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CRUCIBLE SPECIALTY METALS

A Division Of
Crucible Materials Corporation

Revised Landfill Closure Plan

VOLUME 1

ENGINEERING REPORT

January 1986

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Since 1876 Crucible Materials Corporation

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January 28, 1986

Mr. Paul Counterman, P.E.
Chief
Bureau of Hazardous Waste Technology
Division of Solid and Hazardous Waste
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, New York 12233-0001

Re: Crucible Landfill Closure/Post-Closure Plan
EPA ID#NYD085161008

Dear Mr. Counterman:

Enclosed you will find the Revised Landfill Closure/Post-Closure ("the Plan") for the Crucible Landfill operated by the Specialty Metals Division of Crucible Materials Corporation located in the Town of Geddes, New York. In addition, you will find enclosed the appendices, figures, drawings and other materials referenced in the Plan.

Upon your review of the Plan, you will note that we have included in the Plan the modifications you requested in your November 25, 1985 letter and the attached Technical Completeness Review Notice of Deficiency. We believe that the modifications included in the Plan comply with your requests and that this Plan, as submitted herein, is complete with one exception. That exception, which will be resolved on or before March 31, 1986, involves the submission of the figures for the 1985 fiscal year by Colt Industries Inc. to comply with the financial responsibility requirements dealing with closure and post-closure care costs and liability coverage for sudden and nonsudden accidental occurrences at the Landfill.

In a telephone conversation on January 22, 1986, with Harvey King of your office, one of our attorneys, Mary Louise Barhite of Nixon, Hargrave, Devans & Doyle, explained to Mr. King that Colt's financial statements for the 1985 fiscal year are presently in the process of being compiled. Thus, the Chief Financial Officer's letter submitted at this time (in Appendix I) in support of Colt's use of the financial test to meet the financial responsibility requirements contains figures for the 1984 fiscal year. In addition to the Chief Financial Officer's letter, Appendix I contains the 1984 Colt Annual Report in which the independent certified public accountant's report on examination of Colt's financial statements for the 1984 fiscal year is set forth. It is my understanding that Mr. King has agreed that the third document which should accompany the Chief Financial Officer's letter and the accountant's report, i.e. the special audit report which compares the figures contained in the Chief Financial Officer's letter with the audited financial statements of the completed fiscal year, need not be included at this time. Rather, he has agreed that the special audit report can be submitted with the revised Chief Financial Officer's letter and the accountant's report on or before March 31, 1986, all of which will reflect the 1985 figures.

Finally, you will note that in this Plan we have scheduled the closure of the Landfill to take place over a three-year period. Despite the fact we have used three years as the projected time period for closure, we still believe that the original eight-year closure plan schedule, detailed in our closure plan submitted in July 1984, is the better alternative. Our technical consultants continue to recommend a gradual closing in order that actual field measurements of stress and settlement can be made as closing progresses with subsequent fine-tuning of the closure procedures to maximize the integrity of the Landfill site. As you know, we have participated in the on-going USEPA rulemaking on the issue of the length of the closure time period. We thus wish to inform you of our continued desire to preserve our right to have the longer closure period considered should the regulatory question concerning time for closure be resolved in our favor.

We would be pleased to respond to any questions you may have concerning this submission.

Very truly yours,

Robert J. Taggart

Robert J. Taggart
Vice President
Manufacturing Services

RJT:ifs

cc: Larry Gross, P.E.
(NYSDEC, Region 7)

enclosures

LANDFILL CLOSURE PLAN

For

CRUCIBLE SPECIALTY METALS DIVISION

CRUCIBLE MATERIALS CORPORATION

GEDDES, NEW YORK

Prepared By: Calocerinos & Spina
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JANUARY 1986

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SECTION 1

INTRODUCTION

1.01 General Description of Crucible Mill Operations

Crucible operates steel making and conditioning processes to produce a variety of high grade and specialty steels. Although the processes are complex both physically and metallurgically, they can be broken down into the following general groups:

1. Melting - Crucible utilizes an electric arc furnace to melt various mixtures of scrap metals and added alloys. The electric arc furnace uses large electrodes of carbon or graphite to melt the scrap metals, and then specific alloys are added to obtain the desired metallurgical qualities in the melt.
2. Argon Oxygen Decarburization Process (AOD)- The AOD process is designed to refine stainless, tool, valve and other high grade steels. The process involves taking a melt from the electric arc furnace, pouring it into the AOD vessel, and injecting oxygen into the liquid steel while keeping the mixture in an inert atmosphere. This method removes unwanted carbon and metallics by oxidation.
3. Forging - Crucible uses a 2,000 ton press to compress large hot ingots into billets, flats, and rounds. The ingots are heated to forging temperatures and then repeatedly brought through a press in a predetermined manner. The forging results in sounder centers and a greater uniformity throughout the billet. Two large steam hammers are also used in the forging operation to provide a better hot finished surface.
4. Rolling Mills - The Rolling Mills reduce heated ingots and billets into products of specific sizes as needed to fill individual orders.

The hot materials are passed back and forth between rollers where it is rolled into smaller diameter but longer billets. The Rolling Mills provide a more uniform structure in the steel.

5. Conditioning - Depending on the desired process, conditioning involves processing billets from press hammers or Rolling Mills by grinding, pickling or any combination thereof. Grinding involves an abrasive wheel used to remove mill scale and any surface defects. Pickling involves dipping the material in various acid or caustic baths to remove scale and other surface impurities.

6. Finishing - In finishing, the steel may again be rolled in progressively smaller mills until the desired size and shape is reached. Lathes, drawblocks, straighteners, grinders and cut-off saws may also be used to reach the desired size, shape and finish of the steel.

7. Annealing and Heat Treatment - Annealing and heat treating are used to prevent strain cracking and to soften or harden the steel. In this step, the steel is heated to predetermined temperatures and then cooled in a specific manner (slow or fast, and in air, water, or oil).

1.02 Description of Crucible's Solid Wastes

A. Non-Hazardous Solid Wastes

Table 1-1 lists the Mill's non-hazardous wastes which are currently being landfilled by Crucible, along with their approximate percentages by volume. A description of the wastes and their sources follows. Most of these wastes are metallic or metallic oxides which are chemically inert.

1. Slag - Crucible utilizes an electric arc furnace to melt various mixtures of scrap metals and added alloys. Slag is a bulky mineral

TABLE 1-1

CRUCIBLE SOLID WASTES

Waste Description	Approximate Annual Quantity (yd^3)	Percentage of Total
Slag	6,290	43.4
Construction and Refractory Debris, Sorbents, Misc.	4,104	28.3
Boiler House Ashes	1,437	9.9
Coolant Swarves	1,375	9.5
Mill Scale	1,121	7.7
WWTP Sludge	165	1.2
TOTALS	14,492	100.0

residue generated in this furnace. Mainly composed of silicates, the material also contains small amounts of iron, aluminum, chromium and nickel.

2. Construction and Refractory Debris, Absorbents, Miscellaneous - As with any large industrial facility, Crucible generates quantities of bricks, mortar, wood, steel, etc., from a variety of activities. These materials are stable and inert and generally are a result of maintenance activities. Because of the nature of Crucible's business, a major portion of this waste category is refractory debris.
3. Boiler House Ashes - Crucible generates steam from the combustion of coal. The fly ash and bottom ash collected from the Boiler House are composed mainly of silicates and iron with a small amount of aluminum.
4. Coolant Swarves - Coolant is used in metal finishing processes, such as grinding, to provide proper lubrication and cooling. The resulting waste coolant swarf contains iron, chromium and nickel.
5. Mill Scale - The rolling and forging operations utilized at Crucible result in the loosening of scale which develops on the surface of the metals as they are processed through various heating operations. Mill scale contains iron as the major component with small amounts of chromium and nickel.
6. Wastewater Treatment Plant Dewatered Sludge - Crucible operates a two-stage Wastewater Treatment Plant to maintain the quality of both recycled water and discharged effluent. In the Wastewater Treatment Plant, suspended solids are coagulated, removed from the wastewater

and dewatered by vacuum filters. The sludge is composed of hydroxide precipitates of mainly iron and chromium with small amounts of nickel.

B. Hazardous Wastes

No hazardous wastes have been deposited at the Crucible landfill since March 3, 1982. The following hazardous wastes, however, have been landfilled in the past by Crucible.

1. Waste Caustic Solids - Molten caustic is employed in the pickling operation for scale removal. As pickling proceeds, spent caustic chips deposit along the edges of the tank and on equipment that comes into contact with the caustic. These solids are removed periodically and must be disposed of. Caustic-coated mill scale is also removed from the tank when it is periodically cleaned. These solids contain hexavalent chromium and are considered hazardous because they exceed the limits of the EP Toxicity test with respect to chromium in the leachate. Currently about 200 yd^3/yr of such solids are shipped to a licensed disposal site.

2. Acid Pickling Sludges - Acid pickling sludges are residues left in pickling tanks when the acid solutions are spent. Such sludges contain significant amounts of iron and chromium and fail the EP Toxicity test with respect to chromium. The 50 yd^3/yr of acid pickling sludges are removed with pickle acids to a licensed disposal site.

3. EAF and AOD Dusts - Air pollution dust from the electric arc furnace (EAF) at Crucible is a listed hazardous waste (K061). Crucible's EAF dust also exceeds the EP Toxicity limitation with respect to

chromium. Air pollution dust from the Argon-Oxygen Decarburization (AOD) vessel is similar in character to electric arc furnace dust. AOD dust is hazardous because it exceeds the EP Toxicity limitation with respect to chromium. Over 1,000 yd^3/yr of EAF and AOD bag house dusts are now shipped to a reclaiming facility in Pittsburgh and returned as recycled metal for remelting in the electric arc furnace.

Figure 1-1 shows the approximate limits of the Crucible landfill in March, 1982, when disposal of hazardous materials ceased, along with the June, 1984 limits, and the proposed final limits at closure. Since these waste materials were not classified as hazardous during the mid-1970's, they were landfilled with non-hazardous wastes. The dotted line in Figure 1.1 therefore, represents the area of the facility which has received scattered deposits of hazardous wastes in the past. All of these areas have since been covered with non-hazardous materials.

Table 1-2 lists the estimated annual quantities of hazardous wastes which were landfilled. The quantities in the table were calculated based on the number of containers (assumed full at 7.5 $yd.^3$ each) which were transported to the landfill in 1975. For all other years, production numbers at the mill were divided by the 1975 production to calculate a ratio which was then multiplied by the volumes of materials which were landfilled in 1975.

Containers of waste are not transported at full capacity. To better approximate the actual volumes of material transported, therefore, the calculated value based on 100% container capacity was multiplied by 75%, which is the average load capacity as estimated by the landfill operator.

Table 1-2

ANNUAL HAZARDOUS WASTE QUANTITIES LANDFILLED (CU. YDS.)

Year	AP & AOD Dusts	Waste Caustic Solids	Acid Pickling Solids	Annual Totals
1982	57.5	0	0	57.5
1981	679.7	0	29.0	708.7
1980	691.1	0	29.4	720.5
1979	830.0	0	35.3	865.3
1978	705.4	120.0	30.0	855.4
1977	667.5	113.6	28.4	809.5
1976	451.7	76.8	19.2	547.7
1975	882.0	150.0	37.5	1,069.5
1974	849.5	144.5	36.2	1,030.2
1973	770.4	131.0	32.8	934.2
Totals	6,584.8	735.9	277.8	7,598.5

1.03 Landfill Location

Since 1973, Crucible has utilized a landfill site on top of abandoned Solvay Process Wastebeds between Interstate 690 and Onondaga Lake, in the Town of Geddes, New York. Figure 1-2 presents the regional setting of the Crucible Landfill. These lakeside wastebeds were constructed over a period of years in a series of terraced levels surrounded by steep slopes. The top terrace, on which the Crucible Landfill is located, is approximately 60 feet higher in elevation than Onondaga Lake.

As shown, the Lakeside Wastebeds are bounded by Onondaga Lake on the east, Ninemile Creek on the north, Interstates 690 and 695 on the west and land owned by Onondaga County on the south. Surrounding land use is dominated by Interstates 690 and 695. There are no residences within 1,000 feet of the Landfill.

1.04 Site History Prior to Landfill

The present site of the lakeside wastebeds was formerly swampland that was drained in 1822 when the State of New York constructed the State Ditch. The Ditch deepened the channel between Onondaga Lake and the Seneca River and this resulted in a two-foot drop in the Lake level. The original swamp areas extended along most of the southern and western shores of the Lake.

In 1881, the Solvay Process Company was formed to produce Soda Ash (sodium carbonate) in what is now the Village of Solvay. The process involves the burning of coal in the presence of limestone to produce carbon dioxide and lime (calcium oxide). The carbon dioxide is reacted with an ammoniated brine solution (ammonia and sodium chloride) to produce sodium bicarbonate. The bicarbonate is heated to convert it to soda ash while releasing carbon dioxide and water vapor. The lime is slaked (mixed with water) and the resulting calcium hydroxide is used to recover ammonia from various waste streams. The resulting waste, along with boiler ash and other process wastes, was then deposited in large surface impoundments that are called Solvay Process Wastebeds.

For several years, Solvay Process waste was deposited along the shores of the southern corner of Onondaga Lake and in 1903 the company began depositing process waste into lakeside wastebeds on the western edge of the Lake. Initially, dikes for the wastebeds were constructed of fill from the area. Solvay Process waste was pumped from the plant in slurry form, through pipelines, to the wastebeds. As the solids settled out, the supernatant liquid drained through pipelines directly into Onondaga Lake. As a wastebed filled, the waste stream was diverted to another wastebed, and the original wastebed was allowed to dewater. Settled waste material was then used to raise the dike level and the additional waste was pumped into the wastebed. In this manner, with alternating periods of deposition, dewatering and dike construction, the wastebeds rose in stages to their final elevations. In the early stages, new wastebeds were added by covering more land, but later, new wastebeds were constructed on top of older wastebeds. The lakeside wastebeds were abandoned in stages from 1939 to 1950 and cessation of waste deposition at different levels resulted in the terraced appearance visible today.

During expansion of the wastebeds onto Ninemile Point (circa 1929), it was necessary to divert Ninemile Creek to its present location. The former creek bed is located under Solvay Process waste directly below the Crucible Landfill.

The lakeside wastebeds were deeded to the people of the State of New York in 1953 as a right-of-way for I-690 and were administered by the State's Department of Transportation. In 1985, Onondaga County obtained title to the majority of the lakeside wastebeds including the entire Crucible Landfill (see sheet 2 of the attached drawings for boundary details). Future plans for the area include the construction of a bicycle path which would be connected with an existing path by a bridge over Ninemile Creek. The lakeside wastebeds are currently zoned by the Town of Geddes for industrial use.

Portions of the lakeside beds have been put to use by other area organizations. The New York State Fair utilizes large areas for parking and, in the past, has stored animal manure in other areas. Sections of I-690 and I-695 have been constructed on the wastebeds. NYSDOT deposited construction spoil materials from I-690 in the wastebeds. The City of Syracuse and Onondaga County utilized an area of the wastebeds from 1925 to 1978 for disposal of sewage sludge from the City Sewage Plant and the present Metropolitan Syracuse Waste Treatment Plant on Hiawatha Boulevard. In addition, lakeside wastebeds have been used by several area colleges and universities for both field trips and long-term research projects.

1.05 Crucible Landfill History

A. Land Use and Ownership

The Crucible Landfill is located on the northern portion of the inactive Solvay Process Wastebeds, as shown on Figure 1-2. The Crucible Landfill encompasses approximately 20 acres. Boundaries of the disposal site are shown on Sheet 3 of the attached drawings.

Appendix A contains a copy of a permit issued by Onondaga County to Crucible and Colt Industries, Inc. (which, until December 20, 1985, was the parent corporation of Crucible) authorizing Crucible and Colt, as co-permittees, to utilize the land as a solid waste disposal location.

B. Landfill Operations

Since 1973 when the Crucible Landfill began operation, there have been established operating procedures. Waste material is transported to the Landfill site in Crucible owned and operated load lugger trucks which back up to the working face and dump material along the face. A contractor hired by and under the direction of Crucible operates a bulldozer on the site to level and grade waste material. All hazardous wastes deposited at the landfill in the past were covered with nonhazardous materials including mill scale and treatment plant sludge. Likewise, wastes which are susceptible to dusting, such as boiler house ashes are also covered with more stable materials (such as mill scale or treatment plant sludge) to prevent wind-blown dust.

C. Traffic Patterns

Figure 1-3 shows the Landfill site and the transportation route from the Mill. All trucks leaving the Mill for the Landfill exit from the shipping gate and turn left onto State Fair Boulevard. They proceed approximately 300 feet to the first intersection, make a right-hand turn under I-690 to a stop sign, then another left turn up a short hill, through the access gate, and proceed approximately 1,000 feet across the lower State Fair parking lots. There is another short hill up to the next level of parking lots and then the remaining 1,500 feet to the entrance of the Crucible Landfill where another gate is located. Truck traffic averages eight-to-ten loads per day based on total annual production, but will vary on any given day.

D. Site Access

Access to the site is controlled by an entrance gate to the State Fair parking lots which is located at the top of the entrance road opposite the Solvay/State Fair/Route 297 exit from I-690 west. The gate is locked unless someone is present at the site. A second gate at the landfill extrance prohibits access to the landfill proper. The very steep slopes create a physical barrier which makes unauthorized site access extremely difficult. The Crucible Mill normally operates 24 hours a day for five days a week, but the Landfill is usually open only from 7:00 a.m. to approximately 3:00 p.m., Monday through Friday.

E. Climate and Meteorological Data

The following is a summary of climatological data for Hancock Airport, Syracuse, New York, compiled by the National Oceanic and Atmospheric Administration. Hancock Airport is located approximately four miles northeast of the Crucible Landfill. Climate data were reviewed for a 20-year period from 1964 to 1984. The climate of Syracuse is of temperate, relatively humid, continental character, with marked seasonal and diurnal changes.

