



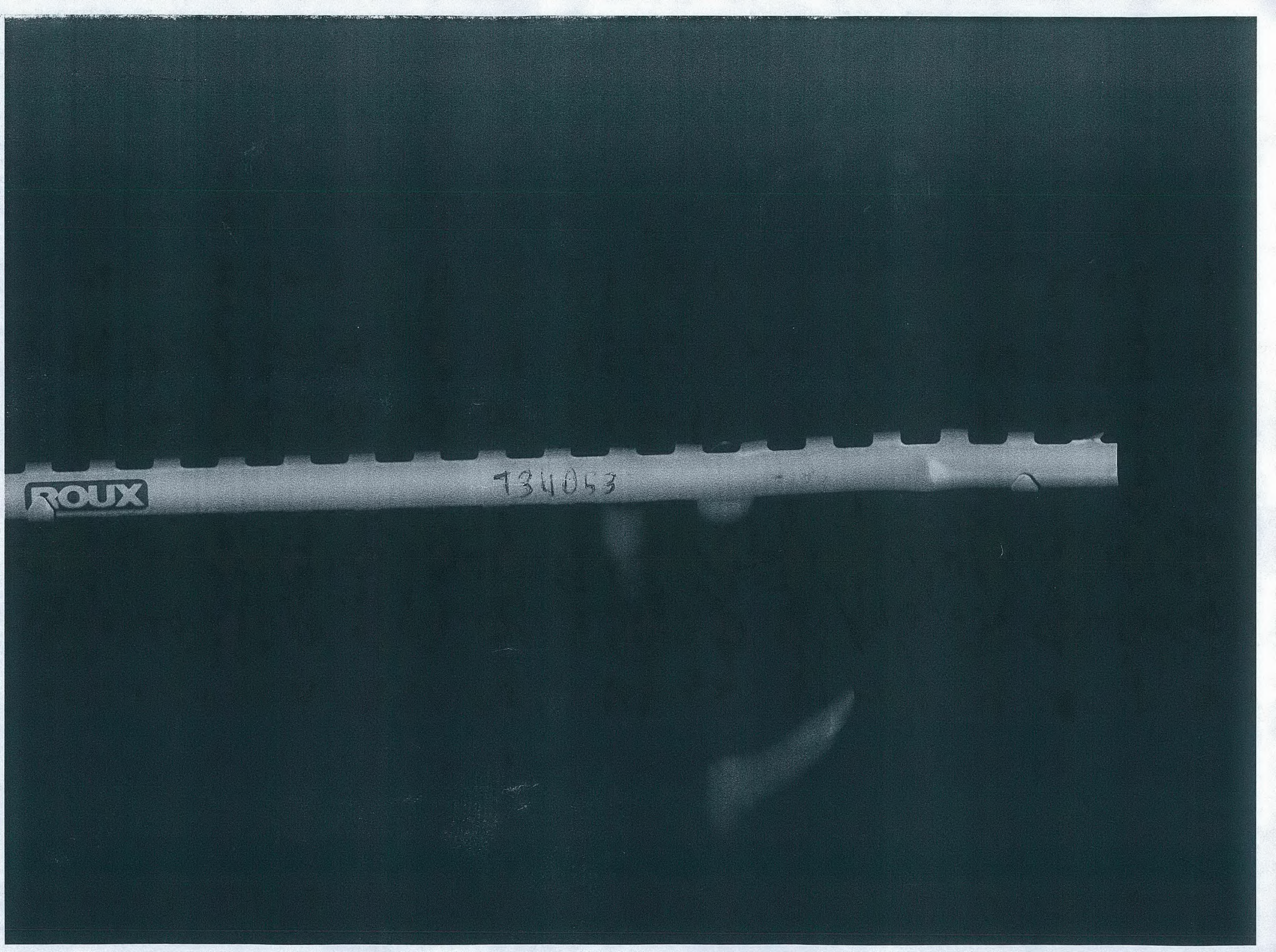
Write or Copy/Paste Document Title In This Space

WorkPlan.HW.734053.1997-10-15.Pre-Remedial_Design_Sampling

DO NOT PHOTOCOPY. PRINT FROM PDF VERSION ONLY.






ROUX
734053

OCT 20 1997

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
50 Wolf Road, Albany, New York 12233-7010

John P. Cahill
Commissioner

October 15, 1997

Elaine Bobletz
Nixon, Hargrave, Devans, & Doyle
Clinton Square
P.O. Box 1051
Rochester, NY 14603-1051

Dear Ms. Bobletz:

This letter is in response to your October 14, 1997- submission of the Pre-Remedial Design Sampling Work Plan for the Syracuse China Landfill site. The Department accepts this workplan with the following conditions:

- Depending on the results of the sampling, the Department may request a maximum of 15 samples to characterize areas below 500 ppm of lead. One of the goals of this field activity is to have enough information to allow NYSDEC and the PRPs to discuss cleanup goals and/or areal extent of the removal.

- From our discussions, it evident that there will probably be a need for field decisions to perform sampling that is different than is specified in the workplan. There will be a NYSDEC representative on site during this field activity to participate in the decisions made.

If there are any questions, please call me at 518 / 457-4343.

Sincerely,

Wayne D. Mizerak
Environmental Engineer I
Bureau of Western Remedial Action
Division of Environmental Remediation

McLaren Hart®

ENVIRONMENTAL ENGINEERING CORPORATION

September 30, 1997

Ms. Elaine Bobletz
Nixon, Hargrave, et al.
Clinton Square
Rochester, New York 14603

Re: Pre - Remedial Design Sampling Work Plan
Syracuse China Landfill
Site Number: 7-34-053

Dear Ms. Bobletz:

Enclosed please find one (1) copy of the Pre-Remedial Design Sampling Work Plan for the Syracuse China Landfill for your review.

Should you have any questions, please do not hesitate to contact this office.

