Site Suitability Review of the New Salem Landfill

by
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North Dakota State Water Commission
and
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North Dakota Geological Survey

Prepared by the
North Dakota State Water Commission
and the
North Dakota Geological Survey

ND Landfill Site Investigation No. 2
SITE SUITABILITY REVIEW
OF THE
NEW SALEM LANDFILL

By Jeffrey M. Olson, North Dakota State Water Commission,
and Phillip L. Greer, North Dakota Geological Survey

North Dakota Landfill Site Investigation 2

Prepared by the NORTH DAKOTA STATE WATER COMMISSION
and the NORTH DAKOTA GEOLOGICAL SURVEY

Bismarck, North Dakota
1993
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INTRODUCTION

Purpose

The North Dakota State Engineer and the North Dakota State Geologist were instructed by the 52nd State Legislative Assembly to conduct site-suitability reviews of the municipal landfills in the State of North Dakota. These reviews are to be completed by July 1, 1995 (North Dakota Century Code 23-29-07.7). The purpose of this program is to evaluate site suitability of each landfill for disposal of solid waste based on geologic and hydrologic characteristics. Reports will be provided to the North Dakota State Department of Health and Consolidated Laboratories (NDSDHCL) for use in site improvement, site remediation, or landfill closure. Additional studies may be necessary to meet the requirements of the NDSDHCL for continued operation of municipal solid waste landfills. The New Salem municipal solid waste landfill is one of the landfills being evaluated.

Location of the New Salem Landfill

The New Salem municipal solid waste landfill is located 1/2 mile east of the City of New Salem in Township 139 North, Range 85 West, E1/2, NW1/4 Section 22 (Fig. 1). The landfill site encompasses approximately 10 acres, of which all the area has been used.
Figure 1. Location of the New Salem landfill in the NW 1/4 of section 22 T139 N. R85 W.
Previous Site Investigations

No previous geological or hydrological investigations have been completed at the New Salem landfill. A test hole, drilled by Opp Well Drilling in 1982, was completed to determine the site geology. The test hole was drilled to a depth of 50 feet and did not detect any ground water. The exact location of the test hole is not known. The log for the test hole is included in Appendix C.

Methods of Investigation

The current New Salem landfill study was accomplished by: 1) test drilling; 2) construction and development of monitoring wells; 3) collecting and analyzing water samples; and 4) measuring water levels. Well abandonment procedures were followed for non-permanent monitoring wells.

Test Drilling Procedure

The drilling method at the New Salem landfill was based on the site's geology and depth to ground water, as determined by the preliminary site evaluation. A forward rotary drilling rig was used at the New Salem landfill for the initial drilling. This method was selected by the depth to ground water and the presence of layers of lignite. The lithologic descriptions were determined from the drill
cuttings. The water used with the forward rotary rig was obtained from the New Salem municipal water system.

An eight-inch hollow-stem auger was used to drill well 139-085-22BAD3. When using the hollow-stem auger, the well casing is installed through the center of the auger and placed at the desired depth. No additional water was used in this method of drilling.

Monitoring Well Construction and Development

The number of wells installed at the New Salem landfill was based on the geologic and topographic characteristics of the site. Seven test holes were drilled at the New Salem landfill, and monitoring wells were installed in six of the seven locations. Well 139-085-22BAD1 was abandoned and replaced with well 139-085-22BAD3 because of the lack of water in the well. The depth and intake interval of each well was selected to monitor the water level at the top of the uppermost aquifer.

Wells were constructed following a standard design (Fig. 2) and comply with the construction regulations of the NDSDHCL and the North Dakota Board of Water Well Contractors (North Dakota Department of Health, 1986). The wells were constructed using a 2-inch diameter, SDR21, polyvinyl chloride (PVC) well casing and a PVC screen, either 5 or 10 feet long, with a slot-opening size of 0.012 or 0.013 inches. The screen was fastened to the casing with stainless-steel
Soil
Neat Cement
or Bentonite Grout

Concrete Pad
4-Inch Diameter
Steel Casing

Locking Cap

2-inch diameter PVC Casing

Soil

Neat Cement
or Bentonite Grout

No. 10 Silica Sand
No. 12 Slot PVC Screen

Figure 2. Construction design used for monitoring wells installed at the New Salem landfill.
screws (no solvent weld cement was used). After the casing and screen were inserted into the drill hole, the annulus around the screen was filled with No. 10 (grain-size diameter) silica sand to a height of two feet above the top of the screen. High-solids bentonite grout and/or neat cement was placed above the silica sand to seal the annulus to approximately five feet below land surface. The remaining annulus was filled with drill cuttings. Permanent wells were secured with a protective steel casing and a locking cover protected by a two-foot square concrete pad.