Average annual precipitation for the area is approximately 35 inches. Areal distribution of precipitation (water equivalent) in the Syracuse area is uniform. Approximately 45 percent of the annual precipitation is received from May through September. Thunderstorms occur approximately 30 days per year. The maximum 1-hour, short-duration precipitation recording from 1980 to 1984 was 0.83 inches on August 9, 1982. Frost-free conditions (temperatures above 32°F) average 160 to 165 days per year. From November through April precipitation is primarily in the form of snow. Average snowfall in the Syracuse area is over 100 inches per year, while frost typically reaches a maximum depth of 48 inches.

Rainwater samples were collected in connection with the pilot-scale leachate testing program during the period between May 1981 and April 1982. The average pH value for this period was 5.85. A rainwater grab sample was collected April 1, 1984, by Calocerinos & Spina sampling personnel and showed a pH of 5.3.

Average wind velocity is between 6-7 mph, from the west-northwest (see Figure 1-4, Wind Rose Diagram.) Cloudy skies predominate the Central New York weather picture limiting the percent of available sunshine to less than 50 percent. The Syracuse area receives, on the average, 60 clear days, 100 partly cloudy days, and 200 cloudy overcast days per year.

F. Groundwater Monitoring

During initial studies in the summer of 1980 three borings were drilled through the Crucible Landfill. Wastebed materials were sampled at various depths, and one deep and one shallow well were installed on the Landfill. In June 1981, the Phase I detailed geotechnical work was completed and a total of 25 piezometers and 14 monitoring wells were installed in 20 borings. In March and April 1982, 22 monitoring wells, 6 piezometers and 5 lysimeters were installed during Phase II detailed geotechnical work. In addition, five seepage galleries were installed along several dikes and other areas peripheral to the site during that program. In 1983 an additional monitor cluster consisting of five wells was installed. A total of 84 groundwater monitoring installations are now available at the site as shown in Figure 1-5.

The groundwater monitoring program allows sampling of groundwater at various locations and depths in the wastebeds under Crucible wastes and in the proximity of Ninemile Creek on the west and Onondaga Lake on the east. A sampling program utilizing key selected installations has been operating for nearly two years, providing data from every season.

Two of the 84 monitoring installations at the landfill have experienced chromium above the Class GA groundwater standard of 0.05 mg/l. In both instances these occurrences have been attributed to other activities in the immediate vicinity of the installations. The first occurrence was with Composite Monitor 201 (CM 201) where levels of chromium above the detection limit suddenly appeared in the second quarter monitoring of 1983. These levels occurred, however, after a test pit was dug immediately adjacent to the installation in order to examine a contaminant enclave. The pit was approximately ten feet deep and was subsequently backfilled with Crucible landfill waste. The top of the screen for CM 201 is approximately 13 feet below the test pit, and the close proximity of the pit to the well installation apparently created a short-circuiting of leachate which was not sufficiently reacted with Solvay wastes. The test pit was re-excavated and refilled with clean Solvay waste. Additional monitoring facilities were then installed immediately downgradient. None of the wells in this cluster have shown any contamination.

A similar appearance of detectable chromium occurred at one monitor (MS-105.2) of a five-well cluster. Hydrogeologic analysis of that occurrence provided positive evidence for failure of the annular seal on the well. MS-105.2 was subsequently removed and the hole grouted with bentonite. Replacement well MS-105.2R was then installed into the same hydrologic horizon at the well cluster. Monitoring for over one year has not indicated the presence of detectable chromium, thus supporting the thesis of well failure.

Details on both occurrences were presented in the Groundwater Quality Assessment Program submitted to the EPA in January of 1984.

G. Permitting History

In June 1976, Crucible submitted an Application to New York State Department of Environmental Conservation (NYSDEC) for a Permit under 6 NYCRR 364 to transport industrial waste from the Production Facility to the Landfill. The Permit was received in April 1980 with a letter notifying Crucible that a Part 360 Operating Permit was required for the Landfill. The letter indicated that the Application for the Permit was to be filed by July 1, 1980.

On July 1, 1980, the requested Part 360 Application was submitted to NYSDEC along with an Engineering Report and package of Drawings. On July 17, 1980, NYSDEC advised that the Crucible Application was incomplete and requested additional information on a variety of items. Crucible submitted a response to NYSDEC on August 12, 1980, that clarified several items. In addition, Crucible indicated that a revised Report would be submitted subsequent to completion of additional studies at the Landfill.

On August 13, 1980, Crucible submitted a Notification of Hazardous Waste Activity to the U.S. Environmental Protection Agency (USEPA) as a disposer of hazardous waste.

On November 14, 1980, Crucible submitted to USEPA (Region II) a consolidated Permit Application for a Part A USEPA Interim Status Permit to operate a hazardous waste landfill.

Several times between December 1980 and December 1981, Crucible resubmitted its Part 360 Permit Application to NYSDEC but each time additional information, including geotechnical and chemical investigations, was required before the NYSDEC could process the Application. Finally, Crucible decided to seek an NYSDEC Part 360 Permit for nonhazardous operations only.

On June 4, 1982, Crucible submitted an extensive six-volume Report to NYSDEC thoroughly documenting its request for a Part 360 Permit to continue operation of the Landfill. The submittal contained a draft Environmental Impact Statement and documentation of extensive discussions of the Project with a Citizens' Advisory Committee. It also contained an Operation and Closure Plan developed in conjunction with Onondaga County and the New York State Department of Agriculture and Markets. The Part 360 Permit was issued by NYSDEC in October 1982 and the Landfill has since been operated in accordance with the provisions of that Permit with quarterly sampling of some 20 groundwater monitoring installations.

In December 1983, Crucible submitted its Application for a Part B RCRA Permit to continue operation of its Landfill (for disposal of non-hazardous wastes only). In April 1984, Crucible received a letter from USEPA indicating that the Part B Permit Application was deficient since it did not address the disposal of hazardous wastes at the landfill and required submittal of a revised Application package by May 31, 1984.

On May 24, 1984, representatives of Crucible, Calocerinos & Spina, and Nixon, Hargrave, Devans & Doyle met with representatives of the USEPA and the NYSDEC in the USEPA Region II office in New York City. Since Crucible had made other arrangements for disposal of its hazardous wastes it was agreed that Crucible would submit a Closure Plan for the landfill in lieu of a Part B resubmittal.

In July 1984, Crucible submitted the referenced Closure Plan to the USEPA. In a May 14, 1985 letter, the USEPA determined that the plan was unacceptable.

This current resubmittal contains a revised Closure Plan which features a revised cap design along with a substantially abbreviated closure period. Due to the unique nature of the Crucible landfill, the key elements of this Closure Plan were discussed in detail with members of key technical staff from both USEPA Region II and the NYSDEC Head- quarters and Regional Office at scheduled meetings during the preparation process.

SECTION 2

TECHNICAL EVALUATIONS

2.01 Previous Investigations

Extensive research and investigations have been conducted on the Crucible Landfill in order to understand the site leachate attenuation mechanism, groundwater regime and site stability characteristics. Findings from critical portions of that work were presented in detail in the NYSDEC Part 360 Application and accompanying Engineering and Scientific Reports. Copies of that six-volume document are included with this report.

Critical to the review of this Closure Plan are the results of findings from those previous investigations which (1) documented the apparent in-situ attenuation of Crucible leachate, (2) indicated no detectable migration of contaminants, and (3) recommended that the site not be capped because of resultant settlement and stability problems.

Specific previous hydrogeologic and geotechnical investigations included:

1. Subsurface Investigations in 1980 by Calocerinos & Spina. These initial studies were to verify use of Solvay Process wastes as an attenuation mechanism for Crucible waste leachate.
2. Phase I Hydrogeologic Investigations in 1981 by Thomsen Associates in support of a Part 360 Hazardous Waste Permit.
3. Phase II Hydrogeologic and Geotechnical Investigations by Thomsen Associates in 1982 in support of the current Part 360 Permit.
4. A Groundwater Quality Assessment Program conducted in 1983 by Calocerinos & Spina.

Copies of the Part 360 Application and Reports contain Item No. 3 above. Copies of Item No. 4 above were also provided to NYSDEC and USEPA for review. Both of these documents also contain summary information from Item Nos. 1 and 2 above. Presented in this document are summaries of hydrogeologic and geotechnical data and findings from all referenced investigations and the reviewer is encouraged to utilize those references whenever an interest in more detail is desired.

The scope of work provided by earlier investigations included:

1. Installation of 83 groundwater monitoring wells, piezometers, lysimeters and seepage galleries.
2. Numerous groundwater quality analyses.
3. 16 field permeability and 30 laboratory permeability tests.
4. 16 grain size analyses.
5. 16 field shear strength tests.
6. 2 laboratory consolidation and shear tests.
7. Tritium age dating analysis.
8. A three-dimensional finite difference groundwater model.
9. Computer stability analyses.

These investigations were conducted in agreement with and with advice from technical advisors and reviewers from the NYSDEC, Dames & Moore, and Williams & Works. The following subsections present (1) summaries of findings of investigations previously conducted and (2) re-evaluation of those findings in order to provide a Closure Plan with capping which would minimize settlement and stability problems.

2.02 Summary of Hydrogeologic Findings

A. General Hydrogeologic Setting

The Crucible Landfill site is within the Erie Ontario Lowlands Physiographic Province of New York State. Topography is characterized as a low relief undulate lake plain, overprinted with drumlins and drumloid features (Figure 2-1). Regional drainage is essentially northwest from the Onondaga Escarpment to the Lake Ontario Basin.

The Landfill site overlies a buried bedrock channel occupying the central portion of Ninemile Creek Valley and its junction with the deeply buried, northwest trending, Onondaga Lake trough (glacial scour) bedrock channel. The bedrock channel beneath the site is filled, in excess of 130 feet, with unconsolidated fluvial and glacial deposits. These deposits diverge and thicken with proximity to the axis of the Onondaga Lake trough.

The site specific nature and aspect of unconsolidated deposits, underlying the Crucible Landfill site, have been well defined via extensive subsurface borings (Thomsen Associates, 1982). Numerous borings and monitoring installations have been placed throughout the site. These, as well as an additional 600 boring logs from construction of Interstate 690, have been used to delineate variations in horizontal and vertical subsurface stratigraphy. Information from these borings was used to construct geologic profiles shown along the lines on Figure 2-1.

Unconsolidated glaciofluvial and glaciolacustrine channel fill deposits can be separated into six distinct geologic horizons (presented in Figures 2-2 and 2-3) based on changes in morphology and physical parameters inferred from samples. Physical properties of the units are summarized in Table 2-1. The six geologic units are defined as the following:

TABLE 2-1

PHYSICAL PROPERTIES OF GEOLOGIC UNITS

Geologic Unit	Boring/Well	Depth	% Gravel	% Sand	% Silt and Clay
Solvay Process Waste	MS 104	30'-32'	0	0	100
Swamp/Lacustrine	B1	64'	-	-	95
	B4	53'	-	-	98
	MS 105	68'-70'	0	22	78
	MS 106	66'-68'	0	35	65
Alluvio-Deltaic Deposits	B4	81'	-	-	15
	B9	66'	-	-	19
	MS 105	76'-78'	15	63	22
Upper Glaciolacustrine Deposits	B3	51'	-	-	77
	DW 102	138'-140'	0	22	78
	DW 103	82'-84'	0	3	97
	MS 104	76'-78'	0	13	87
	MS 104	80'-82'	0	0	100
Ablation Till	DW 101	128'-130'	7	73	20
	DW 103	160'-162'	10	77	13

Reference: Thomsen Associates, 1982

1. Bedrock - Local bedrock information in the site vicinity is Silurian Vernon Shale. This formation is characteristically soft and poorly cemented. Site specific subsurface bedrock topography suggest truncation of the incised pre-glacial Ninemile Creek channel by later glacial scour of the Onondaga Lake trough resulting in a discordant junction or hanging valley configuration. In general, the shale bedrock possesses low permeability and is not considered as an aquifer.

2. Ablation Till - Overlying the shale bedrock is a 5-15 foot section of poorly graded silty sands and gravels. These mixed deposits are a result of waning glacial activity and represent ablation till or reworked basal till deposits.

   In essence, as the glacial ice floes became stagnant, melted, receded and/or changed flow direction, ice suspended materials were left behind as a depositional blanket on previously ice-covered topography. This is the most permeable depositional unit encountered and has been characterized by the USGS as the principal local aquifer. Because of this aquifer's extreme natural saline condition, it is not considered a potable source of water. Field permeability tests determined the average horizontal conductivity of this unit to be 6×10^{-4} cm/sec.

3. Glaciolacustrine Deposits - Above the ablation till unit is a thick sequence of low permeability glaciolacustrine materials. Glaciolacustrine deposits are composed of fine-grained sediments transported via glacial meltwater streams and deposited in bordering glacial lakes. They are characteristically interbedded fine sands, silts and clays. The site specific unit is an upward finding

sequence of moderately permeable sands (10^{-4} cm/sec) at the base of the unit and lower permeability silts and clays at the top ($4x10^{-5}$ cm/sec). The vertical hydraulic conductivity ($5x10^{-8}$ cm/sec), calculated from piezometric data, is sufficiently low to impede the downward migration of groundwater.

4. Alluvio-Deltaic Deposits - Deposits of alluvial sands, silts and clay formed by the fluvial processes of Ninemile Creek are located above the glaciolacustrine sequence. The higher energy fluvial processes were probably reinitiated when water levels in the Onondaga Lake trough dropped in response to post-glacial environmental changes. The alluvial deposits range in thickness from 8 to 18 feet diverging in a deltaic configuration towards the northeast (where the stream channel entered the lake). The alluvial silty sands have relatively high horizontal hydraulic conductivities ($9x10^{-4}$ cm/sec) compared to the underlying glaciolacustrine sequence. Horizontal hydraulic conductivities of the alluvial silty sands are 3 to 4 orders of magnitude greater than the vertical conductivity of the glaciolacustrine silts and clays. Principal groundwater flow through this unit is horizontal with very little vertical inflow to the underlying glaciolacustrine unit.

5. Swamp and Lacustrine Deposits - The swamp and lacustrine deposits are composed of peat, marl, silt, fine sand and clay and range in thickness, under the site, from 8 to 15 feet. Deposited during post-glacial times, this unit represents the most recent naturally occurring geologic sequence comprising the Ninemile Creek delta complex. These deposits are characterized by horizontal hydraulic conductivities ($2x10^{-5}$ cm/sec) higher than the underlying

glaciolacustrine layer and a low vertical hydraulic conductivity ($7x10^{-9}$ cm/sec). As in the alluvial deposits, the largest component of groundwater flow is in the horizontal direction.

6. Solvay Process Waste - The layer immediately beneath the Crucible Landfill consists of approximately 60 feet of emplaced Solvay Process waste. This material consists of silt and colloidal-sized particles of insoluble residues, carbonates, silicates, hydroxides and other salts derived from the Solvay Process soda ash process. Hydraulic placement has resulted in interbedded layers of waste and thin fly-ash stringers. Laboratory and field permeability tests indicate a mean horizontal hydraulic conductivity of $6x10^{-5}$ cm/sec and a mean vertical hydraulic conductivity of $8x10^{-6}$ cm/sec. The lower vertical value is due to the placement of wastes in layers and pozzolanic cementation of some horizontal layers containing fly ash.

B. Surface Hydrology

Settlement mechanisms of the Solvay Process waste combined with Crucible waste loading at the center of the Solvay Process waste have resulted in a dish-shaped waste bed. Surface water flow is minimized on this internally drained watershed. There is no surface water flow entering the Landfill as the Solvay Process waste beds are situated at the highest local topographic elevation.

Freeze-thaw mechanisms have produced a loose or fluffy layer at the surface of the Solvay Process waste. Precipitation enters this layer and infiltrates into the groundwater regime or is lost to evaporation. Therefore, there is a minimal amount of surface flow on the Solvay Process waste and limited ponding occurs only when the layer becomes saturated or is frozen in winter.

It was estimated that transpiration does not play a significant role in the water balance as the wastebeds are not heavily vegetated. A finite-difference model of the wastebeds, performed by Thomsen Associates, estimated that of the 34.6 inches of annual precipitation about 9 inches infiltrates into the Solvay process waste while the remainder is lost to evaporation.

The model also predicted that about 23 inches of precipitation infiltrates into the Solvay Process waste through the Crucible waste. This occurs because the Crucible waste acts as a precipitation reservoir, retarding evaporation which in turn permits a greater amount of infiltration through the low-permeability Solvay Process waste.

There are two surface water bodies adjacent to the Crucible Landfill, Ninemile Creek and Onondaga Lake. Onondaga Lake is the ultimate sink for surface water or groundwater discharges from the Landfill area.

C. <u>Subsurface Hydrology</u>

1. <u>Water Table Elevations</u> - Piezometric surface measurements have been recorded from groundwater monitoring installations since 1982. Figure 2-4 presents a mean annual water table map. Water table contours demonstrate a large groundwater mound beneath the Crucible wastes that generally follows the topographic contours of the Solvay Process Wastebeds. This mounding is due to low permeability of the Solvay Process waste and to greater surface-water infiltration through Crucible wastes relative to surrounding Solvay Process waste. Groundwater flow in the Solvay Process waste is radial from the center of the Landfill towards Ninemile Creek and Onondaga Lake. All groundwater from the site ultimately discharges into Onondaga Lake. Water levels in the Solvay Process waste show significant

annual fluctuations (Figure 2-5). This is due to unequal distribution of annual precipitation, presence of the Crucible waste and the nature of the Solvay Process waste.

Water levels are highest in the spring due to snow melt, spring rains, and absence of significant evaporation. Surface-water evaporation during the summer decreases the amount of water available for infiltration, resulting in low water levels in the fall. The Crucible waste acts as a precipitation reservoir, allowing more infiltration to the underlying Solvay Process waste. This, in turn, results in higher annual water-table fluctuations under the Crucible waste as shown in Figure 2-5. Another reason for large annual water-table fluctuations is the high specific retention of Solvay Process waste. The Solvay Process waste has a significant capillary fringe due to its colloidal nature. Therefore, only a small volume of infiltrating water is necessary to saturate this zone and raise the water table significantly.