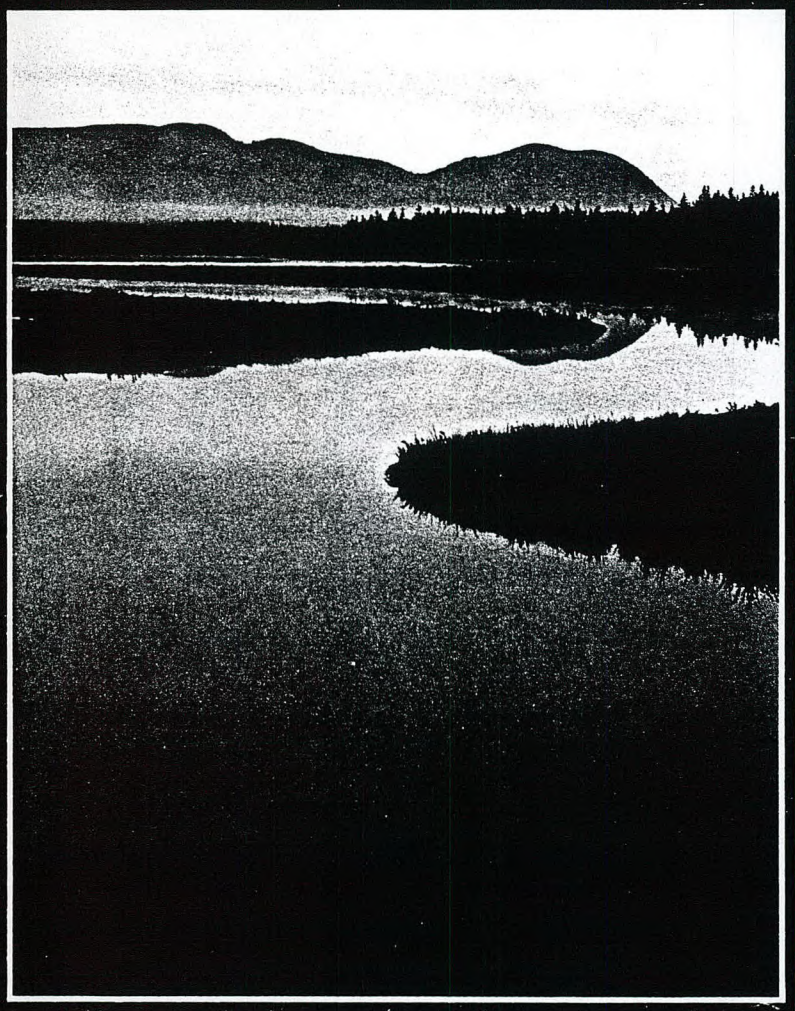
Sincerely,

McLAREN/HART, INC.

Andrew J. Barber
Principal Environmental Scientist

28 Madison Avenue Extension, Albany, NY 12203-5326 (518) 869-6192 FAX (518) 869-3971

recycled paper



McLaren Hart

PRE-REMEDIAL DESIGN SAMPLING WORK PLAN
SYRACUSE CHINA LANDFILL
SYRACUSE, NEW YORK
SITE NUMBER 7-34-053

PRE-REMEDIAL DESIGN SAMPLING
WORK PLAN
SYRACUSE CHINA LANDFILL
SYRACUSE, NY
SITE NUMBER 7-34-053

This work plan has been prepared by McLaren/Hart on behalf of The Pfaltzgraff Company, Inc. for the Syracuse China landfill located in the Town of Salina, New York (see Figures 1 and 2). A Record of Decision ("ROD") was issued by the New York State Department of Environmental Conservation ("NYSDEC") in March of 1996 for the landfill. Among other components, the ROD calls for the following:

- "A remedial design program to provide the details necessary for the construction and monitoring of the remedial program. This will include additional sampling and wetland environmental testing as necessary to better delineate the areas of concern, in the wetland and the extent of the groundwater."

- "Installation of an upgradient groundwater interception system, which will be designed to intercept groundwater passing through the fill and lower the water table below the fill, or other appropriate system to prevent leaching of lead from the fill material into the groundwater."

This work plan describes the procedures for the collection and analysis of samples of wetland soils and the collection of hydraulic data in support of the remedial design, as required by the ROD. Specifically, soil sampling will be conducted in the wetland to delineate the areal and vertical extent of lead concentration in the wetland soils. Hydraulic data will be collected from the perimeter areas of the western portion of the landfill to determine whether the fill material is currently in contact with the water table, and if so, to collect and evaluate sufficient data to design a remedy to prevent leaching of lead into the groundwater.

