United States
Environmental Protection
Agency

Risk Reduction
Engineering Laboratory
Cincinnati, OH 45268

Research and Development

EPA/600/SR-93/070 June 1993

EPA

Project Summary

LDCRS Flow from Double-Lined Landfills and Surface Impoundments

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A study, sponsored by the U.S. Environmental Protection Agency (EPA), on measured flows from leakage detection, collection, and removal systems (LDCRSs) of 28 double-lined landfills and 8 double-lined surface impoundments indicated

- **all landfills with geomembrane top liners leaked;**
- **landfills with composite top liners had LDCRS flows from consolidation water;**
- **60% of surface impoundments with geomembrane top liners leaked;**
- **landfill flows were within the expected range; those from impoundments were lower;**
- **facilities constructed with rigorous construction quality assurance (CQA) report leakage of less than 1,000 liters per hectare per day (L/hd).**

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Liquid flows have been observed from LDCRSs of many landfills and surface units. The purpose of this report is to summarize and evaluate field data on flows from double-lined landfills and surface impoundments. In January 1992, the Liner/Leak Detection System Rule was made final. In this final rule, the concept of an action leakage rate (ALR) was defined as "the maximum design leakage rate that the leak detection system can remove without the fluid head on the bottom liner exceeding one foot." The preamble to the final rule states that the Agency believes units meeting the minimum requirements would not require ALRs below 1,000 L/hd for landfills and 10,000 L/hd for surface impoundments. These flow rates are referred to as EPA's recommended ALRs.

The Study

Because the types of liners (geomembrane and composite) and the types of drainage materials (granular, geonet, other geosynthetic) influence the frequency, the source, and the rates of flow from LDCRSs, they are separated in this report into Group I (with geomembrane top liner and geonet drainage material), Group II (geomembrane and sand drainage material), Group III (composite top liner and geonet), and Group IV (composite and sand).

To evaluate LDCRS flow data, potential sources of flow must be identified. Leakage through a geomembrane usually occurs because of defects in the membrane.

Calculated leakage rates through composite liners range from 0.01 to 90 L/hd; through geomembrane liners, 400 to 6,300 L/hd. The calculated leakage rates from geomembrane top liners are two to five orders of magnitude greater than those calculated for composite liners. Further, it may take from several months to many years for liquid to flow through the clay components of a composite liner, but only several days to several years through the geosynthetic clay liner. The flow through a geomembrane liner can occur almost instantaneously.

Source of Flow

Construction Water

Construction water is the precipitation that percolates into the LDCRS before the top liner is placed (Figure 1). Some of this water can be retained by capillary tension to the drainage material; the rest flows by gravity from the LDCRS. The kind of drainage material affects the flow rate and duration of flow.

Compression Water

As an LDCRS's granular material compresses under the weight of the overlying waste or impounded liquid, not only does the pore volume and porosity of the LDCRS decrease, the capillary tension of water in the pores increases as the soil particles are packed more densely.

The flow rate of compression water from granular material initially is small and frequently negligible in comparison with flow rates from other sources.

Consolidation Water

When a landfill or impoundment is being filled, thick layers of compacted natural clay, or bentonite-treated soil, will consolidate and expel water into the LDCRS drainage layer. Because geosynthetic clay liners are put in place dry, they do not contribute additional liquid to the LDCRS. The flow rate from consolidated water may range from 10 to 1,500 L/hd. For most landfills, consolidation will end near the end of the landfill's active life. For some plastic clay materials, compression water may be a significant source after the end of the landfill's active life.

Infiltration Water

If there is a sustained groundwater table above the bottom of the bottom liner or if it is a composite liner with a clay layer undergoing consolidation or secondary compression, infiltration water can migrate. The infiltration through clay layers will be relatively small; through geomembrane bottom liners, it can be very great and occur quickly.

Data Collection

Data on LDCRS flow rates were collected from 76 monitored cells in 28 double-lined landfill facilities and from 17 monitored ponds from 8 double-lined surface impoundment facilities.

Under EPA's January 1992 final rule, owners/operators are required to monitor the rate of flow from LDCRSs. These are the data used here.

Flow rate measurements ranged from the simple (calculating the flow quantities based on changes in liquid depth in the sump) to the complex (using tipping buckets and flumes and recording the flow data with automated data-logging systems).

The most common method used involved a flow meter equipped with a mechanical accumulator; the change in flow volume was divided by the time since the last measurement.

