A GEOSYNTHETIC CLAY LINER PILOT PROJECT FOR ON-FARM LIVESTOCK BURIAL
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ABSTRACT
Even though small scale livestock mortality burial is commonly practiced and regulated in Canadian provinces, very little research has been performed to evaluate the effectiveness of livestock burial. With potential changes to waste disposal regulations of specified risk material from livestock mortalities, it is anticipated that there will be an increase in on-farm burial. The purpose of this paper is to outline a field research program being performed to evaluate the contaminant migration through both a clayey liner system and a GCL liner system for livestock mortality burial. The GCL being examined is a relatively new polypropylene coated GCL. Design considerations and construction details are presented as well as future monitoring and operation details for the pilot project.

RÉSUMÉ
Quoique l'enterrement de mortalité de bétail à échelle réduite soit généralement pratiqué et réglementé dans les provinces canadiennes, la recherche très petite a été effectuée pour évaluer l'efficacité de l'enterrement de bétail. Avec les changements potentiels aux règlements de disposition de rebut du matériel indiqué de risque des mortalités de bétail, on le prévoit qu'il y aura une augmentation d'enterrement à la ferme. Le but de cet article est de décrire un programme de recherche de champ étant exécuté pour évaluer la migration de contaminant par un système argileux de recouvrement et un système de recouvrement de Géosynthétiques Bentonitiques (d'argile) G.S.B.) pour l'enterrement de mortalité de bétail. Le G.S.B. étant examiné est un G.S.B. enduit par polypropylène relativement nouveau. Des considérations de conception et les détails de construction sont présentés comme des détails de surveillance et d'opération de futur pour le projet pilote.

1. INTRODUCTION
Rendering of typical livestock mortalities has been the preferred method of disposal for most Canadian producers (Freedman and Fleming, 2003). Proposed new Canadian Food Inspection Agency (CFIA) controls on enhanced agriculture feed will prohibit specified risk material (SRM) from being utilized in animal feed, pet food and fertilizer (CFIA, 2004). If such measures are adopted, complete disposal of SRM via rendering will no longer be an option. Each province will then be required to revise their current waste management guidelines and regulations (if present). It is expected that the elimination of rendering as a complete disposal option will lead to increased amounts of small scale, on-farm burial.

A review of current guidelines and regulations for on-farm burial of typical livestock mortalities has shown that there are large discrepancies between recommendations put forth by various Canadian provinces (Freedman and Fleming, 2003). For example, only three Canadian provinces specify the minimum depth to groundwater within their guidelines/regulations and no provinces have included soil characteristics (i.e. hydraulic conductivity). This inconsistency in recommended burial practices is partially due to a paucity of dedicated research in this area. There is also little research that has examined the incorporation of economically sustainable landfill technology (e.g. geosynthetic clay liners, GCLs) into on-farm burial practices. With increased pressure on regulators to protect society and the environment from agriculture related health issues, research is required to better understand contaminant movement (inorganic, bacteria, viruses, etc) from livestock mortality burial pits such that improved, sustainable designs can be implemented.

The objective of the present paper is to describe the design and construction of two small scale livestock burial plots that will form the basis for future research being conducted by Dalhousie University and The Nova Scotia Agricultural College. Within the paper, an overview of the research project is provided, along with details of the field component of the project. In particular, the various provincial environmental approvals obtained prior to construction are described as well as considerations involved in selecting the disposal cell site. Details are also provided on the design considerations for the disposal cell, the construction process, materials used in construction, as well as future monitoring plans for
examining the effectiveness of the two different burial liner systems employed (i.e. compacted clay versus GCL/compacted clay).

2. PROJECT OVERVIEW

The purpose of the joint Dalhousie/Nova Scotia Agricultural College research program is two-fold; firstly to provide information for making rationale decisions related to regulating small scale livestock mortality burial; and secondly, to assess the performance of GCL technology for livestock mortality burial systems. Although the research program will involve both laboratory testing and field work, the focus of this paper is the field project. The information that will be obtained from the field research program includes:

1) temporal leachate data for small scale livestock disposal cells,
2) contaminant migration through the base of a compacted earthen–lined (clayey till soil) disposal cell, and,
3) contaminant migration through the base of a GCL/compacted earthen-lined (same clayey till soil) disposal cell.