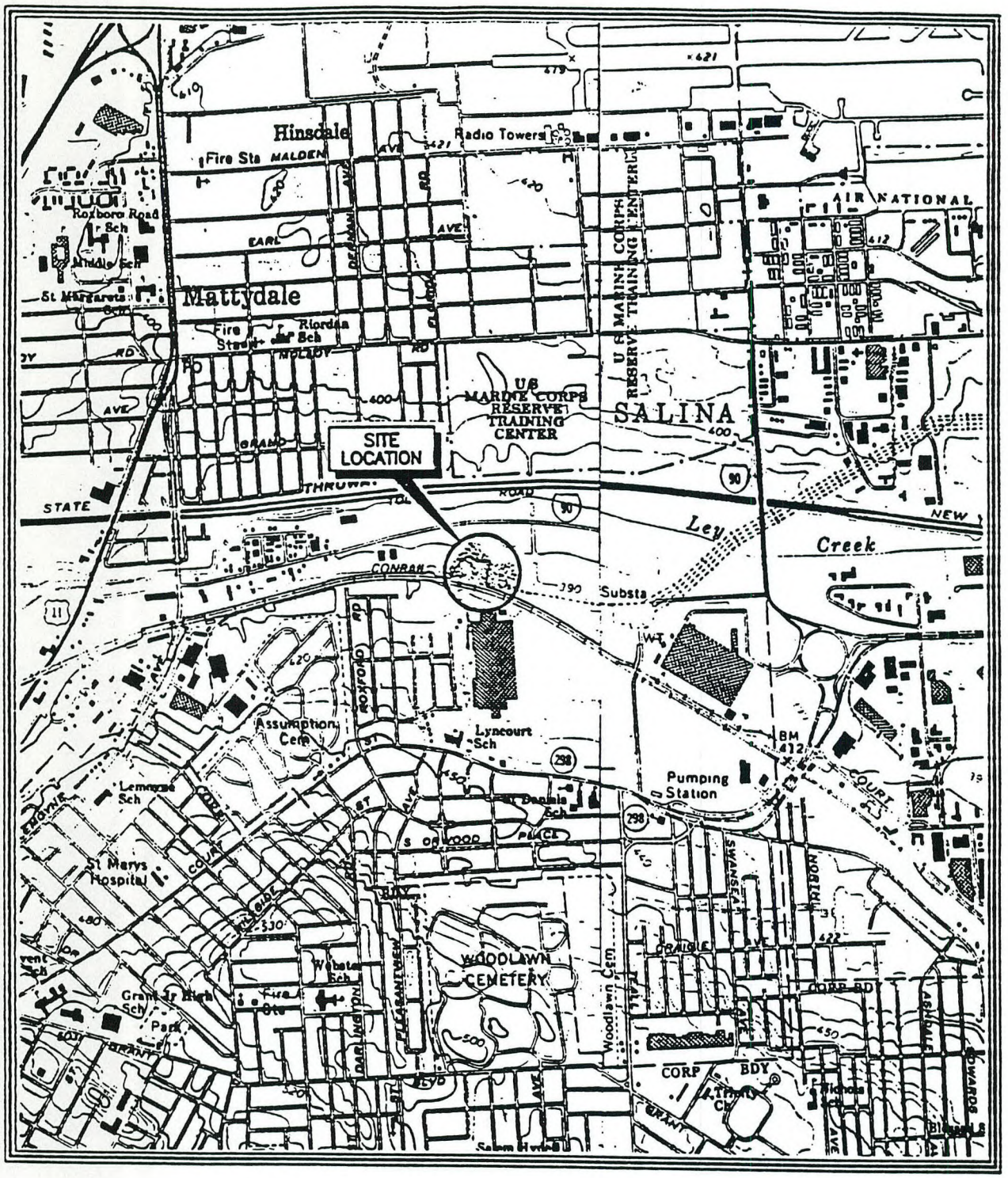


FIGURE 1



SCALE IN FEET

0 1000 2000

McLAREN/HART
ENVIRONMENTAL ENGINEERING CORPORATION
28 Madison Avenue Extension
Albany, NY 12203