2. Groundwater Flow - In order to define the characteristics of groundwater flow beneath the Crucible Landfill, the following information was obtained during previous investigations:

   (a) Piezometric data from monitoring well installations.

   (b) Laboratory permeabilities of "aquifer" materials obtained from test borings.

   (c) Field permeability tests of "aquifers" performed in monitoring wells (slug tests).

   (d) Horizontal and vertical hydraulic gradients derived from piezometric data.

(e) Storage coefficients estimated from effective porosities (grain size distribution).

(f) Infiltration rates of surface water predicted from a finite-difference groundwater model (Thomsen, 1982).

The above data are summarized in Table 2-2.

Groundwater flow beneath the Solvay Process waste is complex due to the heterogeneity and anisotropy of the underlying geologic units as depicted in Geologic Profiles A-A' and B-B' (Figures 2-2 and 2-3). All the groundwater that infiltrates through the Crucible wastes flows through Solvay Process waste. Most of the groundwater also flows through the swamp/lacustrine layer and silt/sand deposits before discharging into surface waters. Only a small percentage of percolating groundwater passes through the underlying glaciolacustrine unit which acts as a confining layer to significant amounts of downward vertical flow.

Groundwater seepage rates were estimated for Solvay Process wastes and other geologic materials underlying the Crucible wastes (Thomsen Associates, 1982) using Darcy's Law. Table 2-2 presents seepage velocities along with the parameters used in their calculations. The average seepage velocity through Solvay Process waste is about 32 ft/year (average of horizontal and vertical velocities). Considering a Solvay Process waste thickness of 60 feet, approximately two years is required for infiltrating surface waters to reach the bottom of the Solvay Process waste. Correspondingly, a flow distance of some 700 feet from the Crucible waste to Onondaga Lake would require a period of at least 20 years considering under-

TABLE 2-2
SUMMARY OF HYDROGEOLOGIC DATA

	Crucible Waste	Solvay Process Waste	Swamp Lacustrine	Alluvial	Upper Glacio-lacustrine	Lower Glacio-lacustrine	Ablation Till
Mean Horizontal Hydraulic Conductivity (Field) (cm/sec)	10^{-4} (est.)	$6x10^{-5}$	$2x10^{-5}$	$9x10^{-4}$	$4x10^{-5}$	10^{-4}(est.)	$6x10^{-}$[illegible]
Mean Vertical Hydraulic Conductivity (Laboratory) (cm/sec)		$8x10^{-6}$	$7x10^{-7}$		$5x10^{-8}$		
Vertical Gradient		0.2-0.5	0.6-1.25	1.0	0.16-0.3		
Horizontal Gradient		0.01-0.08	0.01-0.1	0.003-0.1	0.003-0.01		
Seepage Velocities Vertical (ft/yr)		33	3	69	0.1		
Horizontal (ft/yr)		31	9	310	4		
Estimated Infiltration Rates	23 in/yr	9 in/yr					

lying geologic deposits have permeabilities with the same approximate magnitude as Solvay Process waste.

3. Groundwater Modeling - The USGS Trescott Three-Dimensional Finite-Difference Model was used (Thomsen Associates, 1982) to simulate hydrogeologic conditions of the groundwater regime beneath the Crucible Landfill and to verify results of field testing. A complete description of model assumptions, input data and results was contained in Volume 2 of the Part 360 Application. The model was calibrated using data collected from field and laboratory testing. Figure 2-6 shows the node plan used to define model limits and boundaries. Profiles C-C' and D-D' (Figures 2-7 and 2-8) are representative cross sections of the calibrated model relative to actual field data. The model showed that in order to simulate actual conditions with the groundwater regime (Field data), current surface-water infiltration through the Crucible waste must be 23 inches/year as opposed to about 9 inches/year through barren Solvay Process waste.

The amount of water that must be recharged into the Solvay Process waste in order to provide a stabilized water table was also estimated using a well field model. This computer model simulates the effects of injection of water into an aquifer according to non-steady Theis conditions. Modeling was performed using a program written for the TI-59 programmable calculator (U.S. Office of Surface Mining, 1981). It was found that if the Crucible Landfill were capped with an impermeable membrane, the groundwater mound caused by increased infiltration through the Crucible waste would recede to a level lower than that of the pre-Crucible wastewater table. This is because capping the Crucible Landfill eliminates not only increased infiltration through the Crucible waste but also infiltration which occurred prior to Crucible waste placement. The maximum drawdown is on the order of 30 feet or more, resulting in a drop of the average maximum high water table elevation from 405 feet to a post-closure elevation of 370. The importance of this lowering is discussed in the Sections relating to geotechnical engineering evaluation and post-closure groundwater monitoring.

D. Landfill Chemistry

1. General - The Engineering Report (Volume 1a) submitted with the Part 360 Permit Application in June of 1982 contained an extensive discussion of landfill chemistry and, in particular, the process by which metallic contaminants are attenuated. This subsection summarizes the major points of the original study.

2. Chemistry of Crucible Wastes - The primary metallic components of Crucible wastes are iron, chromium, and nickel. A variety of laboratory tests were conducted during the numerous investigations to evaluate the leaching potential of the various individual Crucible wastes and mixtures of the various wastes with Solvay Process wastes.

The first such test was conducted in 1977 and involved mixing ten grams of each Crucible waste in 100 mls of distilled water for one hour with no pH adjustment. After filtering, the supernatants were analyzed and found to mainly contain iron, chromium, and nickel. The second phase of this test involved making an equal-weight composite of the wastes and mixing that composite with distilled water. The results were as above, with the supernatant containing mainly iron, chromium, and nickel. The second set of tests involved subjecting each of the landfill wastes to the EP toxicity test. The results showed that EAF and AOD dusts, waste caustic solids and acid pickle sludges leached enough chromium to cause them to be classified as hazardous wastes. Since EAF and AOD dusts exhibited the highest level of leachable chromium, and since these dusts represented the largest volume of hazardous wastes deposited at the landfill, these wastes eventually became the focal point of the attenuation research.

3. Chemistry of Solvay Process Waste - Solvay Process waste is an alkaline material resulting from the production of synthetic soda ash. The major constituents of Solvay Process waste are calcium carbonate, calcium silicate, calcium and magnesium hydroxides and the chlorides of sodium and calcium. Metallic contaminants include low concentrations of iron, aluminum, lead, arsenic, mercury, chromium, cadmium and copper.

During one of the laboratory scale leaching tests, 100 mls of the distilled water used to leach Crucible wastes was subsequently percolated through 100 grams of Solvay Process waste. The resulting leachate, which had a pH of 12, contained very low levels of lead, nickel, aluminum, iron and chromium.

4. Attentuation Testing - A preliminary series of attenuation tests were conducted in order to determine the nature of the reaction of leachate from Crucible wastes with the Solvay Process waste. Note however, that these tests were conducted on mixtures of wastes that were not representative of the volumes of wastes deposited at the Crucible landfill. These tests were intended to generate a Crucible waste leachate with maximum contaminant levels. These tests included column leaching and jar tests and the results were similar: Chromium, in the hexavalent state, was the major constituent, with iron and nickel also being found.

In 1979, field scale tub leaching tests were conducted where Solvay Process waste was overlayed with a mixture of Crucible waste that was representative of the wastes generated at the Crucible mill. The tubs were exposed to natural rainfall for a full year and the resulting leachate was collected and analyzed. Certain results, however, were considered to be of little significance since low pH and alkalinity values indicated that the rain water had short-circuited the Solvay Process waste and migrated along the wall of the container.

In order to further define the chemical reactions occurring at the landfill, a series of columns were constructed using Solvay Process waste with various leachate solutions being passed through the columns by either gravity feed or a pressurized nitrogen gas system. These tests showed that the hexavalent chromium that is leached from the Crucible hazardous waste is readily absorbed onto Solvay Process waste. Once the source of chromium is removed (i.e. the Crucible hazardous wastes are completely leached), the hexavalent chromium in the Solvay Process waste is slowly desorbed by uncontaminated leachate percolating downward. This was confirmed in the field using test pits dug through Crucible waste and 8 to 10 feet into Solvay Process waste.

The test pits, along with analyses of split spoon samples and the results of the column studies provided strong evidence for the mechanism of chromium attenuation in Solvay Process waste. The slowly desorbed hexavalent chromium moves downward through the unsaturated zone at concentrations below analytical detection limits. Below the water table, ferrous iron reduces the hexavalent chromium to the trivalent state. The trivalent chromium is then irreversibly precipitated onto the Solvay Process waste.

While the exact chemical mechanism of chromium attenuation is theoretical, the extensive lab and pilot studies, coupled with field investigations, indicate that the chromium is held within the Solvay Process waste. Further evidence is given by the hundreds of chemical analyses on groundwater samples which have not yet shown a chromium content above the analytical detection limit.

E. Impact on Water Quality

Over three years of extensive monitoring have shown that the Crucible Landfill has had a negligible effect on groundwater and surface water quality in the area. The analytical results of the Quarterly Monitoring Program are shown in Appendix B.

The Engineering Report submitted with the Part 360 Application in June of 1982 estimated that approximately 12,500,000 gallons per year (34,247 gpd) of leachate from the Crucible landfill flows downward through the Solvay process waste and underlying strata toward Onondaga Lake. Using the extremely low metal concentrations found in the uppermost layer of groundwater beneath the Landfill and assuming no further removal in the 40 feet of additional Solvay Process waste in the flow pattern, poundages of Crucible-derived contaminants that would find their way to Onondaga Lake were calculated. These values are shown in Table 2-3. That Report also estimated the percentage of the total load of each contaminant on the Lake that is contributed by the Crucible leachate. The highest percentage attributable to Crucible leachate was 0.02 percent of the total iron load to the Lake.

The extremely low contaminant concentrations found in Crucible leachate and the projected impact that this leachate has on both ground and surface waters in the area should be a factor in determining the final closure requirements for the Crucible landfill.

TABLE 2-3

PRESENT CONTAMINANT LOADS TO ONONDAGA LAKE

Parameter	Average Concentration in Leachate	Leachate Flow	Leachate #/year	Leachate #/day To Lake
pH	12.0	12,490,100	N/A	N/A
Alkalinity	1,943 mg/l	gals/yr	202,234	554
Conductivity	10,617 umhos/cm		N/A	N/A
Calcium	2,610 mg/l		271,660	744
Sodium	285 mg/l		29,664	81.3
Chloride	1,810 mg/l		188,392	516
Sulfates	32.3 mg/l		3,483	9.5
TOC	9.6 mg/l		999	2.74
Phenols	.022 mg/l		2.29	.0063
Cyanides	.022 mg/l		2.29	.0063
Cadmium	.005 mg/l		.52	.0014
Chromium	.005 mg/l		.52	.0014
Copper	.005 mg/l		.52	.0014
Iron	.072 mg/l		7.49	.021
Manganese	.007 mg/l		.73	.002
Lead	.01 mg/l		1.04	.0028
Zinc	.033 mg/l		3.43	.0094

In 1983, after substantial monitoring, levels of chromium above the 0.05 mg/l Class GA Groundwater Limit had appeared in two isolated wells out of the total of 48 installations sampled. A detailed investigation of these excursions was conducted and the conclusions of that investigation were presented in the Groundwater Quality Assessment Program Report submitted to the USEPA and NYSDEC. The results of that very intensive study indicated that faulty well construction and localized ground disturbances were the most probable cause of the slightly elevated levels of chromium found in the two monitoring wells.

2.03 Geotechnical Engineering Evaluations

A. General

The unique setting of the Crucible Landfill presents several concerns regarding closure design and post-closure monitoring. These concerns relate to geotechnical engineering considerations not normally found at landfill sites. The most important concerns evaluated and discussed herein are:

1. The unique settlement and stability characteristics of the 60 feet of Solvay Process wastes which directly underlie the Crucible wastes,
2. The settlement and stability characteristics of the natural materials underlying the Solvay Process wastes, and
3. The embankment stability of Solvay Process waste dikes around the perimeter of the Crucible Landfill.

These geotechnical concerns have been addressed throughout past as well as present submittals regarding operations and closure of the landfill and are summarized below.

B. Previous Geotechnical Engineering Investigations

Settlement and stability analyses were performed by Thomsen Associates in 1981 and the results and recommendations presented in Volume 2 of the Part 360 Application. Additional Analyses were performed in 1984 by Ray M. Teeter, P.E., in support of the initial closure plan submittal. Each of those investigation programs indicated concerns for thicknesses of materials emplaced above the Solvay Process waste, limitation of waste emplacement distance from the Solvay Process waste dike edges, settlement and strength monitoring and testing, and groundwater level monitoring.

C. Extended Geotechnical Engineering Evaluations

The development of a closure plan in accordance with the latest guidelines to provide for minimization of liquid migration from the landfill, long term structural stability, adequate drainage and minimal corrective maintenance required performance of additional geotechnical investigations. These investigations were performed during the summer of 1985 by Mr. Teeter and his complete report is included with this submittal as Appendix C. Review of that entire report is essential to an understanding of the proposed Closure Design, Closure Schedule and Post-Closure Monitoring Requirements.

A summary of Mr. Teeter's report and discussion of associated design requirements are presented below. The scope of his geotechnical engineering investigations included:

1. Reconnaissance of the site.
2. Review of previous reports, papers, and correspondence applicable to the project.
3. Coordination of a program of exploratory drilling and field testing.
4. Coordination of a program of geotechnical laboratory testing.
5. Conducting a program of geotechnical engineering analyses, directed primarily at the settlement and stability characteristics of the landfill.

The results and recommendations of Mr. Teeter's investigations have been utilized in development of the Closure Plan proposed in Section 3. For ease of review, each recommendation is listed in its entirety below as a requirement along with a discussion of the implementation of the recommendation within the Closure Plan. For detailed rationale for each recommendation, the report in Appendix C should be referenced. The details of the Closure Plan are explained more fully in Section 3.

D. <u>Geotechnical Engineering Design Requirements</u>

1. <u>Requirement</u> - No Crucible waste or cap material should be placed within 100 feet of the crest of the upper Solvay Process waste "plateau".

   <u>Implementation</u> - As shown in the Closure Plan Drawings (Sheet 3), the limits of the landfill are set back 100 feet.

2. <u>Requirement</u> - No slopes of the completed cap or drainage channels should be steeper than one vertical on three horizontal.

   <u>Implementation</u> - The final grading plan calls for slopes no greater than one vertical to four horizontal to facilitate maintenance of the vegetative cover.

3. <u>Requirement</u> - The maximum combined thickness of Crucible waste and cap material should not exceed 13 feet along the central longitudinal ridge of each of the eight 500 foot by 250 foot landfill sections.

   <u>Implementation</u> - The final grading plan utilizes a design of symmetrical longitudinal landfill sections with a central thickness of 13 feet.

4. <u>Requirement</u> - The combined thickness of Crucible waste and cap material should not exceed seven feet along the interior drainage swales and at the crest of the perimeter slopes.

   <u>Implementation</u> - The final grading plan provides for a maximum seven foot thickness along the break-in-slope at the landfill perimeter and the interior drainage swales.

5. <u>Requirement</u> - The average combined thickness of Crucible waste and cap material should not exceed 10 feet.

   <u>Implementation</u> - The grading design will be accomplished with even slopes between the crests, drainage swales and landfill perimeter to assure maximum thicknesses are not exceeded. Controls will be maintained using the settlement plates as key grade stake locations.

6. <u>Requirement</u> - For the two southernmost landfill sections (those nearest Ninemile Creek), the combined thickness of Crucible waste and cap material should increase uniformly from zero feet, along a line at least 100 feet from the crest of the upper Solvay "plateau", to 13 feet, along a line at least 225 feet from the crest of the upper Solvay "plateau".

Implementation - The final grading plan is designed with these dimensional requirements and will necessitate removal of existing wastes along the southern perimeter of the landfill.

7. Requirement - The longitudinal ridges and interior drainage swales should run east-west, paralleling Ninemile Creek and Route 690.

   Implementation - The design is based on this requirement which also necessitates collection of runoff from interior swales and perimeter slopes by a perimeter drainage swale.

8. Requirement - Each landfill stage should be rough graded at least nine months before it is capped.

   Implementation - The closure plan schedule calls for rough grading of the Crucible waste in the four sections of Stage A during the summer of 1986 with final capping in the following spring.

9. Requirement - Capping of the four southern landfill sections (Stage B) should not be started until the four northern landfill sections (Stage A) have been fully capped for at least nine months.

   Implementation - As shown in the Closure Plan Drawings (Sheet 4), the closure sequencing will commence at Stage A. Rough grading of Stage B will occur during the summer of 1987 with final grading and capping completed in 1988.

10. Requirement - To prevent the localized and concentrated infiltration of water near the edges of the landfill, drainage channels should be lined with impervious material.

    Implementation - As shown on the details, (Sheet 9) the geomembrane will be extended continuously from the cap over the wastes beneath the perimeter drainage swales and beneath the two feeder swales to the dike on the north side of the upper Solvay Process waste plateau.

11. Requirement - No part of any perimeter drainage channel should lie within 50 feet of the crest of the upper Solvay "plateau".

Implementation - Perimeter drainage channels will be kept as close as possible to the perimeter of the landfill to maintain uniform slopes and a maximum possible distance (greater than 50 feet) from the dike's edge.

12. Requirement - Uncontrolled runoff over the crest of the upper Solvay "plateau" should not be permitted.

Implementation - The two feeder channels will be constructed by excavation and installation beneath the dike crest to provide necessary slopes and erosion protection. Post-closure use of the site requires continuity of the dike crests for use as bicycle trails.