The earthen liner is intended to represent “existing” soil that would be present in the base of the disposal cell in this study location. The GCL/earthen liner was selected for comparison to assess any possible benefits to using this particular GCL in the livestock disposal cells. GCLs represent a feasible technology that could be installed by local farmers with common farm equipment. It is expected that the addition of this particular GCL at the base of the disposal cell could provide additional protection in situations where undesirable burial soil conditions exist.

The field project design was initiated in early 2005 and subsequent project construction took place between August 2005 and September 2005. Cell instrumentation, livestock disposal and final cell backfilling are scheduled for summer 2006. Design considerations and construction details for the field project are provided in the various sections below.

3. SITE SELECTION AND APPROVALS

The requirements for an appropriate site for the disposal cells included the following:

- the base of the cells had to be situated above the natural ground water table (provincial regulatory requirement),
- leachate generated from within the cells had to be disposed of according to provincial regulations,
- the cells had to be easily accessible during all months of the year,
- the cells had to be located near readily available construction materials and accessible to construction equipment, and,
- the cells had to be situated such that public access was restricted.

The Guysborough County Waste Management Facility (GCWMF), in Guysborough County, Nova Scotia satisfied each of these criteria. The facility is owned and operated by the Municipality of the District of Guysborough (MODG). The site selected within the GCWMF was an embankment fill (clayey till) remaining from the construction of an adjacent leachate treatment pond. A plan view and cross section of the site are shown in Figures 1 and 2.
3.1 Regulatory Approvals

After preliminary discussion with landfill representatives in April 2005, a request by the research group was prepared and submitted to the Public Service Committee of the Guysborough Municipal Council. On April 20, 2005, the Committee passed a motion authorizing the field pilot project. The authorization was accompanied by a set of conditions imposed by the Committee, prior to passing the authorization motion. The primary condition imposed by the committee was that the project concept, cell design, testing program, project location and post-project decommissioning plan be approved by the Nova Scotia Department of Environment and Labour.

In June 2005, an environmental approval application form was completed and submitted to the Nova Scotia Department of Environment and Labour (NSDEL). In compliance with application requirements, a completed set of engineer approved drawings and a detailed report, describing the project and associated environmental concerns, were prepared and submitted to NSDEL. On July 27, 2005 NSDEL approval to construct and operate the field pilot project was obtained subject to various environmental conditions.

At the time of paper preparation, the researchers were finalizing these conditions and preparing an environmental report to NSDEL. Since environmental approval falls within the provincial jurisdiction, NSERC funding approval was conditional on meeting conditions set forth by the NSDEL.

4. FIELD PROJECT DESIGN CONSIDERATIONS AND CONSTRUCTION DETAILS

As previously mentioned, two livestock mortality disposal cells were designed and constructed. Cell A contained only an earthen liner while Cell B contained a GCL overlying a similar earthen liner system. Because of the similarities in conceptual design and construction, both disposal cells are discussed concurrently below.

Cell construction began with two excavations, 3.6 m wide by 3.6 m long by 2.45 m deep. The cells were excavated using a 160 Komatsu excavator, owned and operated by Con and Con Construction Limited. Side slopes of both cells were constructed at a 1H:1V slope due to spatial constraints. Trenches from each cell to a sampling house (see Figure 1) were then excavated and several 0.1 m diameter PVC leachate transport pipes were installed. A 4 percent slope was specified for these pipes to ensure efficient drainage from each cell to the sampling house (described below). The piping was then backfilled with site material to protect against freezing.