SITE LOCATION MAP

SYRACUSE CHINA COMPANY
SYRACUSE CHINA SITE LANDFILL

CITY OF SYRACUSE ONONDAGA COUNTY, NY

DWG NO. SYR1 - 9/97

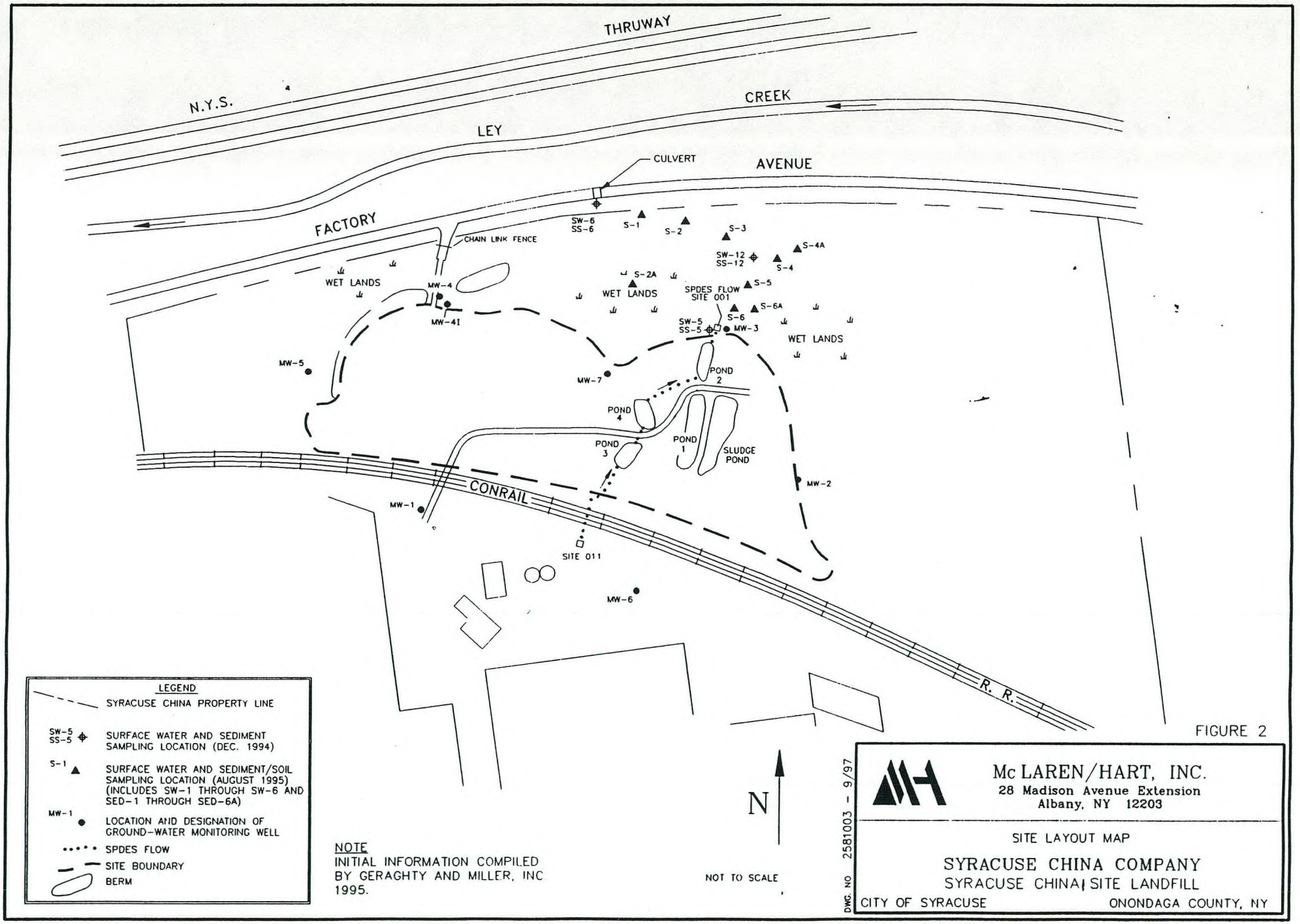

THRUWAY
N.Y.S.
CREEK
LEY
AVENUE
CULVERT
FACTORY
CHAIN LINK FENCE
SW-6
SS-6
S-1
S-2
S-3
S-4A
SW-12
SS-12
S-4
S-2A
S-5
WET LANDS
MW-4
SPDES FLOW
SITE 001
S-6A
MW-4I
S-6
SW-5
SS-5
MW-3
WET LANDS
MW-5
MW-7
POND
2
POND
4
POND
3
POND
1
SLUDGE
POND
MW-2
CONRAIL
MW-1
SITE 011
MW-6
R. R.
LEGEND
SYRACUSE CHINA PROPERTY LINE
SW-5
SS-5
SURFACE WATER AND SEDIMENT SAMPLING LOCATION (DEC. 1994)
S-1
SURFACE WATER AND SEDIMENT/SOIL SAMPLING LOCATION (AUGUST 1995) (INCLUDES SW-1 THROUGH SW-6 AND SED-1 THROUGH SED-6A)
MW-1
LOCATION AND DESIGNATION OF GROUND-WATER MONITORING WELL
SPDES FLOW
SITE BOUNDARY
BERM
NOTE
INITIAL INFORMATION COMPILED BY GERAGHTY AND MILLER, INC 1995.
N
NOT TO SCALE
DWG. NO 2581003 - 9/97
Mc LAREN/HART, INC.
28 Madison Avenue Extension
Albany, NY 12203
SITE LAYOUT MAP
SYRACUSE CHINA COMPANY
SYRACUSE CHINA SITE LANDFILL
CITY OF SYRACUSE
ONONDAGA COUNTY, NY

FIGURE 2

BACKGROUND

As noted above, the NYSDEC issued a ROD for the Syracuse China Landfill in March 1996. The remedy described in the ROD consists of the following components:

- A remedial design program to provide the details necessary for the construction and monitoring of the remedial program. This will include additional sampling and wetland environmental testing as necessary to better delineate the areas of concern, in the wetland and the extent of the groundwater.

- Excavation and consolidation of the contaminated settling pond sludges and fill materials, located beyond the cap boundary in the eastern portion of the landfill, into the area to be capped.

- Excavation and consolidation under the cap of approximately 1.3 acres of the landfill to restore the Class 2 wetland to original area prior to encroachment by the landfill.

- Excavation and consolidation under the cap, of the contaminated wetland soils in an approximately ten acre area. This area and the depth of contamination will be further defined during the predesign phase of the project. Remediated wetland areas will be revegetated to control erosion.

- Installation of an upgradient groundwater interception system, which will be designed to intercept groundwater passing through the fill and lower the water table below the fill, or other appropriate system to prevent leaching of lead from the fill material into the groundwater.

- Capping of the landfill consistent with the applicable requirements of 6NYCRR Part 360, which will include but not be limited to: 1) installation of a 40 mil. Geomembrane liner cap; 2) 24 inches of barrier protection; 3) six inches of top soil; 4) installation of surface drainage, and; 5) performance of explosive gas and hydrogen sulfide generation surveys, and if necessary, design of a landfill gas collection system based on these results. The cap will be designed so that no additional encroachment on the wetland will result.

- Reconstruction of the settling ponds, as necessary to maintain the current wastewater discharge. State Pollution Discharge Elimination System ("SPDES") permit compliance must be maintained during remediation.

- Since the remedy will result in untreated hazardous waste remaining on the site, a long-term monitoring program will be instituted. This program will allow the effectiveness of the selected remedy to be monitored and will be a component of the operation and maintenance for the site.