All monitoring wells were developed using a stainless-steel bladder pump or a teflon bailer. Any drilling fluid and fine materials present near the well were removed to insure movement of formation water through the screen.

The Mean Sea Level (MSL) elevation was established for each well by differential leveling to Third Order accuracy. The surveys established the MSL elevation at the top of the casing and the elevation of the land surface next to each well.

Collecting and Analyzing Water Samples

Water-quality analyses were used to determine if leachate is migrating from the landfill into the underlying ground-water system. Selected field parameters, major ions, and trace elements were measured for each water sample. These field parameters and analytes are listed in Appendix A.
with their Maximum Contaminant Levels (MCL). MCLs are enforceable drinking water standards and represent the maximum permissible level of a contaminant as stipulated by the U.S. Environmental Protection Agency (EPA).

Water samples were collected using a bladder pump constructed of stainless steel with a teflon bladder. A teflon bailer was used in monitoring wells with limited transmitting capacity. Before sample collection, three to four well volumes were extracted to insure that unadulterated formation water was sampled. Four samples from each well were collected in high density, polyethylene plastic bottles as follows:

1) Raw (500 ml)
2) Filtered (500 ml)
3) Filtered and acidified (500 ml)
4) Filtered and double acidified (500 ml).

The following parameters were determined for each sample. Specific conductance, pH, bicarbonate, and carbonate were analyzed using the raw sample. Sulfate, chloride, nitrate, and dissolved solids were analyzed using the filtered sample. Calcium, magnesium, sodium, potassium, iron, and manganese were analyzed from the filtered-acidified sample. Cadmium, lead, arsenic, and mercury were analyzed using the filtered-double acidified sample.

One well was later sampled for Volatile Organic Compounds (VOC) analysis. The procedure used for collecting the VOC sample is described in Appendix B. Each sample was
collected with a plastic throw-away bailer and kept chilled. These samples were analyzed within the permitted 14-day holding period. The standard water-quality analyses were performed at the North Dakota State Water Commission (NDSWC) Laboratory and VOC analyses were performed by the NDSDHCL.

Water-Level Measurements

Water-level measurements were taken at least three times at a minimum of two-week intervals. The measurements were taken using a chalked-steel tape or an electronic (Solnist 10078) water-level indicator. These measurements were used to determine the shape and configuration of the water table.

Well-Abandonment Procedure

The test holes and monitoring wells that were not permanent were abandoned according to NDSDHCL and Board of Water Well Contractors regulations (North Dakota Department Health, 1986). The soil around the well was dug to a depth of approximately three to four feet below land surface (Fig. 3) to prevent disturbance of the sealed wells. The screened interval of the well was plugged with bentonite chips to a height of approximately one foot above the top of the screen and the remaining well casing was filled with neat cement.
Figure 3. Monitoring well abandonment procedure.
The upper three to four feet was then filled with cuttings and the disturbed area was blended into the surrounding land surface. Test holes were plugged with high-solids bentonite grout and/or neat cement to a depth approximately five feet below land surface. The upper five feet of the test hole was filled with soil cuttings.

Location-Numbering System

The system for denoting the location of a test hole or observation well is based on the federal system of rectangular surveys of public land. The first and second numbers indicate Township north and Range west of the 5th Principle Meridian and baseline (Fig. 4). The third number indicates the section. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarter section (160-acre tract), quarter-quarter section (40-acre tract), and quarter-quarter-quarter section (10-acre tract). Therefore, a well denoted by 139-85-22BAD would be located in the SE1/4, NE1/4, NW1/4 Section 22, Township 139 North, Range 85 West. Consecutive numbers are added following the three letters if more than one well is located in a 10-acre tract, e.g. 139-85-22BAD1 and 139-85-22BAD2.
Figure 4. Location-numbering system.
GEOLOGY

Regional Geology

The lithologies in the New Salem area consist of eroded bedrock sediments and discontinuous bodies of glacial sediment. Bedrock in the New Salem area is assigned to the Sentinel Butte Formation and the Bullion Creek Formation (formerly called Tongue River Formation). These formations are Paleocene in age and were deposited in deltaic environments (Jacob, 1976). They are composed of sand, sandstone, silt, clay, lignite, and limestone. The formations are similar in appearance. The main distinguishing characteristic is a difference in color in weathered exposures: the Sentinel Butte Formation is dark gray or brown; the Bullion Creek Formation is light gray or buff.