13. Requirement - Prior to the closure of any landfill section, 39 horizontal steel plates with attached vertical steel rods or pipes should be installed at the Crucible/Solvay interface, at the approximate locations shown. The plates should be at least three feet by three feet in plan view, and at least 0.25 inch in thickness. The rods or pipes should be at least 16 feet in length and one inch in diameter, should be marked in one foot increments, and should be brightly painted and flagged. The purposes of these devices are to monitor settlements and horizontal movements at the Crucible/Solvay interface, and to limit the combined thicknesses of the Crucible waste and cap material. Upon installation, the elevations of the tops of the rods or pipes should be determined to an accuracy of 0.1 feet, using conventional differential leveling techniques and at least two stable (distant) benchmarks. Also upon installation, the 34 horizontal distances shown should be determined by steel tape to

an accuracy of 0.1 feet. The horizontal measurements should be made at the ground surface at the time of the measurements, and should represent the distances between the centers of the adjacent rods or pipes. (It is recognized that these horizontal measurements may not be entirely meaningful for tilted rods or pipes not yet surrounded by appreciable thickness of fill. Nevertheless, the measurements are neither costly nor time consuming, and should be conducted.

Implementation - All but two of the settlement plates have been installed as specified and initial elevation readings are being established. Ten-foot and 16-foot lengths of two-inch diameter steel pipes are being utilized depending on final thickness grades. Plate locations are indicated on the final closure plans. Final thickness grades have been established on pipes, and settlement will be monitored from these.

14. Requirement - Plate readings (both vertical and horizontal), inclinometer readings, and groundwater level readings should be scheduled for repetition at three month intervals. The quarterly sets of readings should include general visual inspections of the landfill and its surrounding slopes.

Implementation - This geotechnical monitoring has been included within the closure and post-closure monitoring requirements.

15. Requirement - At least six months after capping of the four northern landfill sections (Stage A), but prior to capping of any other landfill sections, a boring should be advanced through the center of each of the four northern landfill sections. In each boring, vane shear testing should be performed throughout the Solvay Process waste, at intervals of five feet.

Implementation - Borings will be accomplished by first carefully excavating to expose a 2 foot square section of the geomembrane at each location. The membrane will be clean cut and a section removed. Upon completion of the boring and testing, a patch will be made in accordance with the manufacturer's specification.

16. Requirement - Between six and nine months after capping of the four southern landfill sections (Stage B), a similar vane shear boring should be advanced through the center of each of these landfill sections.

Implementation - These borings will also be accomplished in the same manner as in Stage A.

17. Requirement - All field monitoring and strength testing data should be evaluated by a licensed geotechnical engineer familiar with the site. Based on this data, the engineer may elect to maintain, increase, or decrease the frequency of monitoring. The engineer may also elect to recommend additional investigative action which could include field vane shear testing, undisturbed sampling, and laboratory testing. Those actions could be necessitated by projected settlements greater than those estimated, horizontal movements in excess of six inches, unfavorable groundwater level readings, or an apparent loss of strength. Corrective action would probably consist primarily of a modification of the site grading/drainage plan.

Implementation - The final design of landfill sections and drainage slopes have been made to accommodate the maximum settlements projected. To minimize any corrective actions the sequence of closure over the period specified will allow for monitoring and adjustment of necessary slopes and grades prior to final closure of the facility.

SECTION 3

CLOSURE PLAN

3.01 Closure Requirements

A. General

The type of closure performed at the Crucible Landfill is governed by a number of considerations including the following:

- State Regulatory requirements and USEPA guidance for protection of human health and the environment
- Previously discussed unique geotechnical considerations
- Aesthetic requirements for continued land use

Each of these considerations is discussed in the following Subsections.

B. Geotechnical Requirements

As detailed in Subsection 2.03, geotechnical evaluation of the underlying Solvay Process Wastebed material and the soils underlying the wastebed have resulted in the imposition of several requirements that are necessary to prevent excessive consolidation and settlement of the Solvay Process waste and to alleviate concerns over slope failure of the wastebed dikes, especially along the southern face adjacent to Ninemile Creek.

1. Settlement Considerations

In order to maintain settlements in the range that will accommodate positive site drainage, total fill and cover height above the surface of the Solvay Process waste should not exceed an average of 10 feet. This limitation in fill and cover height will result in estimated settlements ranging from 3.5 feet at the outer edge of the Landfill to 6 feet in the center of the Landfill. This 2.5 feet difference can be accommodated in the closure design while still maintaining a positive drainage slope toward the outside edge of the Landfill.

Using USEPA recommended cover slopes of 3-5 percent over the average landfill radius of 600 feet to insure proper runoff of surface water would require a vertical drop of 18 to 30 feet from the center of the Landfill to the outside edge. Since the average depth of the combined fill and cover must not exceed 10 feet to avoid excessive settlements in the underlying Solvay Process waste, it is obvious that a surface drainage pattern other than a conventional radial design must be utilized.

After an exhaustive evaluation of alternatives, a multi-section saw-tooth design profile was developed with surface slopes on each stage at 3-5 percent and slopes on the drainage swales in the range of 0.5-1.5 percent. In this manner, the majority of the Landfill surface is sloped at 3-5 percent while the overall vertical drop in the Landfill is maintained at approximately 13 feet and the total section fill heights vary from 7 to 13 feet for an average of 10 feet.

2. Stability Considerations

As summarized in Section 2 and detailed in the Geotechnical Consultant's Report (Appendix C), potential slope stability problems may exist along the outside dikes of the underlying Solvay Process Wastebed and particularly along the dike that slopes rather steeply toward Ninemile Creek.

In order to alleviate the concerns of slope failure problems involving these dikes it has been determined that localized infiltration of surface runoff along the edges of the Landfill adjacent to the dikes should be prohibited. The surface runoff from the capped Landfill must therefore be collected in an impermeable ditch and carried away from the Landfill.

In order to further reduce the possibility of slope failure along the dike adjacent to Ninemile Creek, it has been determined that the wastes currently placed along that dike should be pulled back and regraded such that the fill and cover begins at 100 feet from the dike edge and gradually increases to a depth of 13 feet at a point 225 feet from the dike edge.

C. Site Use Requirements

Since the site of the Crucible Landfill is owned by Onondaga County and is planned as a portion of a future County park and bicycle path around Onondaga Lake, the type of final cover should be consistent with the County's intended use of the area. The County has expressed its desire that the area be closed in a manner such that the final ground surface will be unobtrusive in nature and blend visually with the surrounding area.

It is not the County's intent to develop the area containing the closed Landfill into an intensive use area where major soil disturbance or heavy wheel loads need to be taken into account.

D. Regulatory Requirements

Requirements for final closure of interim status landfills containing hazardous waste are contained in 6 NYCRR Part 373-3. In addition to the regulatory requirements, USEPA has issued a number of guidance documents which suggest final cover strategies.

1. NYSDEC Requirements

6 NYCRR §373-3, Interim Status Standards for Owners and Operators of Hazardous Waste Facilities, effective on July 14, 1985, contains a performance standard for closure.

Section 373-3(b) states as follows:

(b) Closure performance standard.

The owner or operator must close his facility in a manner that:

(1) Minimizes the need for further maintenance, and

(2) Controls, minimizes or eliminates, to the extent necessary to protect human health and the environment, post-closure escape of hazardous waste, hazardous waste constituents, leachate, contaminated rainfall, or waste decomposition products to the ground or surface waters or to the atmosphere.

More particularly, Section 373-3.14(d) governs the closure and post-closure of landfills. It provides:

(d) Closure and post-closure.

(1) The owner or operator must place a final cover over the landfill, and the closure plan under subdivision 373-3.7(c) must specify the function and design of the cover. In the post-closure plan under subdivision 373-3.7(h), the owner or operator must include the post-closure care requirements of paragraph (4) of this subdivision.

(2) In the closure and post-closure plans, the owner or operator must address the following objectives and indicate how they will be achieved:

(i) control of pollutant migration from the facility via ground water, surface water, and air;

(ii) control of surface water infiltration, including prevention of pooling; and

(iii) prevention of erosion.

(3) The owner or operator must consider at least the following factors in addressing the closure and post-closure care objectives of paragraph (2) of this subdivision:

(i) type and amount of hazardous waste and hazardous waste constituents in the landfill;

(ii) the mobility and the expected rate of migration of the hazardous waste and hazardous waste constituents;

(iii) site location, topography, and surrounding land use, with respect to the potential effects of pollutant migration (e.g., proximity to ground water, surface water, and drinking water sources);

(iv) climate, including amount, frequency, and pH of precipitation;

(v) characteristics of the cover including material, final surface contours, thickness, porosity and permeability, slope, length of run of slope, and type of vegetation on the cover; and

(vi) geological and soil profiles and surface and subsurface hydrology of the site.

(4) In addition to the requirements of subdivision 373-3.7(g), during the post-closure care period, the owner or operator of a hazardous waste landfill must:

(i) maintain the function and integrity of the final cover as specified in the approved closure plan;

(ii) maintain and monitor the leachate collection, removal, and treatment system (if there is one present in the landfill) to prevent excess accumulation of leachate in the system;

2. <u>USEPA Guidance</u>

The following USEPA guidance documents were reviewed as a part of the cover design process and utilized where applicable.

a. SW-867, Evaluating Cover System for Solid and Hazardous Waste

b. SW-870, Lining of Waste Impoundment and Disposal Facilities

c. EPA-625/6-82-006, Handbook for Remedial Action at Waste Disposal Sites

d. SW-963, Groundwater Monitoring Guidance for Owners and Operators of Interim Status Facilities

e. EPA530-SW-84-004, Draft Permit Applicants Guidance Manual for Hazardous Waste Land Treatment, Storage and Disposal Facilities

Major portions of this Section have been written using the general evaluation procedure contained in EPA Publication SW867 to assist the reviewer in evaluation .

3.02 Summary of Proposed Cap Configuration

A. General Configuration

Sheet 3 of the accompanying drawings depicts the topographic plan of the Landfill after closure. The Plan utilizes an impermeable cap with surface runoff collected by a series of parallel drainage swales dividing eight independently sloped sections of 2.75 acres each.

B. Cover Slopes

Each of the eight Landfill sections, measuring approximately 250 feet by 500 feet, will be constructed in a tent-type configuration with the center ridge containing 13 feet of fill and cover material and the valleys between sections containing from 7 feet in the interior to 0 feet at the outer edge.

The majority of the Landfill surface is therefore initially sloped at 6 ft/125 ft or 4.8 percent and the interior drainage swales are initially sloped at 7 ft/500 ft or 1.4 percent. Assuming the maximum anticipated settlement of 6.0 ft in the center and 3.5 ft at the edge of the Landfill, the interior drainage swales will still have a minimum positive slope of 4.5 ft/500 ft or 0.90 percent. It is anticipated, however, that the actual slopes will be greater than the indicated minimum value since some portion of the maximum settlement has already occurred as a result of the existing fill loadings and further settlements will occur in the time period between rough grading of the Crucible waste and final placement of the cover soils.

C. Vertical and Horizontal Controls

Vertical and horizontal fill controls are provided to achieve the desired lateral fill extent, elevations and grades required for closure. Vertical control, because of the variability of settlement over the extent of the Landfill, cannot be provided from referencing USGS elevations. Therefore, vertical control has been facilitated by using settlement plates, which have already been installed in the locations shown on Sheet 3. Horizontal control will be maintained by actual survey markers set in the field at corners or angle points shown on Sheet 3.

Using these controls, waste will be deposited by Crucible personnel to the approximate elevation and grade required for closure. During each closure stage this fill will be rough graded to its final slopes and allowed to settle prior to the construction of the buffer and final cover layers.

D. Control of Surface Runoff and Runon

The raised nature of this unique site is such that surface runon cannot occur and only direct precipitation on the site needs to be considered. As shown on Sheet 3 rainfall running off the Landfill slopes will flow to interior drainage swales which in turn drain to a peripheral drainage ditch surrounding the site. The drainage ditch drains the water through two culverts on the eastern dike of the upper terrace and routes it through a system of energy dissipators to the lower level wastebed. A drainage ditch continues along the bottom of the dike in a northerly direction conveying the runoff down another protected embankment with energy dissipaters and discharging the runoff into Onondaga Lake.

3.03 Recommended Cover System

The final cover system recommended includes an impermeable synthetic membrane supported by a layer of well- drained soil and overlain first by a soil drainage layer and then by a layer of soil capable of sustaining a vegetative growth. Well-graded soil would be compacted in layers beneath the synthetic membrane in sufficient thickness both to support the membrane easily and to protect the membrane from puncturing from the bottom. A drainage layer of well-drained sand would be placed above the liner followed by a layer of soil of adequate thickness to hold sufficient water to maintain the desired level of plant growth. This system, which of necessity would be installed above the frost line, would both minimize infiltration of surface water and minimize movement of the cover due to freeze-thaw cycles, thus insuring the long-term integrity of the synthetic liner.

3.04 Evaluation of Alternative Synthetic Membranes

A. General

There are a number of synthetic membrane materials that are available for use in a cover system such as that outlined. Any evaluation of such synthetic membranes should start with a listing of criteria to be considered in the evaluation process as well as the various types of membranes to be evaluated.

B. Screening of Rating Criteria

In accordance with Section 3.4.5.3 of SW 870 the following physical properties of a synthetic membrane are applicable to its use as a liner material for waste disposal and impoundment facilities in general and should be evaluated:

1. Tensile properties
2. Modulus of elasticity
3. Hardness
4. Tear resistance
5. Puncture resistance
6. Hydrostatic resistance
7. Water vapor transmission
8. High temperature properties
9. Low temperature properties
10. Water absorption
11. Seam strength
12. Chemical resistance

Since the application at the Crucible Landfill consists of a drained cap installation over graded steel mill wastes and buried soil, several of the listed criteria become relatively less important than they would be in a bottom liner installation where wastes would be dumped over the liner and where pooling could occur above the membrane. For instance, the hardness of the membrane has little relevance in such a buried installation provided that it has sufficient puncture resistance to withstand stresses during installation. Similarly, hydrostatic resistance and water absorption are not considered to be particularly applicable criteria to the Crucible cap installation. Chemical resistance of the liner is far less important in the Crucible situation where the Landfill contains no organic liquids, solvents, volatile vapors, or decomposition gases. The membrane cap for the Crucible installation should, however, be resistant to alkaline degradation since it may contact the underlying alkaline Solvay Process waste at the edges of the Landfill where it would be utilized to line the drainage ditches. Likewise, in a buried cap application the membrane should be resistant to biological degradation by mold, mildew, fungus, and bacteria. Installed cost of the liner on the other hand is a very relevant criteria not only in the Crucible application but in all applications.

Thus, for the Crucible Landfill application as an impermeable cap, the following criteria are judged to be most applicable screening criteria:

1. Tensile properties
2. Modulus of elasticity
3. Tear resistance
4. Puncture resistance
5. Water vapor transmission
6. Resistance to high temperatures during installation
7. Resistance to low temperature winter conditions
8. Seam strength
9. Chemical resistance to alkaline conditions
10. Resistance to biological degradation
11. Installed cost

C. Preliminary Screening of Alternate Membrane Materials

A number of different type membranes would seem to be applicable for use as a cap at the Crucible Landfill. The various membrane types discussed in Section 3.4.3 of SW 870 include four general types of materials as follows:

1. Rubber-based membranes including butyl rubber, CO and ECO Rubbers, EPDM rubber, neoprene, and nitrile rubber
2. Chlorinated polyethylenes including chlorosulfonated polyethylene

3. Polyvinyl chloride

4. Polyethylenes including low density (LDPE) and high density (HDPE) polyethylene

A reinforced LDPE membrane is available from Phillips Petroleum Company under the tradename of "Geoseal". The Geoseal membrane utilizes a backing of non-woven polypropylene material on a 12 mil polyethylene sheet to provide the elasticity typical of a low density polyethylene with improved tear resistance properties typical of the high density materials.

Table 3-1 contains a preliminary screening of the listed membrane types utilizing information taken from SW-870. The various membrane types are further described in the following paragraphs.

1. The rubberized membranes have somewhat lower tensile strengths and tear resistance and a high installed cost. Their obvious advantage is resistance to organic chemicals, oils, etc. However, this condition is not present at the Crucible Landfill, thus the higher cost is not justified.

2. Chlorinated polyethylene materials likewise have only fair tensile strength and tear resistance and have a tendency to become brittle upon aging. They also have poor resistance to high temperature such as those encountered during installation at which time some of the plasticizers are driven off changing the material's elasticity. As with rubberized liners, their advantage lies in their high resistance to organic chemicals, oils, etc. Again, their high installed cost is not justified in the case of the Crucible cap since such wastes are not present.

TABLE 3-1

PRELIMINARY SCREENING OF MEMBRANE TYPES

	Rubber Membrane Materials	Chlorinated Polyethylene Materials	Polyvinyl Chloride Materials	High Density Polyethylene Materials	Low Density Polyethylene Materials	Composite Polyethylene/ Polypropylene
Tensile Strength	Fair	Fair	Good	Good	Good	Good
Elasticity	Good	Poor after aging	Poor after aging	Fair	Good	Good
Puncture Resistance	Fair	Fair	Poor	Good	Poor	Poor
Tear Resistance	Fair	Fair	Good	Good	Fair	Good
Water Vapor Transmission	Good	NA	NA	Good	Good	Good
High Temperature Resistance	Good	Poor	Fair-Poor	Good	Good	Good
Low Temperature Resistance	Good	Good	Poor	Good	Good	Good
Chemical Resistance To Inorganic Salts	Good	Good	Good	Good	Good	Good
Resistance To Biological Degradation	Good	Good	Fair-Poor	Good	Good	Good
Installed Cost	High	High	Low	Medium	Low	Medium

3. Polyvinyl chloride membranes again utilize a large percentage of plasticizers which are often lost from the material through volatilization at high temperatures, biological decay, or leaching. Once the plasticizers are lost the material loses elasticity and tends to become brittle as it ages. Its relatively low installed cost is more then offset by its apparent limitations in the Crucible application.