SCOPE OF WORK

Hydraulic Monitoring

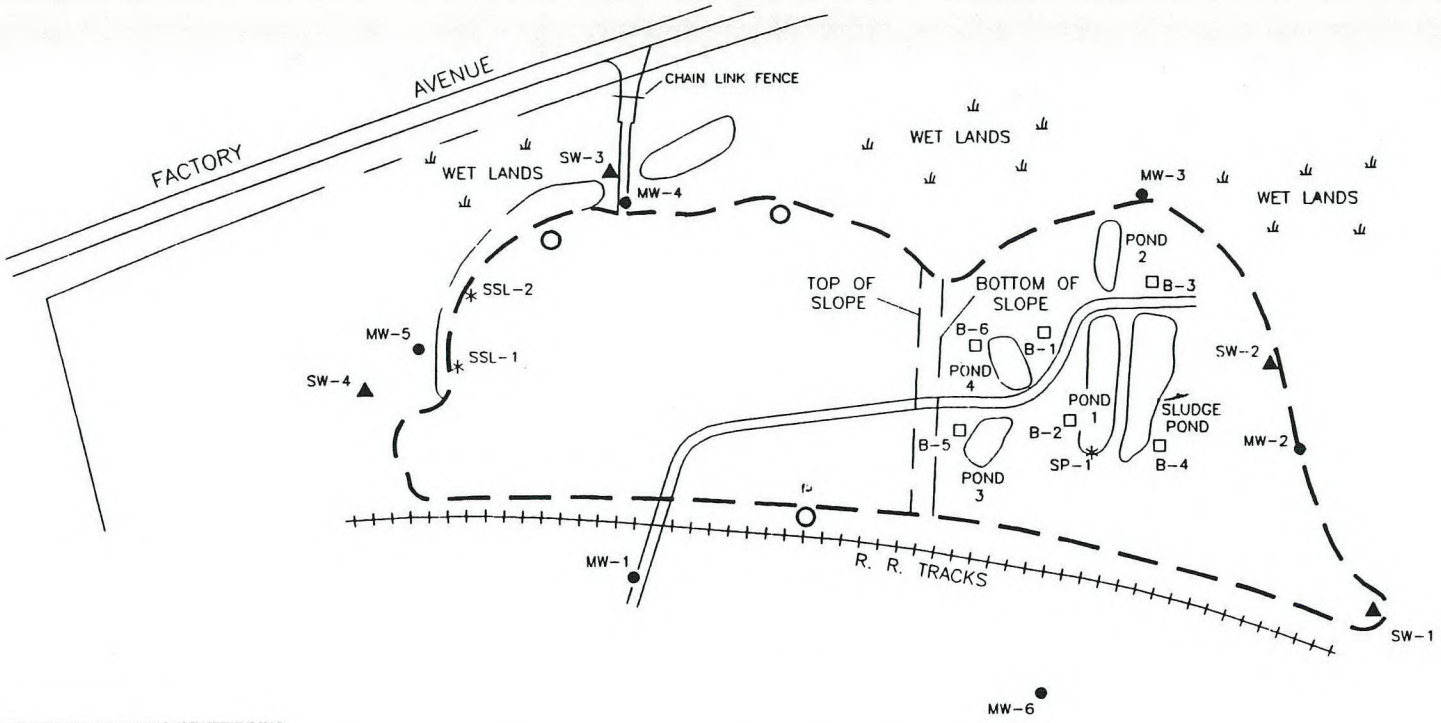
The ROD calls for the installation of an upgradient groundwater interception system or other appropriate system to prevent leaching of lead from the fill material into the groundwater. The installation of the cap will effectively eliminate leaching by the infiltration of precipitation. The remaining potential leaching mechanism is where the water table may be in direct contact with fill material. Limited water table elevation data gathered during the Remedial Investigation ("RI") suggest that along the northern toe of slope of the western half of the landfill, the bottom of fill material may be in contact with the water table.

The diversion of precipitation resulting from the installation of the cap will lower the water table under the landfill. The necessity for an upgradient groundwater interception system, or other appropriate system, will be determined by evaluating whether the water table is currently in contact with the fill material and whether the lowering of the water table in response to the cap will be sufficient to preclude future contact between the water table and fill material .

A total of three new monitoring wells will be installed to evaluate the precise elevation of the water table relative to the bottom of fill material along the northern toe of slope of the western half of the landfill. The proposed well locations are shown on Figure 3. The wells will be installed and constructed in the same manner as the wells installed during the RI. Figure 4 depicts the proposed well construction and Appendix A provides the well installation procedure.

The newly installed wells will be developed by pumping and/or bailing to remove fine-grained materials from the well screen and casing and also to ensure that the well responds properly to changing water levels within the formation. The elevation of the top of the well casing of the new monitoring wells will be surveyed to the nearest 0.01 foot relative to mean sea level. After water levels have stabilized in the new wells, two rounds of synoptic water-level measurements will be collected roughly two weeks apart from the existing and newly installed landfill monitoring wells.

The water-level elevation measurements from the new and existing landfill monitoring wells will be used to construct current water table maps. The elevation of the water levels in the new monitoring wells will be compared to the observed bottom of fill materials identified during the well installation. If necessary, a water balance calculation will be performed to estimate the anticipated lowering of the water table in response to the installation of the cap.



LEGEND

- PROPOSED LOCATION OF GROUND-WATER MONITORING WELL
- MW-1 ● EXISTING GROUND-WATER MONITORING WELL
- SW-4 ▲ EXISTING SURFACE-WATER MONITORING LOCATION
- SSL-1/SP-1 * SURFACE SOIL SAMPLE
- B-5 □ SOIL BORING LOCATION
- SITE BOUNDARY
- BERM

NOTE
INITIAL INFORMATION COMPILED BY GERAGHTY AND MILLER, INC. 1995.

N

0 150' 300'
Scale in feet

FIGURE 3

Mc LAREN/HART, INC.
28 Madison Avenue Extension
Albany, NY 12203

PROPOSED MONITORING WELL LOCATION MAP
SYRACUSE CHINA COMPANY
SYRACUSE CHINAI SITE LANDFILL
CITY OF SYRACUSE ONONDAGA COUNTY, NY