The contact between the two formations is difficult to recognize. However, information from test holes (Ackerman, 1977) and from the Morton County Geologic Map (Carlson, 1983) indicates that the contact occurs at or near the base of a local lignite bed.

Local Geology

The New Salem landfill is in an area of moderate relief. An intermittent stream at the southwest corner of the landfill drains eastward (Fig. 5).
Figure 5. Location of monitoring wells and test holes at the New Salem landfill and direction of ground-water flow in the uppermost aquifer beneath the landfill.
A small amount of glacial drift occurs in the landfill area. Several erratic boulders were observed on the property. A refuse cell near the southwest corner of the landfill exposed a layer of sandy clay till, approximately 6 feet thick, overlying bedrock. Wells 139-085-22BAD1 and 139-085-22BAD3, which are located on the western side of the landfill, also encountered a thin layer of till (Appendix C). No till was observed on the east or north sides of the landfill.

Where till is absent, the lower part of the Sentinel Butte Formation is present at land surface. The upper part of the Sentinel Butte Formation has been removed by erosion and the remaining 30 to 35 feet is composed primarily of fine to medium grained sand (Fig. 6). It is poorly consolidated except for thin zones of indurated sandstone which were encountered in two of the wells. In the northwest corner of the landfill clay is interbedded with the sand (wells 139-085-22BAA1 and 139-085-22BAA2).

The refuse cells on the east side of the landfill were placed within the bedrock sand. The cells in the southwest corner were placed partly in sand and partly in till. Those in the northwest corner were placed partly in sand and partly in clay.

Below the sand there is a lignite bed which ranges from 2 feet to 6 feet thick. This bed is the lowest unit of the Sentinel Butte Formation.
Figure 6. Geohydrologic section A-A' in the New Salem landfill
The areal extent of the sand and lignite units beyond the landfill is not precisely known. A review of local wells and test holes revealed that both units are present at least one-half mile to the west and south of the landfill. To the north, in Sections 15 and 16, T. 139 N., R. 85 W., the lignite bed is present but the sand has been largely replaced by clay. In some areas to the east of the landfill the sand and lignite have been removed by erosion.

The material below the lignite bed is part of the Bullion Creek Formation. A 20-foot-thick layer of clay occurs immediately below the lignite. The remainder of the Bullion Creek Formation is composed of clay, sand, sandstone, and lignite.

HYDROLOGY

Surface-Water Hydrology

No surface-water impoundments are located within a one-mile radius of the landfill. An ephemeral stream that intersects the landfill at the southwest corner of the property appears to flow only during large precipitation and/or snow melt events. Surface ponding is likely at the south end of the landfill boundary during large precipitation events. There is no diversion or interception of the runoff at the landfill. Surface ponding on the landfill site may increase infiltration through the sandy cover material thereby increasing leachate production.
Regional Ground-Water Hydrology

The regional aquifers around the New Salem landfill consist of bedrock. Most of the domestic wells are screened in the Bullion Creek Formation, although a few are screened in the Sentinel Butte Formation or the Cannonball Formation. The average depth of the wells in the Bullion Creek Formation is approximately 250 feet below ground surface. The flow direction in these aquifers is south-southeast from the landfill (Ackerman, 1980). These aquifers tend to be characterized by a sodium-bicarbonate type water.

Local Ground-Water Hydrology

Six monitoring wells were installed in and around the landfill boundaries (Fig. 5). The landfill boundaries intersect a lignite layer and the bedrock sand at a shallow depth. The well screens were placed near the top of the uppermost aquifer. The uppermost aquifer beneath the landfill is perched within the lignite layer and bedrock sand. The lignite layer was present at all the well locations and was used as the target horizon for placing the screens of the monitoring wells.