4. High density polyethylene (HDPE) membranes have good tensile strength and tear resistance plus good resistance to temperature variations. Their resistance to inorganic salts, high temperatures and biological degradation may be due to the fact that plasticizers are not utilized to any great extent. Puncture resistance of HDPE is good mainly due to the thickness of the material. However that same thickness results in reduced elasticity of the material.

5. Low density polyethylene materials (LDPE) offer excellent elasticity to accommodate the anticipated movements caused by settlement under the Crucible cap. However, their low puncture and tear resistance is a decided weakness in the Crucible application.

6. The Phillips Geoseal material provides greatly improved tear resistance over the unreinforced LDPE materials. However, puncture resistance of the material in the 12 mil thickness currently manufactured may well be insufficient to withstand the loads imposed on the material during the construction process.

Based on this evaluation, it was determined that high density polyethylene materials offer the most advantageous and cost-effective membrane for use as a cap on the Crucible Landfill. It was considered necessary, however, to evaluate the high density polyethylene materials further with respect to sheet thickness, elasticity, and puncture resistance as well as tensile strength, tear strength, and installed cost to prove its effectiveness as a cover material.

D. Detailed Evaluation of Polyethylene Membrane Materials

High density polyethylene is available in various thicknesses ranging from 40 to 120 mils from several suppliers including Schlegel Lining Systems.

Table 3-2 on the next page is a comparison of key criteria between three different thicknesses of high density polyethylene membranes similar to that manufactured by Schlegel Lining Systems. Data presented are excerpts from manufacturer's literature. The data show the tear resistance and puncture resistance of the HDPE material to increase with thickness with the tear and puncture resistance of the 60 mil material being adequate for the wheel loads utilized during construction.

The 600 percent elongation of the HDPE material prior to break will effectively handle localized stresses due to any settlement or expansion and contraction that may occur. Puncture resistance of the HDPE material is superior and the large sheet size of the HDPE material results in a large reduction in the length of field seams necessary which should reduce the chances of leakage.

While HDPE material similar to that supplied by Schlegel has a medium installed cost, its good puncture resistance and elongation properties tend to compensate for that increased cost.

TABLE 3-2

COMPARISON OF HIGH DENSITY MEMBRANES

FOR USE AS CRUCIBLE CAP

	Criteria			
1.	Thickness of impermeable membrane	60 mil	80 mil	100 mil
2.	Modulus of Elasticity	--	128,000	--
3.	Puncture Resistance (#)	270	350	440
4.	Tear Resistance (#)	50	70	85
5.	Tensile Strength at yield (PSI)	2700	2700	2700
6.	Tensile Strength at break (PSI)	4000	4000	4000
7.	Elongation at break (%)	600	600	600
8.	Resistance to soil burial			
	Tensile Strength at break (%)	±10	±10	±10
	Elongation at break (%)	±10	±10	±10
9.	Sheet Size	33' x 500'	33' x 500'	33' x 500'
10.	Approx. Installed Cost	55¢/ft.	70¢/ft.	85¢/ft.

The rigidity of thick (greater than 60 mil) HDPE material would seem to be its chief disadvantage since its lower elasticity may not allow it to conform to the soil surface if localized settlement occurs.

E. Recommended Synthetic Membrane

With the foregoing considerations, it is recommended that the 60 mil thickness of HDPE material be utilized to minimize the rigidity of the material and to maximize its elasticity in the unique settlement situation at the Crucible Landfill. This minimum thickness will provide sufficient puncture and tear resistance to withstand the stresses experienced during installation and at the same time provide the required elasticity to perform satisfactorily with the settlements anticipated in long-term operations.

It is recommended that the 60 mil HDPE membrane be procured through a competitive bidding situation utilizing strict specifications that insure a product and an installation of a specified quality.

3.05 Detailed Description of Recommended Cover System

A. Functions of the Cover System Components

Each of the components of the cover system has an intended purpose in the overall cover design as summarized below.

1. Buffer Layer - To protect the membrane from puncture and abrasion from beneath and to support the membrane firmly reducing localized tensile stresses.
2. Synthetic Membrane- To act as a long-term impermeable barrier to infiltration of surface water through the buried wastes.
3. Drainage Layer - To convey all infiltrating surface water uniformly off the top of the synthetic membrane so as to minimize infiltration and prevent erosion of the soil on top of the membrane and to protect the membrane from puncture on the top side.

4. Vegetative Soil Layer - To prevent erosion of the drainage layer and subsequent exposure of the membrane. To provide a growth medium and to hold sufficient water to support the desired level of plant growth.

5. Cover Vegetation - To provide a measure of erosion control plus provide an aesthetically acceptable finished environment. Also vegetation will result in evapotransporation of water from the site to minimize both infiltration and runoff.

B. Quality Assurance Specifications

In order for the completed cover system to meet its intended purpose, it is necessary to thoroughly specify both the materials and the quality of workmanship utilized in each component of the cap. It is further necessary that a comprehensive quality assurance system be developed to insure that the materials and workmanship comform to the relevant specifications.

Appendix D contains specifications for the various components utilized in constructing the cover system including the Geotextile Fabric, and the Geo-membrane. Appendix D also contains a Comprehensive Construction Quality Assurance (CQA) Plan detailing the Engineer's plan to monitor the quality assurance during construction to the extent necessary to enable the Engineer to certify to all aspects of the closure plan.

C. Design of Component Layers to Meet Specified Functions

The following Subsections discuss the design of the various cover system layers so as to meet their intended functions.

1. Fine Grading of the Crucible Waste - Prior to placement of any final cover, the surface of the Crucible waste will be prepared as follows:

   a. Lines and grades for final waste thickness will be established utilizing existing settlement plates.

b. The wastes will be graded to conform to the thickness contours (less the 3-foot allowance for final cover) as shown in Sheet 3 of the accompanying drawings.

c. The process of fine grading and waste surface preparation will include removal and/or burial of all large objects, stone, slag, etc.

d. The surface of the fine-graded Crucible wastes will be inspected and approved prior to placement of the final cover.

2. Buffer Layer

a. General Considerations - In order to protect the membrane from puncture, it is essential that this layer contain no sharp angular stones or pointed debris. Abrasion can be minimized by eliminating large stones from the material and by assuring that the material is graded such that it does not expand and contract upon freezing and thawing thereby causing movement of the membrane.

In order to protect the membrane from localized tensile stresses, it is important that the subgrade material be compacted thoroughly such that it does not further compact after the liner is in place.

The depth of this buffer material is proposed as 12 inches based on the formula contained in Section 3 of SW 867, "Evaluating Cover Systems for Solid and Hazardous Wastes".

Thus, the thickness (T) of the soil layer should be equal to or greater than two times the height of any irregularities in the waste surface. After final grading of the Crucible wastes and prior to installation of the subgrade it is estimated that the maximum depth of any irregularities will be 6 inches.

It is therefore proposed that a 12-inch layer of subgrade be installed between the waste and the synthetic liner.

b. Materials and Movement - The 1-foot thick buffer layer will be installed in two separate lifts of 6 inches; each lift compacted to a standard Proctor density of 90 percent. The lifts are designed to provide a transitional frost-free protective buffer between the Crucible waste and polymeric liner.

The first 6-inch lift will consist of well-graded sand and gravel conforming to the gradational requirements for NYSDOT Item 304, Type 2, and as shown in Table 3-3.

The second 6-inch lift will consist of moderately graded fine gravel to medium sand conforming to the gradation requirements for NYSDOT Item 304, Type 2, except that the maximum particle size shall not exceed 3/4 inch (see Table 3-3). This maximum particle size shall be reduced if necessary to meet the requirements of the specific membrane supplier.

The selection of buffer layer materials was based on the following criteria:

(1) The material shall be well drained similar to the subbase for paving to minimize the potential for frost heave.

TABLE 3-3

CAP LAYER

GRAIN SIZE DISTRIBUTION REQUIREMENTS

Layer Material	Sieve Size	Percent Passing	NYSDOT Item
1. Buffer A	2 inch	100	304, Type 2
	1/4 inch	25-60	
	No. 40	5-40	
	No. 200	0-10	
2. Buffer B	3/4 inch	100	304, Type 2, Modified
	1/4 inch	25-60	
	No. 40	5-40	
	No. 200	0-10	
3. Drainage Layer (concrete sand)	3/8 inch	100	703-07
	No. 4	90-100	
	No. 8	75-100	
	No. 16	50-85	
	No. 30	25-60	
	No. 50	10-30	
	No. 100	1-10	
	No. 200	0-3	
4. Vegetative Soil Cover	As per discussion in Section 3.05.C.5 of the Text		

(2) The grain size of the material should provide a smooth surface on which to place a polymeric liner as well as adequately buffer the liner from underlying wastes which might puncture the liner.

(3) The material should be readily available from local sources which can supply large quantities of approved screenable materials.

In order to satisfy those requirements, materials selection has been kept as closely as possible to NYSDOT's specified construction items. Several sources of these NYSDOT items can be found within a 20-mile radius of the project site. Gradation sizes were selected which limit the percentage of fines (minus #200) which could result in frost heaving and which limit the larger stone size which would puncture the liner.

c. Verification of Materials - Prior to approval for use of a specific buffer material item, the closure contractor will be required to submit grain-size distribution results from the proposed material source with NYSDOT certification of the specific item to be supplied, as detailed in Appendix D-3.

3. Synthetic Membrane Placement

a. Selection of Materials - The synthetic membrane to be placed on the buffer layer was selected on the basis of the following primary requirements:

(1) Low permeability (10^{-9} cm/sec or less)

(2) High tensile strength and tear resistance

(3) High fatigue and cold stress strength

(4) Sufficient elasticity

In order to satisfy these requirements, a 60-mil HDPE membrane has been selected as the synthetic membrane material to be used. The material is manufactured in sheets of 33-feet wide by 500-600 feet long and delivered in rolls. It has a permeability of less than 10^{-10} cm/sec. Due to the design of the material, it is not subject to fatigue or cold-stress cracking to 118 degrees below zero (C). The material contains no plasticizers that might leach out rendering the material brittle. The liner material is also formulated with 2-5 percent of fine carbon black to obtain optimum protection against ultraviolet and photochemical attack. The 60-mil thickness of the material provides for both excellent puncture resistance and tear resistance to withstand the stresses present during installation.

b. Installation - The 60-mil membrane is produced in 33 foot by 500-600 foot panels which are extrusion welded in the field to form a leak-tight joint which is as strong as the membrane itself. The installation of the liner will be performed by the manufacturer or a licensed representative and will be designed for the specific characteristics of the site. Both manufacture and installation will be in accordance with the specifications and the Quality Assurance Plan contained in Appendix D.

4. Drainage Layer - As described earlier, the synthetic membrane will be covered by a 6-inch layer of well-drained sand the function of which will be to carry away all infiltrating rainwater that percolates through the vegetative layer.

The purpose of the drainage layer which lies directly above the synthetic membrane is to carry infiltrating soil moisture off the cap. The maximum hydraulic gradient in the 18-inch soil layer is equal to 1.0 when the soil is saturated. The hydraulic gradient in the underlying drainage layer is equal to the slope of the synthetic layer upon which it lies. The maximum slope of the synthetic liner is 4:1 so that the maximum hydraulic gradient is 0.25 or one-fourth of the hydraulic gradient within the soil layer.

In order to assure that all soil moisture is carried away by the drainage layer the permeability of the drainage layer must be at least four times greater than that of the soil layer. The drainage layer proposed is estimated to have a permeability of approximately one order of magnitude (10 times) greater than that of the vegetative layer. Therefore, essentially all soil moisture reaching the drainage layer will be carried off the cap resulting in a minimization of static water in contact with the synthetic membrane and nearly complete preclusion of liquid migration through the synthetic membrane.

The drainage blanket material should be well drained and sufficiently coarse such that it will not be washed away on the 3-5 percent slopes of the liner surface, and graded well enough to act as a filter to the overlying vegetative soil layer. The material should also be screened such that it contains no sharp angular stones and no stones in excess of 1/4 inch in diameter.

The type of material proposed consists of concrete sand conforming to the gradational requirements of NYSDOT Item 703-07. This material is available from local borrow pits.

5. Vegetative Soil Cover - The vegetative soil cover for the Crucible Landfill was specified by Dr. Norman Richards, a member of the faculty of SUNY School of Environmental Science and Forestry, who has spent over ten years studying the vegetation of the Solvay Process wastebed environment and has conducted technical studies for Crucible at the Landfill. Dr. Richards' detailed recommendations are included in his Letter Report which is included as Appendix E. Excerpts from his recommendations are as follows:

The soil cover should be in the textural range of a coarse or sandy loam; ideally with 50-60 percent sand in the medium or coarser size range. A soil of this textural range should maintain sufficient water for vegetative growth and also minimize slope erosion. Such a medium-to-coarse sandy loam will not form a significant textural discontinuity with the underlying sand layer, as would be the case with a finer soil. A significant textural discontinuity would promote and/or magnify freeze/thaw effects. A moderate content (10 percent of total volume) of coarse fragments, gravel-size or larger, would be acceptable in this soil material and would, in fact, increase soil stability.

In the textural range specified above, a cover of 18 inches of soil over the sand layer is adequate for the objectives of this

Closure Plan. A sandy loam of this depth would hold a little over 2 inches of water available for plant growth after drainage of gravitational water. This is marginal for plant growth in Central New York; that is, it can support drought-tolerant perennial grasses and forbs, but is unfavorable for plants with higher moisture demands, notable vigorous annuals and most woody plants. This marginal moisture availability should reduce the need for mowing or other treatment to control invading woody plants and noxious weeds that could become a problem on a deeper, more favorable soil for plant growth. Root growth is expected to be weak in the deeper sand layer in comparison with the more favorable soil mentioned above.

The concept of placing two layers of soil, so-called "subsoil" and "topsoil", on reclamation sites is obsolete for sites where high-productivity vegetation is not needed or desired. The main value of "topsoil" is higher fertility usually associated with higher organic content. Soil fertility can be amended by fertilization. Other organic matter constituents are not critical in a soil of favorable texture. Also, finer-textured topsoil is more subject to erosion, particularly if a textural discontinuity exists with the underlying soil.

A single soil layer which will be used should be selected for its textural composition, as described above. The soil fertility status is not important because this can be improved easily. In fact, high fertility is not desirable because it may encourage growth of vigorous annuals during favorable moisture periods, which would interfere with slower-growing, more drought-tolerant species that would be more favorable on this site in the long run. A soil pH in the range of 6.0 to 7.5 should be maintained. If the pH is below 6.0, agricultural ground limestone should be spread at the rate of one ton/acre before seeding.

6. Site Vegetation - Dr. Richards has also recommended the vegetation for the site based on his significant experience with existing vegetation in the vicinity. As detailed in his Letter Report in Appendix E, he recommended that vegetation at the site include "Kentucky 31" tall fescue seed at 20 lbs/acre, with "Chemung" crown-vetch innoculated seed at 15 lbs/acre. It has been observed that these species and varieties are fairly drought-tolerant in Central New York, and both are currently growing well on the Solvay Process Wastebeds.

   (a) Seeding - Tall fescue mixtures would be best seeded in early spring. Alternatively, the grass could be seeded in September, with the crownvetch topseeded early the following spring. For the grasses alone, fertilization with seeding should be at the equivalent rate of about 1,200 lbs/acre of 10-10-10. The site will be hydroseeded. A fiber mulch in the hydroseeding mix will be used to conserve water and reduce crusting of the soil surface while the grass is becoming established.

   (b) Vegetative Cover Maintenance - The planted site may require a top-dressing of more fertilizer the second year if plant cover is lighter than desired. If a legume is established in the cover, the top-dressing should be at the equivalent rate of about 1,000 lbs/acre of 5-10-10. If there is no legume, more nitrogen should be added. Heavy fertilization is not recommended because it will foster invasion of aggressive, noxious species such as ragweed. There is a large seed source of such noxious species on non-Crucible properties near the Crucible Landfill.

The vegetated site will need to be inspected in future years for significant invasion of woody plants. Maintenance of a moderately dense herbaceous cover should inhibit woody plant invasion, so only well-established plants would have to be removed. The site could be mowed as necessary to favor grass growth and discourage woody plants. One mowing in early summer at a setting of about 4 inches should be adequate.

D. <u>Life Expectancy of Cover System</u>

Critical to the evaluation of the closure system is the over-all life expectancy of the system compared to alternative designs. Because design thickness limitations for the cover system on this site are on the order of 3 feet, installation of a double-layer system such as a polymeric membrane over a clay backup layer is impractical. The primary issue regarding installation of a back-up layer is the concern for the durable life of the polymeric membrane. Selection of a 60 mil HDPE membrane should alleviate concern for life expectancy based on research and testing on that material which indicates a potential life expectancy greater than 50 years.

In addition to the technical data presented in the previous subsection of this submittal supporting the selection of HDPE, other detailed testing regarding service life, resistance to burrowers and rodents, long-term performance under stressed conditions and weathering and chemical resistance has been performed. Reports on these membrane life factors all indicate long term durability. Specific reports supplied by Schlegel Lining Technology are presented as Appendix F.

Post-closure testing of the membrane to assure continued long-term durability under actual field conditions will be conducted. It is important to note that should substantial failure of the liner be indicated, replacement of the liner with new material would be more cost effective and provide a more positive cap than a back-up liner.

3.06 Sequencing of Closure Operations

A. General Considerations

The present Crucible Landfill is composed of a largely flat 22-acre plateau with elevated sections where recent Crucible wastes have been placed in an effort to initiate general conformance to the proposed final configurations. When one views the present topography and visualizes the final configuration proposed at closure, it becomes readily apparent that vast quantities of waste must be moved in addition to selective placement of any new wastes and importation of large quantities of soil.

In order to achieve closure of this unique facility, utilizing the recommended system, there are a number of factors which affect the timing of the closure activities. Such factors include the following:

- Climatic considerations
- Settlement considerations

- Site stability considerations
- Environmental impact considerations
- Economic impact considerations

Each of these factors are discussed in the following paragraphs.