DWG. NO. 2581002 - 9/97

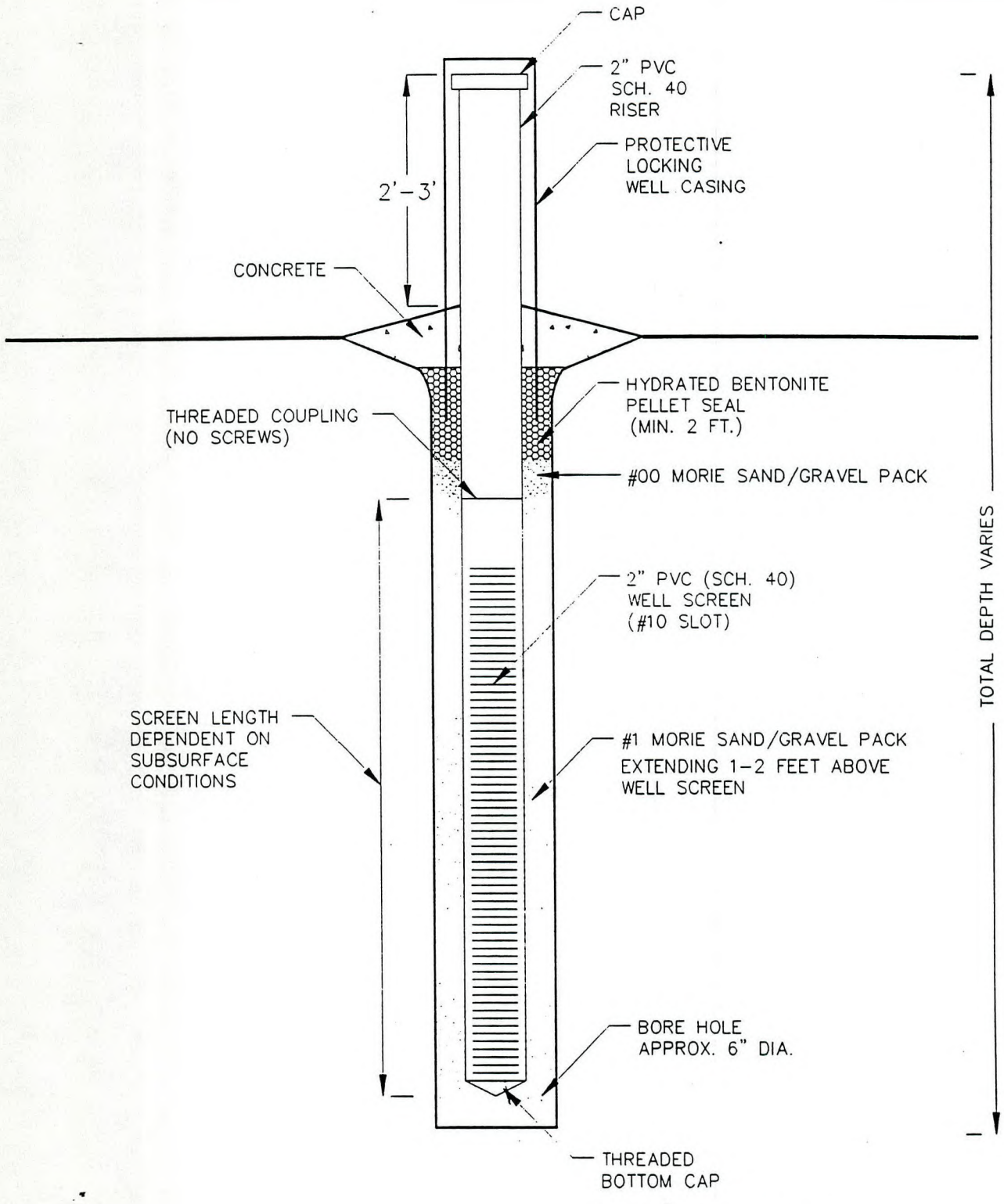


FIGURE 4



NOT TO SCALE

McLAREN/HART, INC.
28 Madison Avenue Extension
Albany, NY 12203

TYPICAL MONITORING WELL DETAIL

SYRACUSE CHINA COMPANY

SYRACUSE CHINA SITE LANDFILL

CITY OF SYRACUSE ONONDAGA COUNTY, NY

DWG NO 2581004 - 9/97

Sampling and Analysis of Wetland Soils

As described in the ROD, additional sampling of the wetland soils is necessary to better delineate the areas of concern. The area and depth of lead concentrations in the wetland soils will be defined during the predesign phase. The strategy for defining the areal extent and depth of lead concentrations in wetland soils will consist of analysis in the field using a portable X-Ray Fluorescence ("XRF") instrument which will allow for decisions to be made on site on the location and depth of samples to be taken.

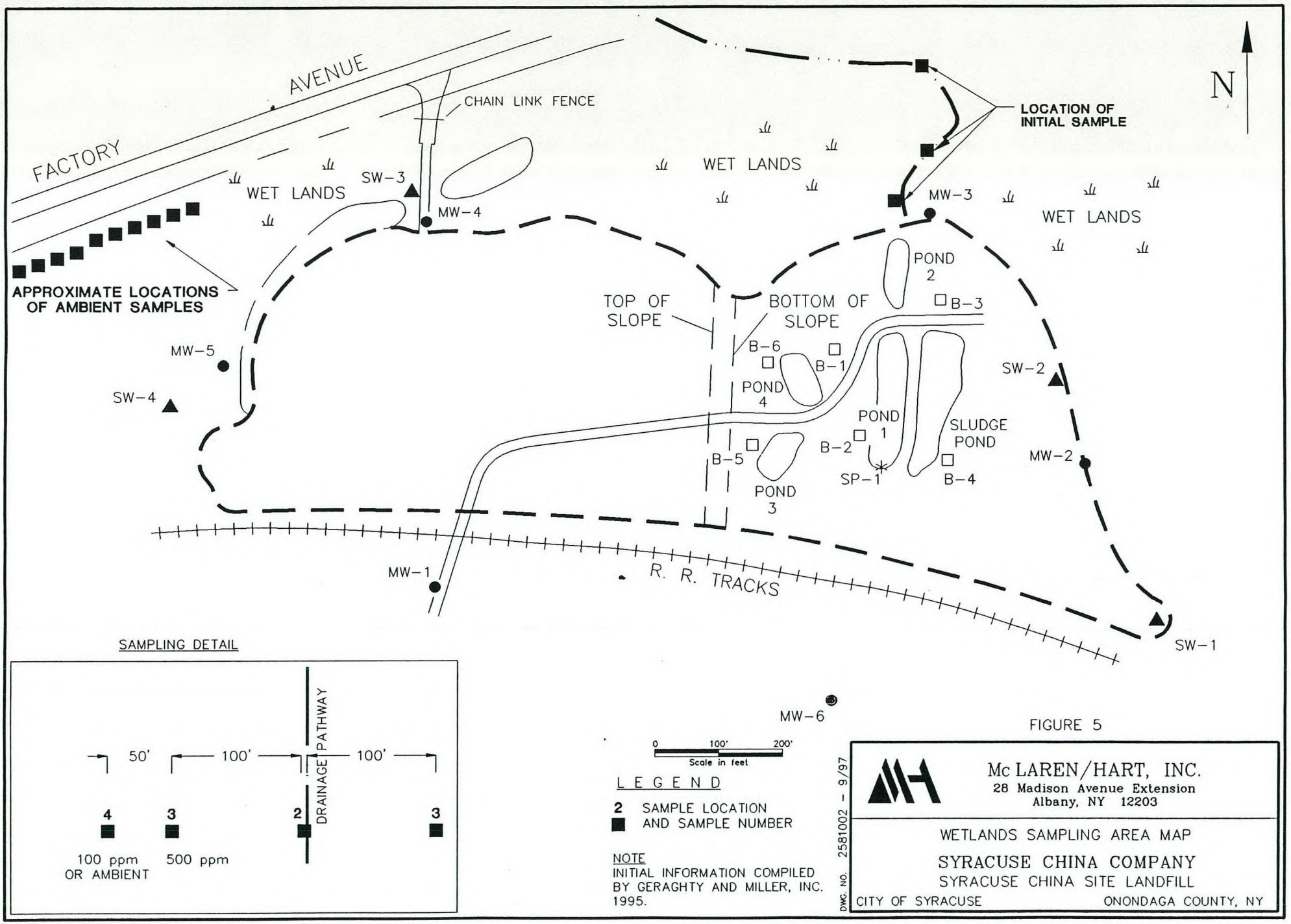
Data collected during the RI suggest that the primary mode of lead migration was from historic discharges from the settling ponds (the current system does not discharge lead to the settling ponds). Consequently, the highest concentrations of lead are anticipated to be found along the preferential drainage pathway from the last settling pond through the wetland. Previous wetland soils sampling has shown a general decrease in lead concentrations along this drainage pathway.