For the study, the measured flow rates for a specific time were compared with calculated flow rates (from different sources) during the same time period. This method involved

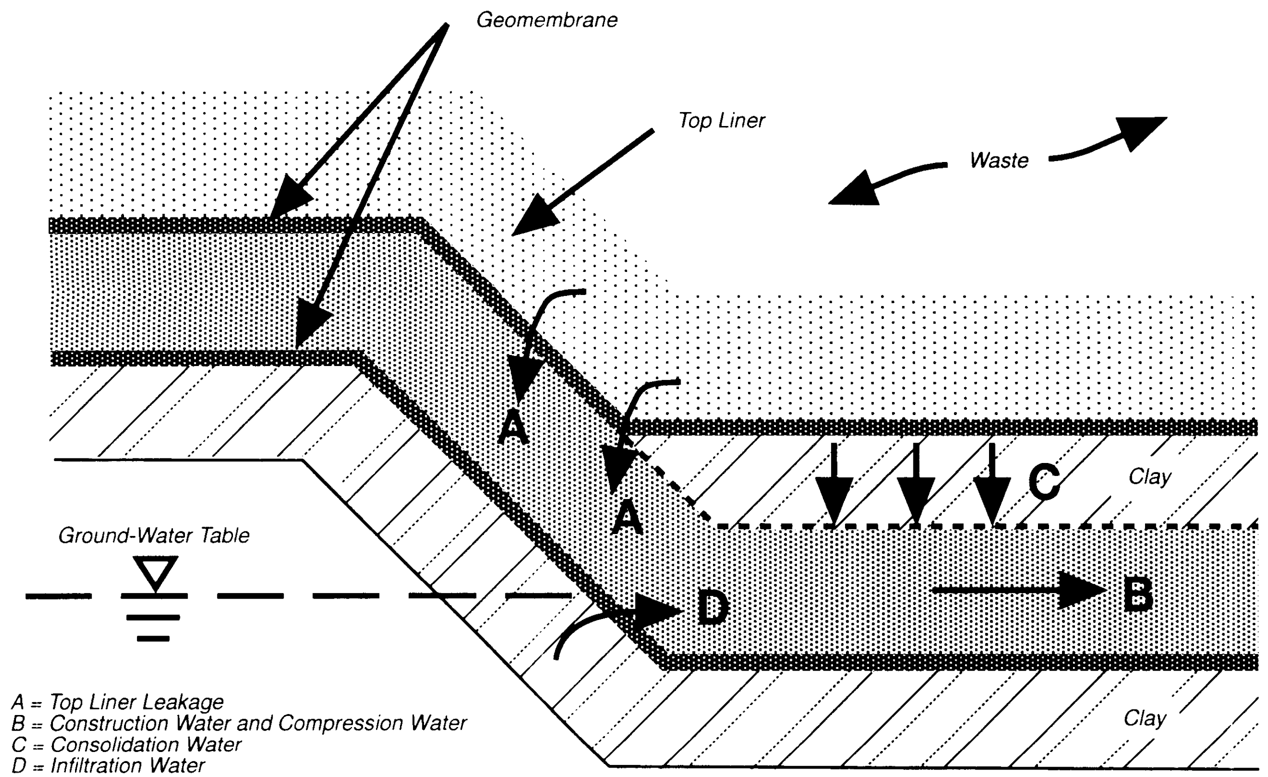

Figure 1. *Potential flow sources from LDCRSs (from Bonaparte and Gross).*

- identifying potential sources based on double-liner system design, climate, hydrogeology, and operating histories;
- calculating flow rates from each potential source;
- calculating time frames for flows from potential sources;
- evaluating potential flow sources by comparing measured flow rates with calculated flow rates at specific points in time.

The chemical constituents in the landfill or impoundment liquid were compared with those of the LDCRS flow to determine whether a flow source is top-liner leakage. Approximately 90% of the landfills in the U.S.A. are located in relatively moist climatic regions.

Results

This methodology was used to evaluate the sources of flow from the 93 individually monitored cells (Table 1). Flow-rate data included information from end of construction, active cells and ponds, closed cells and ponds, and those with CQA programs where information was available.

Group I

Landfills — All seven cells appeared to have top-liner leakage with average flow rates from 0 to 220 L/hd and maximum flow rates about seven times greater than average values.