Up-gradient of the landfill the lignite layer was unsaturated, while the down-gradient wells screened in the same lignite layer supplied sufficient water for sampling. Wells 139-085-22BAA2 and 139-085-22BAD1 were screened up-
gradient of the landfill within the bedrock sand and lignite layer and were dry throughout the study period. Well 139-085-22BAD3 was screened at a lower depth than 139-085-22BAA1 and 139-085-22BAD1 and the down-gradient wells. A hydraulic head difference of almost 30 feet between this well and other down-gradient wells suggest that this well is in a different aquifer.

There are three domestic wells screened within the same lignite layer within one mile of the landfill to the west and south. These wells are used for drinking water. These wells are up-gradient of the landfill and should not be affected by leachate migration.

Three to four water-level measurements were taken over a six-week period (Appendix D). The water levels indicate a northerly flow within the upper bedrock sands and lignite aquifer beneath the landfill.

It is highly possible that stored water in the refuse will contribute downward to the water table. The fine sandy soil in which the refuse is buried provides an easy medium for water and leachate to move through the landfill and into the ground-water system.

Water Quality

Chemical analyses of water samples are shown in Appendix E. Wells 139-085-22BAA2 and 139-085-22BAD1 were dry. Due to the lack of an up-gradient well, water quality analyses from
the Morton County Ground-Water Study (Ackerman, 1977) were used to determine the formation ground-water quality within the surrounding township. Most of the ground water in the study area is a sodium-bicarbonate type (Fig. 7).

Water quality analyses indicate increased concentration of five major ions in well 139-085-22BAD2 (Appendix E). Concentrations consist of 460 mg/L of calcium (Fig. 8), 200 mg/L of magnesium (Fig. 9), 5 mg/L of manganese (Fig. 10) and 1900 mg/L of sulfate (Fig. 11). These concentrations are above the maximum contaminant levels (MCL). Figure 12 shows a chloride concentration of 180 mg/L which is below the MCL. Chloride, a conservative ion, may be a primary indicator for leachate migration. This well is characterized by a calcium-sulfate type water (Fig. 7). The increased concentration of five constituents at well 139-085-22BAD2 suggests downward movement of leachate into the underlying sand/lignite aquifer.

The trace-element analysis indicates a higher concentration of strontium (2400 µg/L) in well 139-085-22BAD2. Strontium occurs in low concentrations in natural ground-water systems (110 µg/L) (Hem, 1989). Increased strontium can result from leaching of incineration ash, municipal waste incineration, and burning piles. These ashes are usually found in municipal waste landfills. The increase may also be caused from the oxidation of overburden associated with the excavation process at the landfill.
Figure 7. Piper trilinear diagram showing range in water quality in the New Salem landfill study area.
Figure 8. Calcium concentration at the New Salem landfill.
Figure 9. Magnesium concentration at the New Salem landfill.
Figure 10. Manganese concentration at the New Salem landfill.
Figure 11. Sulfate concentration at the New Salem landfill.
Figure 12. Chloride concentration at the New Salem landfill.
A VOC sample was collected from well 139-085-22BDA. This well was not directly down-gradient from the landfill and therefore may not be a valid sampling point to detect leachate migration from the landfill. The results of the VOC analysis are shown in Appendix F. The analysis did not detect any VOC migration.

CONCLUSIONS

The New Salem landfill is located within the Sentinel Butte Formation and the Bullion Creek Formation. These formations consist of sand, sandstone, silt, clay, limestone, and lignite. Glacial till exists at the surface along the western boundary of the landfill. Where till has been eroded, the Sentinel Butte Formation is exposed at the surface. The interval of the Sentinel Butte Formation exposed consists of fine to medium grained sand underlain by a layer of lignite. The landfill operation has deposited refuse within the fine to medium-grained bedrock sand which provides an excellent medium for leachate migration.

There is no surface-water diversion or control at the landfill site. This could lead to an increased leachate production.

The direction of ground-water flow in the Bullion Creek aquifer is south-southeast. The landfill operation does not appear to affect the deeper bedrock aquifers. The uppermost
sand/lignite aquifer appears to flow in a north-northeast direction.

The water quality analyses indicate increased concentrations of five major ions in the down-gradient well 139-085-22BAD2. One of these constituents is chloride, a conservative ion, which is commonly an indicator of leachate migration.