The sampling will proceed in a stepwise process. On the first day of sampling, several samples will be collected northwest of the landfill, south of Factory Avenue, as shown on Figure 5. These samples will be collected and analyzed to establish ambient lead concentrations ("Step 1"). Up to ten (10) samples will be collected in this area. The results from the analysis of these samples will be pooled and McLaren/Hart will use an appropriate statistical technique (e.g.–mean, median, etc.) – with NYSDEC concurrence to establish the ambient lead concentration. This area was selected because it is out of the influence of the landfill, typical of an urban/industrial area (for example, it is proximate to an active roadway), and has not been dredged.

The second step ("Step 2") will entail collecting samples at three locations (see Figure 5) along the drainage pathway to establish the elevation profile of lead concentration (Profile Area). Samples will be collected at 6-inch depth intervals (according to the soil sampling protocol provided in Appendix B), up to a maximum of 2 1/2 feet.

The third step ("Step 3") will be performed once the above-described vertical profile and ambient lead concentration have been established. In order to define the areal extent of lead concentration, additional samples will be collected at two (2) locations (roughly perpendicular to the drainage pathway) approximately 100 feet beyond the perimeter of the Profile Area. Samples will be collected at 6 inch intervals corresponding with the same depth interval and the next lower depth at which lead concentrations above 500 ppm* were measured in the Profile Area. If the 0-6 inch sample and/or the lowest sample are found to have lead concentrations above 500 ppm, the underlying 6 inch layer will

* 500 ppm was selected as the appropriate criterion in part based upon the conclusion in TAGM HWR-4046 about average background lead concentrations in metropolitan and suburban areas and near highways.


AVENUE
FACTORY
CHAIN LINK FENCE
WET LANDS
WET LANDS
WET LANDS
SW-3
MW-4
MW-3
LOCATION OF INITIAL SAMPLE
N
APPROXIMATE LOCATIONS OF AMBIENT SAMPLES
MW-5
SW-4
TOP OF SLOPE
BOTTOM OF SLOPE
POND 2
B-3
B-6
B-1
POND 4
SW-2
POND 1
SLUDGE POND
B-2
B-5
SP-1
B-4
MW-2
POND 3
MW-1
R. R. TRACKS
SW-1
SAMPLING DETAIL
50'
100'
100'
DRAINAGE PATHWAY
4
3
2
3
100 ppm OR AMBIENT
500 ppm
MW-6
0
100'
200'
Scale in feet
LEGEND
2 SAMPLE LOCATION AND SAMPLE NUMBER
NOTE
INITIAL INFORMATION COMPILED BY GERAGHTY AND MILLER, INC. 1995.
FIGURE 5
Mc LAREN/HART, INC.
28 Madison Avenue Extension
Albany, NY 12203
WETLANDS SAMPLING AREA MAP
SYRACUSE CHINA COMPANY
SYRACUSE CHINA SITE LANDFILL
CITY OF SYRACUSE
ONONDAGA COUNTY, NY
DWG. NO. 2581002 - 9/97

also be sampled. This depth-wise successive sampling will continue until lead concentrations below 500 ppm are measured or a depth of 2 1/2 feet is reached.

The fourth step ("Step 4 ") will be performed if samples at the 100 foot distance location(s) have lead concentrations above 500 ppm In this case a sampling location will be selected 50 feet further out from the Step 3 location (150 feet from the Profile Area). The depth-wise successive sampling described above will be carried out at this location. If the predominant number of samples at this location have a lead concentration below 100 ppm or ambient (whichever is higher), the sampling will be discontinued in this direction. If the predominant number of samples at this location have a lead concentration above 100 ppm or ambient (whichever is higher), the sampling and analysis program will be continued in 50 foot lateral increments until this criterion is met.

If the sample results at the 100-foot distance location(s) from the perimeter of the Profile Area have lead concentrations below 500 ppm, a field decision will be made (with NYSDEC concurrence) as to whether sampling needs to be performed midway between the Profile Area and the Step 3 sampling location(s), that midway point being approximately 50 feet from the perimeter of the Profile Area.