Sampling house construction began with the excavation and installation of a premium treated lumber foundation. The exterior of the foundation was coated with waterproofing and covered with asphalt felt. The walls of the building were constructed with 50 mm x 100 mm spruce lumber and 13 mm thick plywood. The wall height is 2.4 m, with walls having been insulated to reduce the risk of leachate freezing during the winter months. The roof of the building was constructed with 50 mm x 150 mm spruce lumber and 13 mm thick roof board. The building’s roof was also insulated and shingled. Two separate entrances into the sampling house were installed for safety purposes. A drainage system consisting of 0.1 m perforated pipe surrounded by a layer of 25 mm clear stone was installed around the perimeter of the foundation in an attempt to collect any surface or ground water. Two 0.15 m holes were then cut in the foundation walls of the sampling house to provide access for the leachate transport pipes from each cell.

A tipping bucket and auto sampler system was installed in the sampling house to quantify future leachate flows and water quality from the base of each cell. Leachate not collected by the auto sampler system will be transported to a leachate treatment pond via a piping system running from the sampling house to a manhole of the leachate treatment pond (see Figure 1).

After construction of the sampling house, the side slopes and base of each of the cells were smoothed via a hand rake and a GCL bottom liner installed. The purpose of this liner is to mitigate contaminant impacts into the underlying embankment fill. The liner was first placed on the base of the cell, followed by placement on the side slopes. A minimum 0.3 m overlap was maintained between adjacent panels. A seam of bentonite was
placed between all overlaps on the base of the cells. One 0.15 m diameter hole was cut in the liner at the base of the slope in each cell to allow for entrance of the leachate transport pipe. A GCL apron (i.e. a firm fitting piece of GCL) was then placed over the end of the leachate transport pipe and subsequently sealed with bentonite. The GCL was buried in a 1.2 m deep anchor trench at the top of the cell slopes.

Two, 0.1m diameter perforated collection pipes were then installed on top of the GCL and connected to a header pipe to form a “U” shape configuration in each cell. These collection pipes were then connected to the leachate transport pipe. A minimum of a 2 percent slope toward the transport pipe was maintained to ensure proper drainage. The collection pipes were then covered with a 0.3 m thick layer of 25 mm clear stone, followed by a nonwoven geotextile.

After installation of the leachate collection system, the clayey till soil liner was placed and compacted on the base and the side slopes of each cell. The soil liner on the base of both cells was placed in three equal lifts to a final nominal thickness of 0.5 m. Each lift was compacted with a vibratory plate tamper. The clayey till is generally described as brown, sandy, silty clay with gravel (CL-ML). The basic material properties for this soil are provided in Table 1.

Table 1. Clayey till soil used to construct earthen liners for Cells A and B.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Site Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Water Content (%)</td>
<td>11</td>
</tr>
<tr>
<td>Liquid Limit (%)</td>
<td>26</td>
</tr>
<tr>
<td>Plastic Limit (%)</td>
<td>19</td>
</tr>
<tr>
<td>Gravel (%)</td>
<td>18</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>22</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>32</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>28</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>2.7</td>
</tr>
<tr>
<td>Maximum Dry Unit Weight (kN/m³)</td>
<td>19.8</td>
</tr>
<tr>
<td>Optimum Moisture Content (%)</td>
<td>12</td>
</tr>
<tr>
<td>Hydraulic Conductivity (m/s)</td>
<td>1x10⁻¹⁰</td>
</tr>
</tbody>
</table>

* specimen compacted at optimum moisture content to maximum dry density, tested in flexible wall permeameter

The soil on the side slopes was placed and compacted prior to placing the final lift on the base of the cells. For Cell A, a nonwoven geotextile was installed on the surface of the clay, overlain by a 0.15 m sand working layer. For Cell B, the GCL was placed on the base and slopes of the clay (using similar procedures to that described previously), followed by the 0.15 m sand working layer. The geosynthetic clay liner selected for the field pilot project is a relatively new GCL, the Bentofix CSNL GCL (Lucas, 2002). This needlepunch reinforced GCL consists of a layer of granular sodium bentonite encapsulated between a sift film woven and a virgin stable fibre nonwoven geotextile. The fibres are thermally fused to the woven carrier geotextile and coated with polypropylene. The polypropylene coating is applied to the woven fabric side of the GCL. Relevant characteristics of the CSNL GCL are provided in Table 2.