Ground-water degradation from organic materials was not detected from the VOC analysis. The VOC sample was collected from a well that was not directly down-gradient from the landfill and therefore may not be a valid sampling point to detect leachate migration from the landfill. The hydrogeologic setting of the study area is conducive to downward leachate migration from the landfill into the uppermost sand/lignite aquifer.
REFERENCES


APPENDIX A

WATER QUALITY STANDARDS
AND
MAXIMUM CONTAMINANT LEVELS
## Water Quality Standards and Maximum Contaminant Levels

### Field Parameters
- **appearance**
- **pH**
- **specific conductance**
- **temperature**
- **water level**

### Geochemical Parameters
- **iron**
- **calcium**
- **magnesium**
- **manganese**
- **potassium**
- **total alkalinity**
- **bicarbonate**
- **carbonate**
- **chloride**
- **fluoride**
- **nitrate+nitrite (N)**
- **sulfate**
- **sodium**
- **total dissolved solids (TDS)**
- **cation/anion balance**
- **hardness**

### Heavy Metals (µg/L)
- **arsenic**
- **cadmium**
- **lead**
- **molybdenum**
- **mercury**
- **selenium**
- **strontium**

*EPA has not set a MCL for strontium. The median concentration for most U.S. water supplies is 110 µg/L (Hem, 1989).*

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</tr>
<tr>
<td><strong>specific conductance</strong></td>
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<td><strong>temperature</strong></td>
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<tr>
<td><strong>water level</strong></td>
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<tr>
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<td><strong>hardness</strong></td>
<td>&gt;121 (hard to very hard)</td>
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| **arsenic**                | 50          |
| **cadmium**                | 10          |
| **lead**                   | 50          |
| **molybdenum**             | 100         |
| **mercury**                | 2           |
| **selenium**               | 10          |
| **strontium**              | *           |
APPENDIX B

SAMPLING PROCEDURE FOR VOLATILE ORGANIC COMPOUNDS
SAMPLING PROCEDURE FOR 40ML AMBER BOTTLES

Sample Collection for Volatile Organic Compounds

by

North Dakota Department of Health
and Consolidated Laboratories

1. Three samples must be collected in the 40ml bottles that are provided by the lab. One is the sample and the others are duplicates.

2. A blank will be sent along. Do Not open this blank and turn it in with the other three samples.

3. Adjust the flow so that no air bubbles pass through the sample as the bottle is being filled. No air should be trapped in the sample when the bottle is sealed. Make sure that you do not wash the ascorbic acid out of the bottle when taking the sample.

4. The meniscus of the water is the curved upper surface of the liquid. The meniscus should be convex (as shown) so that when the cover to the bottle is put on, no air bubbles will be allowed in the sample.

5. Add the small vial of concentrated HCL to the bottle.

6. Screw the cover on with the white Teflon side down. Shake vigorously, turn the bottle upside down, and tap gently to check if air bubbles are in the sample.

7. If air bubbles are present, take the cover off the bottle and add more water. Continue this process until there are no air bubbles in the sample.

8. The sample must be iced after collection and delivered to the laboratory as soon as possible.

9. The 40 ml bottles contain ascorbic acid as a preservative and care must be taken not to wash it out of the bottles. The concentrated acid must be added after collection as an additional preservative.
Date Completed: 5/11/92
Depth Drilled (ft): 160
L.S. Elevation (ft): 2160.41

Purpose: Test Hole
Source of Data: New Salem

Lithologic Log

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<td>1-3</td>
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<tr>
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LIGNITE  

CLAY  OLIVE-GRAY, 5Y4/1  127-141

CLAY  SILTY, OLIVE-GRAY, 5Y4/1  141-160
### 139-085-22BAAA2

**NDSWC**

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<thead>
<tr>
<th>Date Completed:</th>
<th>5/11/92</th>
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#### Lithologic Log

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<tr>
<td>CLAY</td>
<td>SANDY, MODERATE YELLOWISH-BROWN, 5Y4/1, (SENTINEL BUTTLE FORMATION)</td>
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<tr>
<td>SAND</td>
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<tr>
<td>SAND</td>
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**Lithologic Log**