Surface Impoundments — Only two of the six ponds have had flow since the start of operation. These six ponds were all subject to ponding tests, or leak location surveys, or both as part of the owner's internal or third party CQA programs, and holes identified during these surveys or tests were repaired. The observed leakage rates were smaller than those calculated from landfills and much smaller than those calculated for ponds.

Group II

Landfills — Excluding one landfill cell, which was constructed differently, flow rates at all other 12 were attributed to top-liner leakage, with average rates attributed to top-liner leakage ranging from 0 to 2,200 L/hd and maximum flow rates about five times larger than average values. At the six cells where CQA was not implemented, larger flow rates were attributed to top-liner leakage.

Surface Impoundments — Flow rates at three of five impoundments were attributed to top-liner leakage and construction water.

Chemical quality testing of LDCRS liquids indicated top-liner leakage in both ponds shortly after they began operating; after repairs, the average measured flow rate decreased significantly.

Group III

Landfills — Thirty of 31 cells exhibited flows from LDCRSs during active life, with average flow rates from 0 to 1,300 L/hd; 24 cells had flows less than 500 L/hd. Based on calculated breakthrough times for seepage through the top liner, LDCRS flows primarily came from consolidation water. For the 17 closed or covered cells, LDCRS flows may have resulted from continuing consolidation secondary compression of the clay component.

Surface Impoundment — From available active-life data, flow was attributed to consolidation water with top-liner leakage in one pond. For both landfills and surface impoundments, the flow rate of consolidation water decreased over time.

Group IV

Landfills — For the seven cells with GCL as part of the composite liner, one had no flow, five had average flow rates of 50 L/hd or less, and one had an average of 120 L/hd. The flow rate could be accounted for by a combination of compression and continuing drainage of the sand LDCRS drainage layer or leakage through the geomembrane top-liner on the side slopes.

For the five active cells with a compacted clay layer as a component of the top liner, three had flows less than 200 L/hd, with a range of 40 to 500 L/hd.

Surface Impoundments — For one pond, the flow was zero from month 20 to 43 after construction. The other averaged flow rates from 2 to 1, 120 L/hd, primarily from consolidation water and leakage through the geomembrane top liner on the side of the pond.

Conclusions

EPA's recommended ALR for landfills is 1,000 L/hd. Implementing a CQA program appears to consistently limit top leakage rates to less than 1,000 L/hd. Of the 21 landfill cells in Groups I and II for which data are available, 14 had CQA programs, 7 did not. None of the 14 with CQA programs had flow rates greater than 1,000 L/hd, and 11 of these had rates less than 200 L/hd. Of the seven cells without a CQA program, one had rates less than 200 L/hd and five had rates greater than 1,000 L/hd.

Of the 42 landfill cells in Groups III and IV for which data are available, only 3 averaged flow rates greater than 1,000 L/hd; 34 averaged less than 500 L/hd.

The facilities examined in the report typically had LDCRS flows less than the ALR values given in the final rule. For Groups I and II landfills, the primary LDCRS flows were from top-liner leakage. For Groups III and IV landfills, the primary LDCRS flows were from consolidation water.

About 60% of the surface impoundments with geomembrane top liners leaked, but generally the flows were less than 300 L/hd, considerably less than EPA's 10,000 ALR. Maximum flow rates greater than the recommended ALRs did, however, occur.

Recommendations

The information in the report provides a preliminary understanding of how landfills and surface impoundments perform. Future studies are needed to expand this information. Added data from more units meeting EPA regulations should be gathered. From this data base can be answered such questions as what is the quantity and chemical quality of the leachate being generated? of the liquid flow from LDCRSs? does this vary geographically? is there any indication that one type of design performs better than another?

These answers are needed to determine the long-term effectiveness of landfills and surface impoundments.

Table 1. *Flow Measurements from Four Types of Facilities*

Group	*Top Liner*	*Drainage Material*	*Landfills*	*Landfill Cells*	*SI**	*SI Ponds*
I	*Geomembrane*	*Geonet*	*3*	*7*	*2*	*6*
II	*Geomembrane*	*Sand*	*7*	*18*	*3*	*5*
III	*Composite*	*Geonet*	*10*	*37*	*2*	*4*
IV	*Composite*	*Sand*	*8*	*14*	*1*	*2*

**Surface impoundment.*

*U.S. Government Printing Office: 1993 — 750-071/60248

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The complete report, entitled "LDCRS Flow from Double-Lined Landfills and Surface Impoundments," (Order No. PB93-179885; Cost: $19.50, subject to change) will be available only from:
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