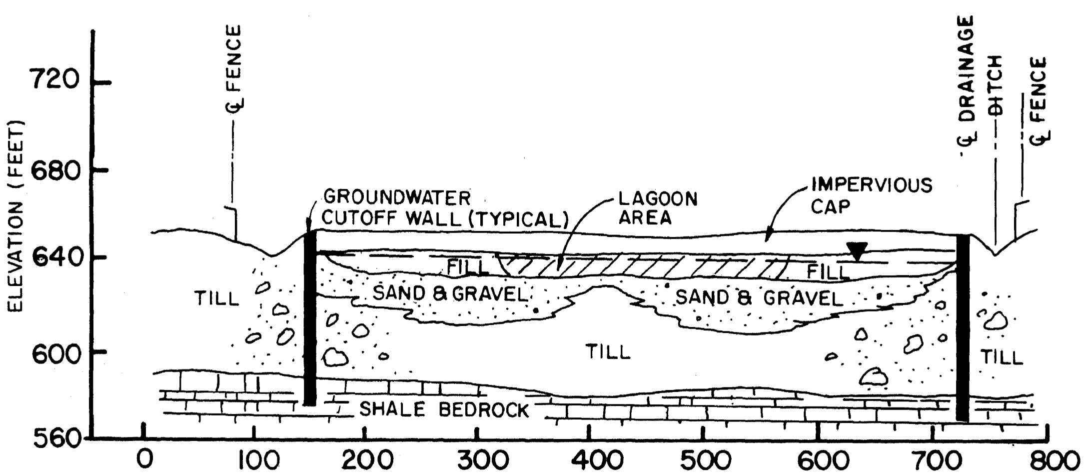
ASSUMPTIONS

The groundwater hydraulics of most hazardous waste sites are complex and are accurately evaluated with transient equations for groundwater flow. Consequently, certain assumptions are necessary to allow analysis using steady-state equations. The principal assumptions that are made in this analysis are:

(1) steady-state conditions exist;
(2) the geologic formations are homogenous;
(3) the geologic formations are infinite in horizontal extent;
(4) uniform, homogenous, and isotrophic materials will be used for remedial construction; and,
(5) remedial construction will be performed as specified in the design.

CALCULATIONS

Site Cap - The calculations used to examine the rate of percolation through the site cap were based on an equation presented by Moore, 1980 (Ref. 2):



LOEFFEL SITE
GENERAL CROSS SECTION WITH REMEDIAL PLAN

FIGURE 2

$$t = \frac{\pi d^2}{4D^*}$$

where: t = time for water to penetrate the cap
d = cap thickness
D* = the linearized diffusivity.

The calculations based on this equation indicated that 370 years would be required before water percolates into the site from the cap. This period of time greatly exceeds the 30-year designed lifetime of the site remediation, therefore, no inflow will occur through the site cap.

Groundwater Cutoff Wall - The second path where inflow and/or outflow could occur is through the groundwater cutoff wall. The groundwater cutoff wall is designed as a low permeability (hydraulic conductivity 1×10^{-7} cm/sec. or less) barrier to groundwater flow.

The potential groundwater flow through the cutoff wall was examined using Darcy's equation for flow:

$$Q = K \frac{dh}{dl} A$$

where: K = hydraulic conductivity,
dh = the difference in hydraulic head on either side of the wall,
dl = the length of the groundwater flow path (the width of the wall); and,
A = the vertical cross sectional area of the wall (A = LH, L = length of wall, and H = height of the wall in contact with groundwater).

The Base Confining Layer - The third path of site groundwater inflow and outflow is through the shale confining layer and the till, at the base of the site. The hydraulic conductivity of the shale bedrock, approximately 1×10^{-6} cm/sec. is sufficiently low enough to be used as a confining unit in-place remediation.

The calculations of the potential groundwater inflow and outflow utilized a simple flow net and the equation:

$$Q = \frac{mkdh}{n} L \text{ (Ref. 3)}$$

where: m = the number of flow channels in the flow net,
K = the hydraulic conductivity,
dh = the difference in head in the clay between the inside and outside of the cutoff wall,
n = the number of divisions of head in the flow net; and,
L = the length of the section considered.

SITE GROUNDWATER BUDGET

A groundwater budget is a summation of the total groundwater flow into and out of the site. The projected groundwater budget for the remediated Loeffel site indicates that the groundwater flow through the site would be about 260 gpd (Reference 4). The net change in the groundwater budget indicates whether groundwater is being added to or subtracted from storage within the confines of the cutoff wall. When the total inflow equals the total outflow, there is no net change in storage, the groundwater bueget is in equilibrium, and an equilibrium groundwater elevation within the site will be achieved.

The calculations indicate that groundwater inflow into the site will occur along the eastern portion of the site and groundwater outflow will occur along the western portion of the site.

The groundwater budget also indicated that the water level within the remediated site would be about 632 ft., which exceeds the lowest pre-construction topographic elevation of the site.

CONCLUSIONS

An evaluation of the projected post construction groundwater hydraulics examined the potential groundwater inflow and outflow at the site after the completion of the remedial measures. This analysis indicated that following the remedial construction, the groundwater flow through the site would be reduced to about 260 gallons per day[4], which is approximately 1% of the original flow. This large reduction in flow indicates that the slurry cutoff wall will very effectively mitigate the release of contaminated groundwater from the site. This analysis also was instrumental in the actual design of the remedial plan with regards to the elevation of the top of the cutoff wall and the requirements for relief wells.

REFERENCES

"Loeffel Site Engineering Report", O'Brien and Gere Engineers, Inc., Syracuse, October, 1981.

Landfill and Surface Impoundment Performance Evaluation Manual, submitted by Charles A. Morre to the United States Environmental Protection Agency, September, 1980.

Freeze, R.A. and Cherry, J.A., 1979, Groundwater, Prentice-Hall, Inc.

"Loeffel Site Post-Construction Groundwater Hydraulics:, O'Brien and Gere Engineers, Inc., Syracuse, October, 1982.