B. Climatic Considerations

Weather conditions in Syracuse, New York, are harsh during the winter months with frost penetration averaging approximately 4 feet. The exposed nature of the plateau containing the Crucible Landfill results in an especially harsh environment due to the predominant westerly and northwesterly winter winds and frost penetration at the Landfill which may substantially exceed the average value for the area. Much of the waste that must be moved to shape the final surface configuration of the Landfill is slag which is difficult to move and regrade under normal conditions. Regrading of these materials during the winter when they are frozen would present sufficient additional difficulty to make such efforts highly impractical.

Likewise, both early spring and late fall seasons in the area are predominantly rainy seasons when regrading efforts would be severely hampered by continued heavy rains.

Thus the construction season for work at the Crucible Landfill can be considered to run from May through September of each year.

C. Settlement Considerations

As detailed in Appendix C and summarized earlier in this Section, geotechnical studies have predicted that substantial differential settlements will take place at the Landfill as the wastes are mounded to construct the proposed final surface. Additional, more uniform settlements will take place upon placement of the additional soil layers that are an integral part of the cover system.

While the more uniform settlements have been accommodated in the past and do not pose insurmountable problems, the differential settlements that are expected to accompany the mounding of the waste could result in extensive localized stresses in the synthetic membrane if such settlements were to occur after the membrane were in place. Such localized stresses could result in damage to the membrane which would compromise the long-term integrity of the cap. It is, therefore, considered essential that the majority of such differential settlements be experienced prior to the time that the membrane is installed. Thus it is recommended that the wastes in each section be graded into the mounded configuration and allowed to stand until a majority of the settlement occurs prior to further cover activities.

D. Site Stability Considerations

As detailed earlier in this Report, the Crucible wastes presently placed along the top of the dike overlooking Ninemile Creek must be pulled back and regraded in order to alleviate concerns over failure along that critical slope. Likewise, inclinometers have been installed at several places in the Landfill to monitor any horizontal movement of the Solvay Process waste under the Landfill.

Concern over the stability of the underlying Solvay Process wastebeds affects only the outside dike areas of the wastebed. Additional waste loads placed in proximity to the dikes may affect the stability of the dikes themselves. Increased loadings due to wastes placed on the remainder of the Landfill surface, however, will affect primarily the extent of settlement and not the stability of the underlying materials. The approximate 1/2 inch per year of additional Crucible wastes represents a minor loading when compared to the 36-inch thickness of the proposed cap.

As pointed out in the Geotechnical Consultant's Report (Appendix C), the physical properties of Solvay Process waste have not been extensively studied in the past and data developed as a part of this Project may be the most extensive data available. Because of this scarcity of solid engineering information and past experience with construction on the unique Solvay Process waste, the Geotechnical Consultant has recommended a cautious approach which involves the application of loads over an extended time period accompanied by regular geotechnical monitoring to ascertain the effects of those loads on the underlying wastes and to allow for any necessary final adjustments in loadings and/or elevations.

E. <u>Environmental Impact Considerations</u>

The environmental impact factors associated with the closure of the Crucible Landfill should also be evaluated to determine if they are affected by the timing or sequencing of closure operations.

The following environmental factors would seem to be affected by the length of the closure period.

1. <u>Traffic Impact and Associated Air Contamination</u> - Approximately 120,000 cubic yards of dirt-fill is needed at the site to provide the various soil layers in the recommended cover. Using 10 cubic yard dump trucks would involve a total of 12,000 truckloads of dirt delivered to the site. Assuming a construction season of five

months at 22 working days/month or 110 working days, the average truck traffic at the site would involve approximately 109 truck loads/day or 11 truckloads/hour of dirt delivered to the site during a 10-hour workday. The average number of truckloads would be further increased to 12 loads/hour or one every five minutes since access to the Landfill site is closed for ten days in late summer for the State Fair. While this level of traffic may well be an acceptable level for the interstate highway adjacent to the site, the amount of traffic over the dirt road traversing the State Fair Parking Lot entrance to the site could create a dusting problem. The impacts of both traffic and blowing dust could be greatly mitigated by extending the closure period over several construction seasons.

2. Impact on Landfill Capacity in the Area - Crucible currently delivers approximately 15,000 cubic yards/year of non-hazardous wastes to its own Landfill. After closure of its Landfill this material will have to be hauled to another permitted facility.

At the present time there are no other permitted landfills in the County and the local municipalities are planning to haul municipal solid waste by truck approximately 60 miles to the Seneca Meadows facility in Waterloo.

Crucible has also investigated the possibility of hauling its waste to the Seneca Meadows facility. The additional volumes of Crucible Waste that would be deposited in the Seneca Meadows facility would use capacity that is vital for continued disposal of municipal refuse until such time that additional facilities become available in the area. Thus any extension of time that Crucible is allowed to utilize its own Landfill will benefit the overall Central New York situation due to the shortage of existing landfill capacity.

3. Economic Impact on Crucible and the Community

It is obvious that at some point in the future, Crucible will have to incur greatly increased costs for disposal of its non-hazardous solid wastes and that these costs will have to be included in the price of its products. It is common knowledge both nationwide and locally that the steel industry in the United States is in a distressed condition with mill closures becoming a frequent occurrence. Crucible's competitive position is certainly no better than most.

Given adequate time, Crucible and/or local governments may be able to formulate a solution to waste disposal problems that will be much more economical than the present prospect of transporting wastes to Seneca Falls on a daily basis.

By spreading out the closure of its Landfill over an extended time period, Crucible will not only be able to spread out its capital outlay for closure, but should also be able to realize a savings on the cost for disposal in the interim period of time. While there are constraints on the amount of time that can be allowed for closure, it would seem to be in the best interests of the community at large, as well as Crucible, to allow the maximum time in an effort to provide security for Crucible's 1,500 employees and the continued economic health of the community which is already experiencing numerous job losses due to manufacturing plant closures.

F. Recommended Closure Schedule

In light of the foregoing considerations, it is recommended that the Crucible Landfill be closed in two stages with Sections 1, 2, 3, and 4 (Stage A) being closed first followed by Sections 5, 6, 7, and 8 (Stage B). Table 3-4 illustrates the proposed timing of the closure activities. Closure of the Landfill in halves and staggering the closure schedule as shown allows necessary monitoring of closure of the first half for almost a full year prior to installation of the cover on the second half.

Sizeable differential settlements could occur after the rough grading of the wastes to form the individual Sections. Such settlement would be due to the mounding of the wastes with depths varying from 4 to 10 feet.

Differential settlements may also occur since certain areas of the Landfill have been essentially preloaded by waste depths greater than the final depth whereas other areas will receive considerably more waste depth than at present.

In order to minimize post-closure maintenance and to avoid localized ponding on top of the synthetic membrane, it is essential that most of the differential settlement be achieved prior to the installation of the membrane. Such uneven settlements would be corrected prior to membrane installation by regrading and compaction of the buffer layer to provide an even slope. Additional bottom material will be supplied as necessary.

The closure schedule for this unique site therefore calls for rough grading of each half of the Landfill followed by construction of the

TABLE 3-4

SCHEDULING OF CLOSURE ACTIVITIES

CRUCIBLE LANDFILL

	FALL 1985	SUMMER 1986	SUMMER 1987	SUMMER 1988
1.	Pull back wastes along Ninemile Creek	Rough Grade Crucible Wastes (A) half of landfill	Fill and regrade buffer layer (A) half	Fill and regrade buffer layer (B) half
2.	Install inclinometers	Install buffer layer (A) half of landfill	Compact buffer layer (A) half	Compact buffer layer (B) half
3.	Start monitoring records of settlements	Stabilize buffer layer from erosion (A) half	Excavate drainage ditches (A) half to Onondaga Lake	Excavate drainage ditches (B) half
4.	Extend monitoring wells (A) half	Monitor inclinometers	Install synthetic membrane (A) half	Install synthetic membrane (B) half
5.		Extend monitoring wells (B) half	Spread soil, vegetate & fertilize (A) half plus drainage ditches	Spread soil, vegetate & fertilize (B) half plus drainage ditches
6.			Rough grade (B) half of landfill	Continue monitoring settlements
7.			Install buffer layer (B) half	Continue inclinometer readings
8.			Stabilize buffer layer (B) half	
9.			Continue monitoring settlements	
10.			Continue inclinometer readings	

buffer layer and allowing each half to settle for a full year prior to regrading and the installation of the synthetic membrane, and vegetative support layers. During that year's settling time, straw will be spread as necessary to prevent excessive erosion of the buffer layer.

The schedule also staggers the application of the impermeable cap with the cap over Stage A of the Landfill being in place for a full year prior to the installation of the cap over Stage B. Considerable monitoring of the groundwater levels, as well as the settling plates and the inclinometers, would take place during that one year period in order to determine any unexpected adverse effects and allow adjustment of the plan as necessary. The critical half of the Landfill (Stage B) from a stability standpoint is closed last to allow for any necessary adjustments.

During the summer of 1986, the wastes in Stage A of the Landfill would be brought to final grade covered with the buffer layer and allowed to settle and consolidate for one year. Then, during the summer of 1987, regrading of the buffer layer, and installation of the synthetic liner, drainage layer, and vegetative cover would be performed on Stage A. Seeding would take place in September when moisture conditions would be optimum.

Also, during the summer of 1987, the wastes in Stage B of the Landfill would be brought to final grade covered with a buffer layer and allowed to settle and consolidate. Any remediation of settlement would be made in the spring of 1988 by the addition of additional buffer material as necessary.

During the summer of 1988, Stage B of the Landfill would be capped with the application of the final cover. Final seeding and fertilization are scheduled for September 1988.

In addition to sizeable benefits with respect to site stability, settlement and cover integrity, the extended closure schedule will substantially reduce both daily traffic loads and accompanying problems with blowing dust.

The additional period of use of the Landfill for disposal of Crucible's non-hazardous waste will both conserve critical capacity in the area's only permitted sanitary landfill and allow Crucible vital time to plan for continued disposal of its solid wastes in an economical fashion.

3.07 Equipment Decontamination

At the time of capping, all leachable chromium will have been removed from the EAF and AOD dusts previously deposited within the Landfill. This chromium will have been attenuated within enclaves in the underlying Solvay Process wastes. Any potential disturbance of Crucible waste during closure operations, therefore, presents a low risk of encountering or exposing hazardous materials. However, should such an event occur, the following closure and post-closure decontamination procedures will be utilized.

A. During Closure

As part of interim status standards for development of the Facility Closure Plan, a description of the procedure to be utilized to decontaminate Facility equipment must be provided. During closure activities, equipment such as backhoes and hand tools may come in contact with previously disposed hazardous wastes. If that should occur, the following steps will be used to decontaminate the equipment:

1. Any loose material will be brushed from the equipment and replaced in the original excavation. This will then be covered with non-hazardous materials. If an excavated area is not available for burial, then a small pit will be dug and the material will be buried as above.

2. The nature of the contaminant of concern (hexavalent chromium) does not require that any special solvent be used for rinsing equipment that has come in contact with hazardous waste. A water rinse will, therefore, be used as a final step in cleaning this equipment. Crucible water supply will be utilized. Since only a small amount of water will be used for rinsing the equipment (less than 25 gallons per rinsing), any washings will be released to the Landfill surface.

B. Following Closure

After closure is completed, decontamination procedures to be followed are essentially the same as those for use during closure activities. The only difference will be that any washings will be collected in 55-gallon drums and will be properly disposed of.

The building and trailer on site will be dismantled or removed as is. Any indication of contamination by hazardous wastes will result in the above decontamination procedures being followed. No hazardous waste activities, however, are known to have taken place in close proximity to those structures in several years.

3.08 Wind Dispersal Control

Wind dispersal of waste materials could potentially occur during any excavation required for conducting closure activities. To minimize and control dispersal, excavation and grading will not take place during periods of strong wind, and application of dust controllers will be utilized when necessary.

3.09 Runoff and Drainage

The preliminary drainage plan shown on the Drawings encompasses concerns for settlement of the Solvay Process waste beneath the Crucible cap. Site grading has been planned to accommodate proper drainage as well as differential settlement. Control of settlements, such that runoff water can be effectively removed from the cover, will require construction of each section such that average thicknesses (including cover) do not exceed ten feet. In order to install effectively sloped drainage courses outward from the center of the dish-shaped fill area, section thicknesses ranging from 7 feet to 13 feet will be required.

Incident precipitation on the closed Landfill will be removed from the site by two mechanisms: (1) flow within the drainage layer and (2) free drainage on top of the vegetative layer. To conservatively size drainage swales, it is assumed that a negligible amount of incident precipitation is routed from the site through the drainage layer, and that all precipitation is surface runoff from a saturated soil.

Stormwater runoff was estimated using the Rational Method as given in the following equation:

$$Q = CiA$$

Where:

- Q = peak runoff rate, cfs
- C = runoff-coefficient = 0.25 (sandy loom, vegetative cover)
- i = rainfall intensity for selected design storm and drainage area concentration time, in/hr (25-year design storm; i.e., low hazard potential of exceeding swale capacity)
- A = drainage area, acres

Initially, the time of concentration must be determined. At the Crucible Landfill, the total time of concentration is the sum of time of overland flow to the drainage swale and time of flow within the drainage swale. Overland flow was estimated by assuming that runoff occurs as laminar flow, which can be modelled as follows:

$$t_e = \frac{41\ b\ L_o^{1/3}}{i^{2/3}}$$

Where:

t_e = time to equilibrium flow, minutes

L_0 = rainfall intensity, in/hr

$b = \dfrac{0.0007\ i + Cr}{S_o^{1/3}}$

Cr = retardance coefficient
0.060 for dense bluegrass turf

S_o = slope (0.048 ft/ft [maximum])

Time of flow in the drainage swale is calculated using the flow velocity computed from the Manning equation.

$$V = Q/A = \frac{1.486}{n} R^{2/3} S^{1/2}$$

Where:

Q = flowrate, cfs

V = velocity, fps

A = area, $ft.^2$

R = hydraulic radius, ft.

S = slope, ft/ft
(0.014 ft/ft initially and 0.009 ft/ft after settlement)

N = Manning coefficient for grass-lined channel = .05

The above equations must be solved iteratively since a rainfall intensity and drainage swale velocity must initially be assumed. With these assumed values the time of concentration for the Landfill site can be computed and the actual rainfall intensity can be extracted from rainfall intensity curves for the area. In this manner, calculations proceed until the assumed rainfall intensity is equal to the actual rainfall intensity.

Using the above procedure, the following values were computed:

1. Time of concentration - 22 minutes total
   - (a) Overland flow - 16 minutes
   - (b) Drainage swale flow - 6 minutes
2. Rainfall intensity - 3.2 in/hr

With this information the peak runoff from the Landfill site can be calculated:

$Q = CiA$

$Q = 0.25\ (3.2\ \text{in/hr})(22\ \text{acres})$

$Q = 17.6\ \text{cfs}$

Having six drainage swales to route flow off site, the flow rate in each swale will be approximately 3.0 cfs. For the drainage swale configuration shown on Sheet 3 of the accompanying drawings, the flow depth and velocity anticipated in each swale can be calculated:

1. Slope = 0.014 ft/ft (before settlement)
   Depth = 7 inches
   Velocity = 2.3 fps
2. Slope = 0.009 ft/ft (after settlement)
   Depth = 9 inches
   Velocity = 1.6 fps

The drainage swales have been designed to accommodate the above computed runoff volumes and velocities. Note on the detailed drawings that a stone lining has been placed within the center of the interior swales. This is to provide a window in the drainage blanket of the cap to allow infiltrating water to drain freely to the swales. A geotextile filter fabric is used under the stone to prevent clogging of the drainage layer with silt. Specifications for the geotextile fabric are included in Appendix D.

The grassed-cover design of the perimeter swales is possible due to the low erosive velocity of collected runoff and will allow for minimal maintenance of the swales.

3.10 Monitoring During the Closure Period

A. Monitoring Considerations

A substantial amount of monitoring of the Landfill will take place during the closure period to confirm the effects of closure on both the groundwater and the physical properties of the underlying Solvay Process waste as well as the impacts of any continuing settlement on the integrity of the landfill cap itself. Such monitoring falls into four general categories:

- Fill Height Monitoring
- Geotechnical Monitoring
- Continued Groundwater Monitoring
- Liner Integrity Monitoring

B. Fill Height Monitoring

Of prime importance during closure is monitoring of the height of the Crucible waste placed in the various active portions of the Landfill. Settlement plates have been installed along the ridges of each Landfill

Section and at the tops of the slopes of the valleys between the Sections. Markers on the settlement plate risers indicate the desired thickness of fill in order to accomplish the required slopes for drainage. Careful monitoring of the fill progress during the remaining period of active landfilling in each Section will be continued to minimize the need for and the costs associated with redistribution of wastes prior to placement of final cover. Such monitoring will be performed on a quarterly basis throughout the closure period on all active areas of the Landfill. A reporting sheet for recording the monitoring results on a quarterly basis is included in Appendix G.

C. Geotechnical Monitoring

As recommended in the Geotechnical Consultant's Report (see Appendix C), several types of geotechnical monitoring will be accomplished on a quarterly basis during the closure period. These include the following:

1. Settlement Plate Readings - During each quarterly inspection, both horizontal and vertical measurements will be made on each of the settlement plates. The vertical survey readings will be utilized to record the settlement occurring in the previous quarter. Tape measurements of the horizontal distance between settlement plate risers will be used to determine the extent of any horizontal movement occurring in the Landfill. Forms for recording the readings are included in Appendix G.

2. Inclinometer Readings - During each quarter, readings will be taken in each of the four inclinometers to assess any horizontal movement of any of the layers of soil and waste underlying the Crucible

Landfill. These readings will be recorded on the form contained in Appendix G and the readings will be reviewed quarterly by the Geotechnical Consultant.