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<td>SILT</td>
<td>CLAYEY AND SANDY, DARK REDDISH-BROWN, 10R3/4</td>
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<tr>
<td>CLAY</td>
<td>SILTY, GRAYISH-ORANGE, 10YR7/4</td>
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<td>GRAYISH-GREEN, 5G/2, (BULLION CREEK FORMATION)</td>
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<tr>
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<td>29-34</td>
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Date Completed: 5/11/92  Well Type: P2 (PLUGGED)
Depth Drilled (ft): 36  Source of Data: 
Screened Interval (ft): 29-34  Principal Aquifer: Undefined
Casing size (in) & Type:  L.S. Elevation (ft)  2170.51
Owner: New Salem

Lithologic Log

<table>
<thead>
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<th>Unit</th>
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<th>Depth (ft)</th>
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<tr>
<td>CLAY</td>
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<td>0-9</td>
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<tr>
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<td>9-16</td>
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<tr>
<td>SANDSTONE</td>
<td>MEDIUM GRAIN, WELL CEMENTED, MODERATE REDDISH-BROWN, 10R4/6</td>
<td>16-19</td>
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**139-085-22BAD2**

**NDSWC**

- **Date Completed:** 5/12/92
- **Depth Drilled (ft):** 33
- **Screened Interval (ft):** 27-32
- **Casing size (in) & Type:** L.S.
- **L.S. Elevation (ft):** 2162.86
- **Owner:** New Salem
- **Well Type:** P2
- **Source of Data:**
- **Principal Aquifer:** Undefined

### Lithologic Log

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
<th>Depth (ft)</th>
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<tbody>
<tr>
<td>TOPSOIL</td>
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<td>0-1</td>
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<tr>
<td>SAND</td>
<td>FINE GRAIN, DARK YELLOWISH-BROWN, 10YR4/2</td>
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<td>SAND</td>
<td>WITH SANDSTONE FRAGMENTS, (SENTINEL BUTTE FORMATION)</td>
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<td>30-32</td>
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<td>SANDSTONE</td>
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139-085-22BAD3
NDSWC

Date Completed: 6/1/92  
Depth Drilled (ft): 90  
Screened Interval (ft): 80-90  
Casing size (in) & Type:  
Owner: New Salem

Well Type: P2  
Source of Data:  
Principal Aquifer: Undefined  
L.S. Elevation (ft) 2170.51

<table>
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<th>Description</th>
<th>Depth (ft)</th>
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<td>SILTY, TRACE GRAVEL, GRAYISH-BROWN, 5YR 3/2, (GLACIAL DRIFT)</td>
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<td>GRAVEL</td>
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<td>12-21</td>
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<td>(SENTINEL BUTTE FORMATION)</td>
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<tr>
<td>SAND</td>
<td>FINE-GRAINED, TRACE SMALL PEBBLES, MODERATE YELLOWISH-BROWN, 10YR 5/4,</td>
<td>21-33</td>
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<td>WITH MOTTLES OF MODERATE REDDISH ORANGE, 10R 6/6</td>
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**Date Completed:** 5/11/92  
**Depth Drilled (ft):** 33  
**Screened Interval (ft):** 25-30  
**Casing size (in) & Type:** 
**Owner:** New Salem  

**Well Type:** P2  
**Source of Data:** Undefined  
**Principal Aquifer:** Undefined  
**L.S. Elevation (ft):** 2149.71  

<table>
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<tr>
<th>Unit</th>
<th>Description</th>
<th>Depth (ft)</th>
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<tbody>
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<td>SAND</td>
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<td>CLAY</td>
<td>MEDIUM GRAY, N5, (BULLION CREEK FORMATION)</td>
<td>29-33</td>
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</table>
WELL DRILLER'S REPORT

County ____________ 1/4  ____________ Twp. ____________ N. Rg. ____________

1/4 Sec. ____________ Twp. ____________ N. Rg. ____________

WELL LOCATION
Sketch map location must agree with written location.

PROPOSED USE
- Domestic
- Irrigation
- Industrial
- Stock
- Municipal
- Test Hole

METHOD DRILLED
- Cable
- Reverse Rotary
- Bored
- Forward Rotary
- Jetted
- Other

WATER QUALITY
- Was a water sample collected for chemical analysis?
  - Yes
  - No
  - If so, to what laboratory was it sent?