Table 2. Characteristics of CNSL GCL (Terrafix, 2002)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonwoven Mass/Area (g/m²)</td>
<td>266</td>
</tr>
<tr>
<td>Woven Scrim Mass/Area (g/m²)</td>
<td>110</td>
</tr>
<tr>
<td>Bentonite Mass/Area (g/m²)</td>
<td>5059</td>
</tr>
<tr>
<td>Peel Strength (N)</td>
<td>131</td>
</tr>
<tr>
<td>Hydraulic Conductivity (m/s)</td>
<td>&lt;5x10⁻¹²</td>
</tr>
<tr>
<td>Tensile Strength (N)</td>
<td>520</td>
</tr>
</tbody>
</table>

Cross sections of Cells A and B are provided in Figures 3 and 4 respectively. The follow abbreviations have been used in these figures:

DLS: Dead Livestock
SCL: Sand Cushion Layer
SL: Earthen/Soil Liner
GT: Nonwoven geotextile
LCS: Leachate Collection System
FM: Embankment Fill Material

5. FUTURE WORK AND OPERATIONAL DETAILS

At present, final cell construction is being completed and the monitoring program is being initiated. The following instrumentation and monitoring equipment will be installed in both disposal cells:

- Moisture and temperature probes will be installed at the top, middle and bottom of the earthen liners,
• a Hobo weather station will be utilized to monitor rainfall, radiation and air temperature, as well as act as a data acquisition system for the moisture and temperature probes,
• Hobo water level loggers will record leachate levels in each cell through screened monitoring wells, and,
• one monitoring well will be installed to satisfy environmental regulations.

Livestock mortalities are currently being solicited from the Nova Scotia deadstock pickup program. Approximately three to five mortalities will be buried in each disposal cell. After final placement of the mortalities, the remainder of the cells will be filled and covered with on-site material. After mortality burial, leachate in each cell will be sampled every week for the first three months and once every month thereafter.

5.1 Liner Sampling

Four soil sampling pipes will be installed in each disposal cell while the cells are being filled. Each sampling pipe will consist of a 1.8 m long, 150-mm diameter, PVC pipe with a cutting shoe attached to the bottom of the pipe. The bottom 100 mm of the pipe will be drilled with 12 mm holes to allow leachate to enter the inner diameter of the tube. The purpose of the sampling pipes is to allow for sampling of the earthen liner and GCL without the necessity of excavating material from the disposal cells. The main function of the sampling pipes is to prevent contamination of the sample during retrieval and to ensure proper sealing of the sampling hole in the liner after the sample has been retrieved. Approximately one year after placement of the livestock mortalities, two of the sampling pipes that have been installed in each disposal cell will be driven 0.1 m into the soil liner. Shelby tube samples will then be driven through the sampling pipes and retrieved. It is the intention that the details of this sampling protocol will be examined further during construction. Porewater analyses (i.e. chloride, ammonium, bacteria) will be performed at various depths within the samples to examine contaminant migration into the base of the disposal cells. Another two samples from each cell will also be obtained five years after mortality placement. All sample holes will be grouted with a cement bentonite mixture immediately after sampling. Figure 5 shows the sampling pipe details.

The proposed decommissioning date for the cells is September, 2015. At this time, all material in the cells will be excavated and transported to the operating GCWM landfill cell. Samples from both liners will also be obtained for future laboratory testing.

6. SUMMARY AND CONCLUSIONS

The design considerations and construction of two small scale livestock burial plots that will form the basis for future livestock mortality burial research has been described. Although currently under development, this research will provide valuable information on the effectiveness of livestock mortality burial and provide quantitative information to assist regulators. The project will also provide the opportunity to evaluate the contaminant migration field performance of a polypropylene coated GCL.

7. ACKNOWLEDGEMENTS

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8. REFERENCES


Terrafix, 2002. Quality Control Certificate, Bentofix CNSL GCL.