3. Vane Shear Readings - Between six and nine months after each stage of the Landfill is closed, a boring will be advanced through the center of each Section in that stage and vane shear tests will be performed in each boring at intervals of 5 feet. Resulting data will be reviewed by the Geotechnical Consultant. The resulting holes in the liner will be field patched in accordance with the manufacturer's instructions.

D. Continued Groundwater Monitoring

The present program of quarterly groundwater monitoring will be continued during closure along with recording of water levels and physical inspection of the Landfill surface and well integrity. Such monitoring is explained in more detail in the following paragraphs. Groundwater monitoring after closure is detailed in a later Section of this submittal.

1. Water Level Monitoring - The present quarterly data gathering effort on water levels in each of the 73 monitoring wells and piezometers at the Landfill will be continued during the closure period to ascertain the effects of capping on the water level beneath the Landfill. The forms contained in Appendix G will continue to be utilized.

2. Groundwater Quality Monitoring

a. General - A quarterly groundwater monitoring program is currently being conducted pursuant to the Part 360 Landfill Operating Permit. The twenty monitoring locations shown on

Figure 3-1 are sampled and analyzed for the 23 parameters shown in Appendix B. This monitoring has been conducted since August 1982. It is proposed to maintain this program until the post-closure monitoring period begins. Variations from the monitoring requirements of 6 NYCRR Part 373-3 are discussed below. These requirements were waived as provided in §373-3.6(a) by a demonstration that there was a low potential for migration of the Crucible hazardous waste constituents to water supply wells or surface water.

b. Upgradient Well - 6 NYCRR §373-3.6(b) requires that the groundwater monitoring system provide an upgradient monitoring well that will be representative of the background water quality in the uppermost aquifer near the facility, but is not affected by the facility. Such a location is not possible at the Crucible Landfill since the mounded groundwater table under the Landfill results in a groundwater flow pattern that is radially outward from the center of the Landfill. This means that the only upgradient well monitors groundwater directly under the Crucible waste. A review of the USEPA Draft Manual, "Groundwater Monitoring Guidances for Owners and Operators of Interim Status Facilities", indicated that this situation was not considered by the USEPA.

Since compliance with the regulation, as written, is impossible, a technically sound alternative is proposed. The only constituent from Appendix 23 of 6 NYCRR Part 371 present in all of the Crucible hazardous wastes deposited in the past was chromium. As the data in Appendix B indicate, no instances of chromium levels exceeding the Class GA Groundwater Standard of 0.05 mg/l have been found (this excludes two faulty monitoring wells that have been remediated). Therefore, the presence of chromium above this level would be indicative of the need for further investigation, as required in 6 NYCRR Part 373-3 and described below. The above rationale also applies to eliminating the need to conduct the test for significance using the Student's t-Test. Therefore, Crucible proposes that the presence of total chromium above the NYSDEC Class GA Groundwater Standard (0.05 mg/l) would prompt further investigation, without any statistical analysis being performed. Note that, although the Class GA Groundwater Standard is for hexavalent chromium, the use of a total chromium analysis is appropriate since it would provide a more conservative approach (i.e., total chromium includes both hexavalent and trivalent).

c. Additional Parameters - Several parameters required under 6 NYCRR §373-3.6(c)(2) have not been reported based on the previously mentioned waiver. The list of excluded parameters is as follows:

Barium	Lindane	Gross Alpha
Fluoride	Methoxychlor	Gross Beta
Nitrate	Toxaphene	Coliform Bacteria
Selenium	2,4-D	Total Organic Halogen
Silver	2,4,5-TP Silvex	
Endrin	Radium	

To provide this data, Crucible will conduct a one-time sampling and analysis program on four monitoring wells (Well 1.1, MS 105.3, MS 104.3, and CM 201) as agreed to previously by USEPA and NYSDEC representatives.

d. Procedures in the Event of Exceedances - In the event that a value of chromium exceeding the 0.05 mg/l limit is found in any of the well samples, a second sample will be obtained, split in two, and reanalyzed (for total chromium). This will be done to determine if the exceedance was significant or the result of laboratory error. If the repeat analyses confirm that chromium has been found in a monitoring location Crucible will notify (in writing) the NYSDEC Commissioner within seven days that groundwater quality may be affected.

Within 15 days of the above notification, Crucible will submit a groundwater quality assessment plan to the Commissioner. At a minimum, the plan will include:

- The number, location, and depth of wells to be monitored during excavation pursuant to the assessment plan
- Sampling and analytical methods used for the determination of hazardous waste constituents of concern
- Evaluation procedures
- A schedule for implementation of remedial measures

The groundwater quality assessment program will be implemented as soon as technically feasible and, within 15 days of the completion of the program, a written report will be submitted to the Commissioner. If no hazardous waste constituents from the Crucible waste have entered the groundwater, the original groundwater monitoring program will be resumed. If there is any groundwater contamination the groundwater quality assessment program will continue until closure is completed or the problem is remediated, whichever occurs first.

E. Cover Integrity Monitoring

Once the first half of the Landfill has been capped, that stage will be inspected in detail on a quarterly basis for the full year prior to placement of the cap on the second half of the facility. Areas inspected will include signs of localized settlements or bulging, areas of erosion of cover material, and liner joint integrity where the liner meets the settlement plates. The monitoring form used for such inspection is included in Appendix G. When the vane shear tests are conducted in each stage, the cap of each stage will have to be disturbed. It is suggested that a 1-foot square piece of membrane material from each stage be removed from the membrane and subjected to physical testing by an independent testing lab. The membrane would be patched in the field in accordance with the manufacturer's instructions. A comparison of test results of the membrane with the original physical qualities determined by the same lab will provide a good indication of any short-term deterioration of the membrane materials. Long-term monitoring of the membrane integrity will also be conducted and is detailed in later Subsections of this submittal.

3.11 Compliance with NYSDEC Performance Standards

The following paragraphs discuss the ways in which the recommended final cover design meets the various factors contained in the NYSDEC Performance

Standard (6 NYCRR Part 373-3).

A. Minimize the Need for Further Maintenance

Maintenance functions at the closed Landfill will consist primarily of the following operations:

1. Repairing and Reseeding Eroded Areas in the Surface Soils - The coarse texture, thickness, and minimal slopes of the vegetative cover layer have been specified so as to minimize erosion yet maintain proper drainage. Thus, there will be little need for much work in the area of correcting erosion damage.

To minimize potential erosion, the surfaces of various Landfill elements have been designed as follows:

Surface	Slope %	Slope Length	Soil Loss Tons/Acre
General stage surface	3-5%	125'	0.16
Perimeter edge of stage berm	26%	21'	0.96
Drainage swale	1.5%	500'	0.07

Soil loss was estimated using the USDA Universal Soil Loss Equation specified in USEPA SW-867. The following values were selected for the coefficients specified in this equation:

R (rainfall and run-off erosivity index) = 100

K (soil erodibility factor, tons/acre) = 0.24

SL (slope-length and steepness factors)

= 0.27 (1.5% slope)

= 0.66 (3-5% slope)

= 4.0 (26% slope)

C (cover management factor) = 0.01

P (practice factor) = 1.0

2. <u>Retarding the Growth of Woody Species with Roots That Could Penetrate the Synthetic Membrane</u> - The vegetative cover layer has been designed to discourage the growth of woody (rooted) plants by specifying the soil type and limiting the thickness, thereby limiting the amount of water that will be retained to support plant life.

   In addition the drainage layer above the synthetic liner will provide a dry layer which will discourage root growth at that level.

B. <u>Controls, Minimizes or Eliminates, to the Extent Necessary, to Protect Human Health and the Environment, Post-Closure Escape of Hazardous Wastes, Hazardous Waste Constituents, Leachate, Contaminated Rainfall or Waste Decomposition Products to the Ground or Surface Waters or to the Atmosphere</u>

The proposed Plan satisfies this performance standard in the following fashion:

1. Since infiltration of precipitation through the impermeable membrane is nearly completely retarded, an insignificant quantity of water will enter the waste deposits and a correspondingly low amount of leachate will be generated from precipitation. Since the Crucible waste is located in excess of 20 feet above the existing groundwater table and since that groundwater levels are expected to drop with placement of the impermeable cap, no infiltrating precipitation will contact the waste to create leachate.
2. Since no measureable leachate will be produced, there will be no escape of hazardous wastes, hazardous waste constituents, or waste decomposition products to the underlying groundwater.

3. All precipitation falling on the Landfill will be directed to lined peripheral drainage ditches either by flowing over the surface of the top cover or through the drainage layer of soil placed on top of the synthetic membrane. The precipitation will therefore not become contaminated by the Crucible wastes and will not carry waste or waste products into the surface waters.

4. All previously deposited hazardous wastes will be confined below the 3-foot thick final cap of soil and an impermeable membrane. Therefore no hazardous wastes, hazardous waste constituents or waste decomposition products can escape to the atmosphere.

3.12 Closure Costs

A detailed cost estimate for closure of the Crucible Landfill is included as Appendix H of the Report. That estimate has been prepared utilizing material and labor costs taken from the 1985 Edition of Means Building Construction Cost Data. Synthetic membrane material and installation costs were supplied by the membrane installer.

Unit prices included in the estimate include the contractor's overhead and profit and numbers contained in the "Reference" column for each item refer to the appropriate item numbers in the "Means" publication.

Table 3-5 below is a summary of that cost estimate showing the major areas of cost. The cost of closure is estimated at $3,222,877.

TABLE 3-5

SUMMARY COST ESTIMATE

CRUCIBLE LANDFILL CLOSURE

(1985 Dollars)

I.	Grading of Crucible Waste	$ 144,414
II.	Peripheral Drainage Ditches	43,360
III.	Buffer Layer Installation	435,926
IV.	Membrane Plus Installation	598,950
V.	Drainage Layer Installation	209,000
VI.	Vegetative Soil and Vegetation	699,985
VII.	Drainage Facilities Offsite	167,142
VIII.	Subtotal Construction Cost	$2,298,777
IX.	Construction Cost x .937 (City Cost Index)	2,153,954
X.	Testing During Closure	271,960
XI.	Engineering Costs (7% Construction Cost)	150,777
XII.	Legal and Administrative (15% of Construction Cost)	323,093
XIII.	Contingencies (15% of Construction Cost)	323,093
XIV.	Total Project Cost	$3,222,877

SECTION 4

POST-CLOSURE PLAN

4.01 General

The suggested sequencing of closure for the Crucible Landfill will result in the final closing of approximately one half of the landfill in the Summer of 1987 and the final half in the Summer of 1988. As discussed in Section 3, the quarterly monitoring of the landfill will continue throughout the closure period. Therefore, the post-closure monitoring discussed below will not be implemented until the landfill is completely closed (i.e. the fall of 1988). In this manner, any maintenance or corrective action needed on the half of the landfill that will be closed first can be readily accomplished since the personnel and equipment necessary will be available on site.

4.02 Site Inspection and Maintenance Plan

Post-closure inspection of the landfill will be conducted with the groundwater monitoring program on a semi-annual basis (spring and fall). Each inspection will be comprehensive and evaluate the overall integrity of the landfill. The inspection will include each of the following items.

1. Erosion Damage - The entire surface of the landfill will be inspected for erosion damage. Of particular concern will be steeply sloped areas and constructed water channels. Given the history and planned usage of the area, the inspection will also be concerned with any areas where man-made disturbances of the vegetation (e.g. from motorcycle trails) could be further eroded by wind or water erosion. In addition, the Solvay Process Wastebeds immediately adjacent to the Crucible Landfill that could be adversely affected by erosion will be included in the inspection. In the event that erosion

damage is noted, the mitigative measures will be twofold. First, action necessary to prevent a recurrence will be implemented. Depending on the source of the problem, these measures could range from a change in the vegetation to adoption of means of minimizing trespassing. The second part of this mitigation will be to repair any erosion damage and restore the area to its originally intended condition.

2. Settlement and Subsidence - Settlement and subsidence at the landfill will be monitored semi-annually during the post-closure period. Initially, a visual inspection will be conducted to identify any readily discernible areas where subsidence or settlement have occurred. More in-depth monitoring will be conducted for the first three years, as during closure, by inclinometer monitoring, measuring elevations of the settlement plates and monitoring the horizontal distance between the settlement plates. If minor localized areas of settlement are found, they will be corrected by the application of additional cover material and revegetation as necessary. If the settlement is significant or areas of subsidence are noted, an investigation will be initiated to identify the cause of the problem and any potential damage to the impermeable membrane. If regrading is needed immediately to maintain run-off control, it will be performed. Otherwise, remedial measures will be initiated subsequent to the completion of the investigation. Mitigative measures, if needed, will most likely involve regrading of the cover material and revegetation with possible membrane repair.

3. Condition of Vegetative Cover - In order to prevent erosion of the final cover material, it is necessary to maintain the proper density and condition of the vegetative cover. The semi-annual inspection of the landfill during the post-closure period will include a thorough examination of the vegetative cover. The scheduling of the inspection (i.e. spring and fall) will allow for monitoring of the cover when the potential for erosion from rainfall is highest. Where the vegetation needs improvement, additional seed or fertilizer will be applied as necessary. The seed mixture will be the same as applied during closure.

During the dry months of the year, July - September, Crucible personnel or their representatives will monitor the condition of the vegetation on the closed landfill to determine if vegetative cover is in danger of destruction due to drought conditions. Crucible will provide temporary irrigation as necessary to avoid the loss of such vegetation.

Maintenance of the vegetative cover will also include a once per year mowing of the vegetation at a 4" setting as recommended by Dr. Richards for control of weedy plant growth.

In the event that the vegetative cover does not perform as required, Crucible will retain the services of an independent consultant or consultants to prepare a Cover Design Report which identifies any deficiencies in the cover design and recommends corrective action. Within thirty days after completion of the study, the report shall be submitted to the NYSDEC (Region 7 and Central Office) for review and comment. Proposed modifications will be made as soon as possible after DEC's approval of such report.

4. Integrity of Run-Off Control System - The entire run-off control system will be inspected for any deficiencies that may hinder performance. In particular, the inspection will center on areas of erosion, deposition or pooling water. Given the nature of the Solvay Process Waste and the anticipated settlement of the Crucible waste, it is possible, though unlikely, that minor problems could develop which would hinder the performance of the runoff control system. As with other actions described above, if remedial measures are needed immediately, they will be accomplished. However, it would be more appropriate to investigate the source of the problem prior to undertaking any major corrective action. If large structural problems occur, the most likely remedial measure will be regrading of the affected areas.

5. Monitoring Well Condition - The inspection of monitoring wells that is currently conducted will be continued through the post-closure period for all active monitoring wells. This inspection includes integrity of the outer protective casing and concrete pad, integrity of the actual well casing, and whether the well is locked and numbered. Any deficiencies will be noted and corrected as soon as practical.

6. Benchmark Integrity - Since monitoring of the settlement plates is important to the overall evaluation of the landfill, it will be necessary to maintain the integrity of the reference benchmark. During each inspection, the benchmark will be checked, and if problems are discovered, remedial action will be taken as necessary.

7. Integrity of liner - Since the long-term viability of the cover system rests on the continual physical integrity of the impermeable

membrane, regular testing of the membrane will be conducted every 5 years to ascertain any changes in the liner integrity.

Such testing will be performed by an independent testing laboratory fully qualified in this area.

The testing plan includes the following elements.

A. Samples of the original material will be tested during installation by the independent lab and results compared with the test results furnished by the liner supplier. These test results will serve as the base line information against which all future testing will be compared. The program will include the following specific tests:

1. Thickness, ASTM D-1593
2. Tensile Strength at Break, ASTM D-638 Type IV
3. Elongation at Break, ASTM D-638 Type IV
4. Volatile Loss of Resin, ASTM D-1203 Method A
5. Resistance by Soil Burial, ASTM D-3083
6. Environmental Stress Crack, ASTM D-1693 Cond. B
7. Puncture Resistance, SIA 280/14
8. Tear Resistance, ASTM D-1004
9. Seam Strength, ASTM D-1623
10. Water Vapor Transmission, ASTM E-96 - Proc. B

B. Upon completion of the membrane installation, the membrane Supplier/Installer and the Engineer will jointly develop and agree on specific values of the referenced tests which will provide a threshold warning of a loss of liner integrity.

C. At five-year intervals beginning in 1992, samples of the membrane will be removed from the cover and subjected to the same battery of destructive tests.

Such samples will be collected during the dry summer months to minimize cover leakage and will be representative of the following locations:

1. At the center of the ridge of one cell where the membrane is bent and most consistently dry.
2. At the lower end of one of the drainage swales where the membrane is bent and most consistently wet.
3. At a seam near the midpoint of one of the cell slopes where the membrane may be subject to tensile stresses.
4. At a point under the peripheral drainage ditch where the membrane is in direct contact with alkaline Solvay Process waste.
5. At a point where the membrane is bent for anchoring in the trench outside of the peripheral drainage ditch.

In each case, the membrane will be exposed by careful hand excavation which will expose an area approximately 3-feet by 3-feet from which a one-foot by one-foot sample will be cut utilizing a sharp knife. A membrane patch will be installed and tested by the membrane supplier/installer. Any deficiencies uncovered by such testing will be remedied prior to back filling.

The excavation will be backfilled by hand with careful replacement of the drainage layer material prior to placement of the soil layer.

A written log of all such work will be maintained by the Engineer who certified the closure. He will witness all work associated with excavation, sample acquisition, patching and backfilling and will keep a detailed log of the exact locations where such samples are obtained.

The Independent Testing Laboratory will tabulate and compare the results of each test with previous tests and prepare a brief report summarizing the comparisons. The Laboratory will send five copies of the report to the Engineer who certified the Closure and one copy to the membrane supplier/installer.

D. The Engineer who certified the Closure shall review the data in conjunction with the membrane supplier/installer and evaluate the significance of any changes in test results on the predictable integrity of the landfill cap, utilizing the threshold values previously agreed on.

E. The Engineer, upon completion of his evaluation shall issue an Engineering Report describing the work which incorporates the Laboratory test results and evaluates those results with respect to the continuing integrity of the landfill cover system.