WELL CONSTRUCTION
- Diameter of hole
- Depth
- Casing
  - Steel
  - Plastic
  - Concrete
  - Threaded
  - Welded
  - Other
  - Pipe Weight
  - Diameter
  - From
  - To
  - Lb/ft.
  - Inches
  - Feet
  - Lb/ft.
  - Inches
  - Feet
  - Lb/ft.
  - Inches
  - Feet
  - Lb/ft.
  - Inches
  - Feet

Was perforated pipe used?
- Yes
- No

Length of pipe perforated
- Feet

Was casing left open end?
- Yes
- No

Was a well screened installed?
- Yes
- No

Material
- Diameter
- Inches
- (Stainless steel, bronze, etc.)

Slot size
- Set from
- Feet to
- Feet

Was a packer or seal used?
- Yes
- No

If so, what material
- Type of well
- Straight screen
- Gravel packed

Was the well grouted?
- Yes
- No

To what depth
- Feet

Material used in grouting
- 

Well head completion
- Packer adapter
- Other

12" above grade
- Other

If other, specify
- Was well dewatered upon completion?
- Yes
- No

7. WATER LEVEL
- Static water level ____________ feet below land surface
- If flowing: closed-in pressure ____________ psi
- GPM flow ____________ through ____________ inch pipe
- Controlled by:
  - Valve
  - Reducers
  - Other
  - If other, specify

8. WELL TEST DATA
- Pump
- Bailer
- Other
- Pumping level below land surface:
  - ft. after ____________ hrs. pumping ____________ gpm
  - ft. after ____________ hrs. pumping ____________ gpm
  - ft. after ____________ hrs. pumping ____________ gpm

9. WELL LOG

Formation
<table>
<thead>
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<th>From</th>
<th>To</th>
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<tbody>
<tr>
<td>Soil</td>
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<tr>
<td>Sand</td>
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<tr>
<td>Sand</td>
<td>____________</td>
</tr>
<tr>
<td>Clay</td>
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10. DATE COMPLETED ____________

11. WAS WELL PLUGGED OR ABANDONED?
- Yes
- No

12. REMARKS: No Dept.

13. DRILLER'S CERTIFICATION

This well was drilled under my jurisdiction and this report true to the best of my knowledge.

Driller or Farm's Name ____________________
Certificat No. ____________________
Address ____________________

42
# New Salem Landfill Water-Level Data
6/5/92 to 7/27/92

### 139-085-22BAA2
**Undefined Aquifer**

<table>
<thead>
<tr>
<th>Date</th>
<th>Depth to Water (ft)</th>
<th>WL Elev (msl, ft)</th>
<th>LS Elev (msl, ft) = 2160.41</th>
<th>SI (ft.) = 26-31</th>
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<tbody>
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<td>06/05/92</td>
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### 139-085-22BAA3
**Undefined Aquifer**

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### 139-085-22BAD2
**Undefined Aquifer**

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### 139-085-22BAD3
**Undefined Aquifer**

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<th>Date</th>
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### 139-085-22BDA
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<td>2134.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07/01/92</td>
<td>15.47</td>
<td>2134.24</td>
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</tr>
</tbody>
</table>
APPENDIX E

MAJOR IONS AND TRACE-ELEMENT CONCENTRATIONS
### New Salem Water Quality

#### Major Ion Analyses

| Location       | Date Sampled | Interval (ft) | SiO₂ | Fe  | Mn  | Ca  | Mg  | Na  | K   | HCO₃ | CO₃ | Cl  | F   | NO₃ | B   | TDS | %CaCO₃ | %Na | SAR | Temp (°C) | pH |
|----------------|--------------|---------------|------|-----|-----|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|-------|-----|-----|-----------|----|
| 139-085-22AA3  | 06/23/92     | 24-29         | 172  | 172 | 24  | 466 | 486 | 0   | 110 | 0.6  | 0.3 | 0.37| 566 | 280 | 0.37 | 40   | 2.2 | 667 | 13       | 7.03|
| 139-085-22AD2  | 07/27/91     | 27-32         | 24   | 0.2 | 28  | 410 | 0   | 0   | 153 | 0.1  | 0   | 0   | 660 | 200 | 0.1  | 85   | 14  | 2030| 14       | 6.64|
| 139-085-22BDA  | 05/26/92     | 22-30         | 46   | 17  | 31  | 86  | 4.4 | 110 | 0.6 | 0.3  | 0.3 | 1.9 | 0.27| 566 | 280 | 0.37 | 40   | 2.2 | 667 | 13       | 7.03|