F. Copies of the Engineers Report shall be submitted to the following:

1. Crucible Materials Corporation
2. The Membrane Supplier/Installer
3. NYSDEC Region 7, Regional Engineer for Solid Wastes
4. NYSDEC Central Office, Division of Solid Wastes

Forms have been developed for all phases of the inspections to be conducted (see Appendix G). A copy of each site inspection report will be sent to Crucible along with recommendations for any maintenance that is required, and suggested schedules for completing the maintenance. Any significant problems uncovered during the inspection will be relayed verbally as soon as practical.

4.03 Groundwater Monitoring - Post-Closure

As part of post-closure care of the Landfill, semi-annual groundwater monitoring will be conducted utilizing monitors that are downgradient from Crucible waste and would, therefore, detect any contaminant migration leaving the Landfill site.

The major impact on the groundwater regime from the landfill closure is the drop in water levels. The general water table configuration and groundwater flow directions will not significantly change. The magnitude of the drop in water levels is very difficult to predict due to the many uncertainties regarding the hydrology of the landfill during the post-closure period. The most important unknown parameter is the amount of change in infiltrating precipitation through the adjacent Solvay Process waste. This change determines the steady-state, post-closure water-table elevations.

The water table drop due to closure was estimated using a non-steady Theis model. The model results showed a maximum possible drop in the water table of 30 feet. An average drop in the water table across the site is estimated to be about 20 feet.

The groundwater monitoring wells to be used during post-closure are listed in Table 4-1 and shown in Figure 3-1. The table also lists the predicted post-closure water levels for each well. It must be emphasized that

TABLE 4-1
GROUNDWATER MONITORING WELL DATA

Well No.	Elevation of Well Screen Top	Elevation of Well Screen Bottom	Mean Water Table Elevation (Pre-Closure)	Estimated Water Table Elevation (Post-Closure)	Groundwater Flow Path Distance From Waste To Well Screen (feet)	Year Reach Scree
W5.6	369.4	364.4	386	366	180	5.6
104.1	352.8	347.8	374	354	195	6.1
104.2	373.7	363.7	398	378	175	5.5
104.3	383.8	373.8	400	380	165	5.2
104.4	393.7	383.7	400	380*	155	4.8
104.5	402.5	392.5	403	383*	145	4.5
105.1	359.4	354.4	378	358	65	2.0
105.2(R)	371.8	361.8	389	369	55	1.7
105.3	383.2	373.2	393	373	45	1.4
105.4	392.0	382.0	396	376*	35	1.
105.5	402.3	392.3	402	372*	25	0.8
106.1	358.8	353.8	384	364	70	2.
106.2	371.5	361.5	386	366	55	1.
106.3	382.2	372.2	396	376	45	1.
106.4	393.1	383.1	396	376*	35	1.
106.5	403.8	393.8	399	379*	25	0.
301.1	265	255	369	349	210	6.
301.2	330	325	372	352	145	4.
301.3	348	343	373	353	130	4.
301.4	360	355	379	359	115	3.
301.5	380	375	391	371*	95	3.
201	403.2	378.2	400	380	25	0.

* Well may be dewatered as a result of closure activities

the predictions are very approximate and are intended only to show wells which may be dewatered due to the landfill closure. The predicted water level elevations are based on mean annual water levels recorded from 1982 to 1985. Because of the large annual fluctuations in the water table, wells may contain water following wet periods and become dewatered after dry periods.

Groundwater will continue to flow radially from the site after closure because a groundwater mound will still exist within the Solvay Process waste, even though it is a subdued reflection of the pre-closure mound. Monitoring wells were selected at locations radially around the site for this reason. Water level monitoring in these wells during the early closure phases can be combined with surface settlements in an attempt to predict future settlements as a result of the lowering water table.

The radial monitoring well locations will continue to provide a warning system for contaminant migration during the closure and post-closure periods. Should several of the shallow wells become dewatered after closure of the site, deeper wells will still be available for monitoring purposes.

Selection of parameters for monitoring during the post-closure period was based on the nature of the wastes and the historical data presently available regarding groundwater quality in the vicinity of the site. These parameters are: total alkalinity, chlorides, specific conductance, pH, redox potential, chromium (total), iron, and phenols. Chromium is the major contaminant of concern related to Crucible waste. More than three years of monitoring (See Appendix B) have shown other metals to be below or generally at the analytical detection limits and of little use in detecting any potential contaminant plume. Phenols are included in the list at the request of the NYSDEC. The phenols are found predominantly in the natural deposits underlying the Solvay Process waste. The remaining parameters reflect the effects of Solvay Process waste on the groundwater quality. Those parameters are also indicative of the general water quality in the sampling zone and will be initial indicators of a shift or sudden change in groundwater patterns under the Crucible waste. In addition, they are valuable in monitoring the integrity of the well construction in the multi-screened monitors since those parameters show definitive trends with differing depths of penetration.

If any of the monitoring well samples show a total chromium level above the level of 0.05 mg/l (based on NYSDEC GA Standards), a groundwater quality assessment program will be initiated. This program is identical to that described under the Closure Plan (Section 3.10) except that once the determination is made as to whether a groundwater contamination problem exists, the original post-closure monitoring program described above will be resumed.

4.04 Geotechnical Monitoring Plan

A key aspect of post-closure monitoring for the Crucible landfill will involve continued monitoring of geotechnical considerations. As part of the semi-annual inspection and for purposes described in 4.02 above, a considerable amount of field work will be conducted to monitor settlement and horizontal movement of the landfill materials. The elevation of the 39 settlement plates will be determined using conventional differential leveling techniques. The 34 horizontal distances monitored during closure will also be determined utilizing a steel tape. These plate readings will be supplemented with inclinometer readings and water level elevation determinations from all site monitors. Forms for recording the data are included in Appendix G.

The above described data will be evaluated by a licensed geotechnical engineer. Based on the data, the engineer may elect to recommend additional investigative or corrective action. Additional investigation could include field vane shear testing, undisturbed sampling, and laboratory testing.

4.05 Post-Closure Costs

Table 4-2 is a detailed estimated of post-closure costs calculated in 1985 dollars and extended to cover a post-closure monitoring period of 30 years. Total post-closure costs are estimated at $1,374,000. Costs for geotechnical monitoring during closure and for three years following closure have been included in the closure cost estimate since they are not expected to continue during the remainder of the post-closure period.

TABLE 4-2

POST-CLOSURE COST ESTIMATE
CRUCIBLE LANDFILL
(ANNUAL COSTS FROM 1988-2018 IN 1985 DOLLARS)

I. Physical Inspection of Landfill

Check erosion damage, settlement and subsidence, vegetation and drainage, settling plates, monitoring wells plus semi-annual reports and maintenance checks.

Senior Project Chemist	3 days x 2/year at 480.00/day	2,880.00
Sampling Crew Chief	1 day x 2/year at 320.00/day	640.00
Subtotal Inspection		$3,520.00

II. Annual Maintenance

A) Repair erosion, settlement and vegetative cover (1/2 acre/year)

- Deliver, spread and roll topsoil 1,200 cubic yards at $10.00	$12,000.00
- Seed and fertilize 1/2 acre	1,000.00
Subtotal	$13,000.00

B) Repair of monitoring well including pipes, caps and concrete	$ 1,000.00
C) Repair of liner expansion joints around settlement plates and monitoring wells and periodic liner integrity testing with field patching of test specimens	$ 1,000.00
Subtotal - Annual Maintenance	$15,000.00

III. Groundwater Monitoring and Analyses

A) Bailing and Sampling of 22 wells

Sampling/Crew Chief	1 x 4 days x 2/year x $320.00	$ 2,560.00
Sampling/Technicians	2 x 4 days x 2/year x $270.00	4,320.00
Lab Technician	1 x 3 days x 2/year x $270.00	1,620.00
		$ 8,500.00

B) Analyses of Samples

Total Alkalinity	7
Chlorides	7
Specific Conductance	7
pH	2
Redox Potential	7
Chromium Total (Furnace)	15
Iron	10
Phenols	25
Per Sample Cost	$80

22 Samples x 2/year x $80/sample = $3,520

C) Data Evaluation and Semi-Annual Reports

Senior Project Chemist	3 days x 2/year x $480.00	$2,880.00
Environmental Scientist	3 days x 2/year x $300.00	1,800.00
		$4,680.00
Subtotal Groundwater Monitoring		$16,700.00
Estimated Annual Costs		$35,220.00
Plus Contingencies (15%)		5,290.00
Plus Administrative Costs (15%±)		5,290.00
Total Estimated Annual Post-Closure Cost		$45,800.00
Post-Closure Cost for 30 years ($45,800 x 30)		$1,374,000.00

SECTION 5

FINANCIAL REQUIREMENTS

5.01 General

State regulations require that the owner or operator of hazardous waste disposal facilities provide financial assurance to cover the costs associated with closure of the facility and post-closure care. The regulations also require that the owner or operator maintain financial liability coverage for both sudden and non-sudden accidental occurrences. The closure cost estimate is provided in Section 3 (Appendix H) while the post-closure cost estimate is provided in Section 4 (Table 4-2).

Crucible is the operator of the Landfill. Prior to December 20, 1985, Crucible was a wholly-owned subsidiary of Colt Industries, Inc. ("Colt"). On December 20, 1985, Colt sold Crucible in a leveraged buyout transaction to certain of Crucible's management and employees. Colt presently retains a limited investment interest in Crucible and remains a co-permittee with Crucible on the land use permit issued by the County of Onondaga, the owner of the Landfill site. In addition, as part of the sale transaction, Colt has agreed to provide financial assurance for the Landfill of the closure and post-closure care costs and liability coverage for sudden and non-sudden accidental occurrences.

5.02 Financial Assurance for Closure and Post-Closure Costs

6 NYCRR §373-3.8(i) requires that the closure cost estimate must equal the cost of closure at the point in the facility's operating life when the extent and manner of its operation would make closure the most expensive. Due to the nature of the Crucible landfill operation, the closure cost estimate given in Section 3 (Appendix H) (which is the real estimated cost of closure), is equivalent to the maximum cost for closure required by the regulations.

Colt has elected to utilize the financial test mechanism to demonstrate financial assurance for closure and post-closure costs. The State requirements are found in 6 NYCRR §373-3.8(d)(5) and §373-3.8(f)(5). The following information is provided in Appendix I:

- A letter signed by the Chief Financial Officer of Colt and worded as specified in 6 NYCRR §373-2.8(j)(9).
- A copy of the independent Certified Public Accountant's report on examination of Colt's financial statements for the 1984 fiscal year.

As agreed to by the NYSDEC, following preparation of the financial statements for the fiscal year ended December 31, 1985, Colt will provide to the NYSDEC on or before March 31, 1986, the following documentation:

1. A revised version of the Chief Financial Officer's letter which will reflect the figures for Colt's 1985 fiscal year;
2. A copy of the independent Certified Public Accountant's report on examination of Colt's financial statements for the 1985 fiscal year; and
3. A special report from Colt's independent certified public accountant to Colt stating that (a) the accountant has compared the data which the letter from the Chief Financial Officer specifies as having been derived from the independently audited, year-end financial statements for the 1985 fiscal year with the amounts in such financial statements; and (b) in connection with that procedure, no matters came to his attention which caused him to believe that the specified data should be adjusted.

State regulations also require that the closure and post-closure cost estimates be kept at the disposal site and updated annually within 30 days of the submittal anniversary date utilizing the annual Implicit Price Deflator for Gross National Product. As portions of the site are closed, the closure cost will be readjusted on an annual basis to reflect the decreased cost of closing only the remaining portions of the landfill. As shown, a current total of $4,596,877 will be needed to finance the costs of both closure of the landfill and post- closure care for 30 years after closure.

5.03 Financial Responsibility for Liability for Accidental Occurrences

6 NYCRR §373-3.8(h) of the State regulations specifies that the owner or operator of a hazardous waste disposal facility demonstrate financial responsibility for bodily injury and property damage from sudden and nonsudden accidental releases from the facility. For sudden occurrences, the liability coverage must be in the amount of $1 million per occurrence with an annual aggregate of at least $2 million. Nonsudden occurrence coverage must be in the amount of $4.5 million per occurrence and $9 million for the annual aggregate.

Colt Industries has elected to utilize the financial test mechanism. See §5.02 for a description of the information provided by Colt in Appendix I in support of its use of the financial test.

SECTION 6

RECORDKEEPING AND NOTIFICATION

6.01 Recordkeeping During Closure

During the time closure is being accomplished, a series of records will be developed and updated on a quarterly basis. These records can be categorized as follows:

1. Water Quality Monitoring Records
2. Groundwater Level Records
3. Settling Plate Elevation Records
4. Inclinometer Readings
5. Landfill Inspection Records

These records will be retained at the Crucible Production Facility in the possession of the Environmental and Energy Engineer. Reports summarizing the above data will be submitted as required.

In accordance with State regulations and as discussed in Section 5, the closure cost estimate will be updated annually until final closure. Copies of all updated closure estimates will be kept in the office trailer at the Landfill and an additional copy will be kept by the Environmental and Energy Engineer at the Production Facility.

6.02 Recordkeeping During Post-Closure

At the conclusion of each post-closure inspection and groundwater monitoring event, a report detailing the results and any remedial action taken will be prepared. These reports will include information and data described in Section 4.

These reports will be kept at the Crucible Production Facility with the most recent version of the Post-Closure Plan. These reports and the Post-Closure Plan will be maintained in the office of:

Environmental and Energy Engineer
Crucible Specialty Metals Division
Crucible Materials Corporation
P.O. Box 977
Syracuse, New York 13201
(315) 487-4111

In the event that the Production Facility should cease operations prior to the completion of the post-closure period, the Post-Closure Plan will be revised to reflect any change in the recordkeeping location for the Plan and reports.

6.03 Notice in the Deed

Crucible notified the former property owner (State of New York) of Federal and State requirements to record in the deed (or some other instrument which is normally examined during a title search) that said property has been used to manage hazardous waste and its use is restricted under 6 NYCRR §373-3.7(j). The notification letter and accompanying statement are included in Appendix J.

6.04 Notice to County Clerk and Commissioner

A survey plat of the fill progression at the Crucible Landfill is maintained and will be periodically updated. The plat will include a prominently displayed note stating the owner's or operator's obligation to restrict disturbance of the site. A record of the type, location and quantity of hazardous wastes disposed at the Landfill in the past will also be included.

Within 90 days after final closure is completed, Crucible will submit to the Onondaga County Clerk and the Commissioner the above-described plat and related information.

SECTION 7

REFERENCES TO NYSDEC REGULATIONS

7.01 Introduction

This closure plan has been developed in accordance with the New York State Department of Environmental Conservation Regulations on closure as found in 6 NYCRR Part 373-3. To aid in review of this plan, Table 7-1 provides specific references to requirements and a page number where that information can be found in this plan.

TABLE 7-1
REFERENCES TO NYSDEC REGULATIONS

6 NYCRR 373-3	Description	Section #	Page #
.7(c)(1)(i)	Description of how and when the facility will be closed; maximum life of the facility	3.06F	3-34
.7(c)(1)(ii)	Estimate of maximum inventory of wastes in storage at any time during the life of the facility	1.02B	1-7
.7(c)(1)(iii)	Description of steps needed to decontaminate facility equipment during closure	3.07A	3-37
.7(c)(1)(iv)	An estimate of the expected year of closure and a schedule for final closure	3.06F	3-34
.7(h)(1)(i)	Description of the planned groundwater monitoring program to be performed during post-closure	4.03	4-8
.7(h)(1)(ii)	Description of the planned maintenance activities and frequencies at which they will be performed	4.02	4-1
.7(h)(1)(iii)	Name, address and phone number of the person to contact during post-closure	6.02	6-2
.7(i)	Notice to County Clerk	6.04	6-2

TABLE 7-1
REFERENCES TO NYSDEC REGULATIONS

6 NYCRR 373-3	Description	Section #	Page #
.7(j)	Notice in deed to property	6.03	6-2
.8(d)(5)	Financial Assurance for Closure Costs	5.02	5-1
.8(f)(5)	Financial Assurance for Post-Closure Care Costs	5.02	5-1
.8(h)	Financial Responsibility for Liability Coverage	5.03	5-2
.8(i)	Determination of Closure Cost Estimate	5.02	5-1
.14(b)(1)	Design construct, operate and maintain a run-on control system	3.02D	3-7
.14(b)(2)	Design, construct, operate and maintain a run-off management system to handle a 24-hour, 25-year storm	3.09	3-39
.14(b)(3)	Collection and holding facilities for run-off systems must be managed to maintain design capacity	4.02.4	4-4
.14(b)(4)	Wind dispersal of hazardous waste must be controlled	3.08	3-38
.14(d)(2)(i)	Control of pollutant migration from the facility via groundwater, surface water, and air	3.11B	3-50

TABLE 7-1
REFERENCES TO NYSDEC REGULATIONS

6 NYCRR 373-3	Description	Section #	Page #
.14(d)(2)(ii)	Control of surface water infiltration, including prevention of pooling	3.11B	3-50
.14(d)(2)(iii)	Prevention of erosion	3.11A	3-49
.14(d)(3)(i)	Consideration of type and amount of hazardous waste and constituents	1.02B	1-5
.14(d)(3)(ii)	Consideration of the mobility and expected rate of migration of the hazardous waste and constituents	2.20D	2-13
.14(d)(3)(iii)	Consideration of site location, topography and surrounding land use with respect to potential effects of pollutant migration	1.03 2.02E	1-8 2-16
.14(d)(3)(iv)	Consideration of climate including amount, frequency and pH of precipitation	1.05E	1-12
.14(d)(3)(v)	Consideration of the cover characteristics including material, final surface contours, thickness, porosity and permeability, slope, length of run of slope, and type of vegetation	3.02 3.05	3-6 3-16
.14(d)(3)(vi)	Consideration of geological and soil profiles, and surface and subsurface geology of the site	2.02	2-3