#### Heavy Metal Analyses

<table>
<thead>
<tr>
<th>Location</th>
<th>Date Sampled</th>
<th>Selenium (micrograms per liter)</th>
<th>Lead (µg/l)</th>
<th>Cadmium (µg/l)</th>
<th>Mercury (µg/l)</th>
<th>Arsenic (µg/l)</th>
<th>Molybdenum (µg/l)</th>
<th>Strontium (µg/l)</th>
<th>TDS (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>139-085-22AA3</td>
<td>06/23/92</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>940</td>
<td>544</td>
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<td>139-085-22AD2</td>
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<td>0</td>
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<td>0</td>
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<td>9</td>
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<td>3590</td>
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<td>139-085-22BDA</td>
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<td>7</td>
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<td>0.4</td>
<td>10</td>
<td>24</td>
<td>950</td>
<td>1720</td>
</tr>
<tr>
<td>139-085-22BDA</td>
<td>05/26/92</td>
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<td>5</td>
<td>4</td>
<td>410</td>
<td>714</td>
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</table>
APPENDIX F

VOLATILE ORGANIC COMPOUNDS
FOR WELL 139-085-22BDA
Volatile Organic Compounds and Minimum Concentrations

Concentrations are based only on detection limits. Anything over the detection limit indicates possible contamination.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Chemical Analysis µg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>&lt;1</td>
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<tr>
<td>Carbon Tetrachloride</td>
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</tr>
<tr>
<td>1,2-Dichloroethane</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Trichloroethylene</td>
<td>&lt;2</td>
</tr>
<tr>
<td>1,1-Dichloroethylene</td>
<td>&lt;2</td>
</tr>
<tr>
<td>1,1,1-Trichloroethane</td>
<td>&lt;2</td>
</tr>
<tr>
<td>para-Dichlorobenzene</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Acetone</td>
<td>&lt;50</td>
</tr>
<tr>
<td>2-Butanone (MEK)</td>
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</tr>
<tr>
<td>2-Hexanone</td>
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<tr>
<td>4-Methyl-2-pentanone</td>
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</tr>
<tr>
<td>Chloroform</td>
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</tr>
<tr>
<td>Bromodichloromethane</td>
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<tr>
<td>Chlorodibromomethane</td>
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<tr>
<td>Bromoform</td>
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<td>trans1,2-Dichloroethylene</td>
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<td>Chlorobenzene</td>
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<td>m-Dichlorobenzene</td>
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<tr>
<td>Dichloromethane</td>
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<tr>
<td>cis-1,2-Dichloroethylene</td>
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<tr>
<td>o-Dichlorobenzene</td>
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<td>Dibromomethane</td>
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<td>Tetrachlorethylene</td>
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<td>Xylene(s)</td>
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<td>1,1-Dichloroethane</td>
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<tr>
<td>1,2-Dichloropropane</td>
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<tr>
<td>1,1,2,2-Tetrachloroethane</td>
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<td>Ethyl Benzene</td>
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<td>Styrene</td>
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<td>Bromomethane</td>
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<tr>
<td>1,2,3-Trichloropropane</td>
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<tr>
<td>1,1,1,2-Tetrachloroethane</td>
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<tr>
<td>Chloroethane</td>
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<tr>
<td>1,1,2-Trichloroethane</td>
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* Constituent Detection
### VOC Constituents cont.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Concentration</th>
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<td>2,2-Dichloropropane</td>
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<tr>
<td>p-Chlorotoluene</td>
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<tr>
<td>Bromobenzene</td>
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<tr>
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<td>&lt;5</td>
</tr>
<tr>
<td>1,2,4-Trimethylbenzene</td>
<td>&lt;5</td>
</tr>
<tr>
<td>1,2,4-Trichlorobenzene</td>
<td>&lt;5</td>
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<tr>
<td>1,2,3-Trichlorobenzene</td>
<td>&lt;5</td>
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<tr>
<td>n-Propylbenzene</td>
<td>&lt;5</td>
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<tr>
<td>n-Butylbenzene</td>
<td>&lt;5</td>
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<tr>
<td>Hexachlorobutadiene</td>
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<td>1,3,5-Trimethylbenzene</td>
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</table>

* Constituent Detection