The result of this sampling and analysis will be the development of a "Wetland Elevation Profile of Lead Concentration" sufficient to support the remedial design.

Note: The concentrations employed for the pre-design sampling are for the purpose of profiling lead concentrations (both areally and vertically) in the wetlands; these concentrations do not represent values which will be achieved during the remedial action. The determination of the area and volume of wetlands soil to be removed will be made during the design phase. This determination will be made based on technical feasibility, as well as the criteria set forth in the ROD.

Samples will be analyzed for lead concentration on-site using a portable XRF instrument. The protocol for lead analysis is provided in Appendix C. It is anticipated that approximately 20 samples can be collected and analyzed per day. The results of sample analyses will be used to guide the selection of subsequent sample locations within the sampling areas. A total of ten (10) duplicate samples will also be collected for lead analysis in a NYS-certified laboratory by USEPA Method 6010. The selection of the sample locations for duplicate samples will be conducted following the completion of the XRF sampling and analysis program, with NYSDEC concurrence. Laboratory Quality Assurance/Quality Control (QA/QC) procedures established for the RI will be employed for this phase of work, including the analysis of a matrix spike (MS) sample and a matrix spike duplicate (MSD) sample.

Report Preparation

The findings of the predesign sampling and data will be compiled and presented in a report. The report will contain supporting figures, tables and appendices.

Appendix A: Well Installation Protocol

1.0 Purpose

This section describes designs, procedures, and materials that will be used to construct monitoring wells at the Syracuse China Landfill.

2.0 Well Installation Materials

The typical well construction is shown on Figure 4. Materials used in the construction of monitoring wells will be new and free of visible residue.

2.1 Drilling

A 6-inch diameter borehole will be advanced with a hollow-stem auger. Split-spoon samples will be collected continuously as the borehole is advanced. Split spoon samples will be examined by an on-site geologist and will be described using the Unified Soil Classification System (USCS). Particular attention will be paid to identifying the elevation of the bottom of fill materials and the relative depth of the apparent water table.

2.2 Well Screen and Casing

The well screen which will be placed into the borehole will be 2-inch diameter Schedule 40 PVC with 0.010 inch slots. The screen will be 10 feet in length and will be equipped with a threaded end cap. The screen will be installed so that the top of the screen will be roughly 2 feet above the apparent water table, if possible. The well casing will be 2-inch diameter threaded Schedule 40 PVC.

2.3 Sand Pack

The annulus around the well screen will be backfilled with a #1 Morie sand pack. The sand will be carefully poured into the annulus to avoid bridging, and a weighted tape will be periodically lowered during sand pack emplacement to verify proper sand pack placement. The sand pack will be emplaced to a point 1-2 feet above the top of the well screen. Above the #1 Morie sand pack, a layer of #00 Morie sand will be emplaced, approximately 1 foot in thickness.

2.4 Seal

A seal of bentonite pellets with a thickness of at least 1 foot will be installed above the filter pack to effectively seal the monitoring zone of the well from surface contamination and to prevent the intrusion of overlying cement or cement bentonite grout material into the filter pack. Bentonite pellets will be slowly poured to prevent caving of the borehole and, before backfilling with grout, potable water will be poured in to allow the bentonite to hydrate and swell.

2.5 Well Completion

The monitoring wells will be completed by placing a concrete seal from the top of the bentonite seal to land surface . The well casing will stick up 2-3 feet above land surface, and a lockable protective casing will be placed over the well casing into the concrete.

3.0 Well Development

3.1 Purpose

Well development is the process of flushing the interface of the aquifer and well to remove sediment from inside the well casing and filter pack and to ensure the free flow of formation water into and out of the well. During the drilling process, the side of the borehole may become smeared if the soil contains clay or silt. This plugging action substantially reduces the permeability of the aquifer in the zone of the boring and retards the movement of water into the well. Fine sediments, which are naturally occurring or from the filter pack material, may also enter the well and require removal.

The purposes of development are as follows:

- restoration of the natural permeability of the formation adjacent to the borehole,
- removal of fines from the filter pack and well casing so that subsequent water samples will not be abnormally turbid or contain undue suspended matter, and
- removal of remnant drilling fluids from the well, filter pack, and aquifer materials, as well as removal of contaminants introduced during the time of drilling.

3.2 Well Development Methods

Well development will be conducted using pumping and/or bailing, but other methods (described below) are available for developing monitoring wells, if necessary.

Surge Block

A surge block is a round plunger with pliable edges. It is constructed of a material such as rubber belting and is equal to or slightly larger than the diameter of the well screen. Moving the surge block forcefully up and down inside the well screen causes the water to surge in and out through the screen, thus accomplishing the desired cleaning action. Close monitoring of the amount of pressure generated must be made to prevent cracking of the well casing or screen. Combined with pumping, surging removes the fines and cleans the filter pack surrounding the well screen.

Air Lift

The air lift method involves pumping compressed air down a pipe placed inside and towards the bottom of the well casing. Pressure applied intermittently and for short periods causes the water to surge up and down inside the casing. Once the desired washing is accomplished, continuously applied air pressure is used to blow water and suspended sediments upward out of the well.

Considerable care must be exercised to avoid injecting air that is under too much pressure directly through the well screen. Air can become trapped in the formation outside the well screen and affect subsequent chemical analyses of water samples and hydraulic conductivity measurements. The bottom of the air pipe should not be placed below the top of the screened section of casing.

Bailing

A PVC bailer, slightly smaller than the diameter of the well casing, can be raised and lowered through the water column to produce an agitating action similar to that caused by a surge block. Unlike a surge block, the bailer has the added capability of removing turbid water and fines each time it is brought to the surface.

Pumping

Pumping may be used effectively in wells where recharge is rapid. A centrifugal (trash) pump with dedicated intake tubing may be used to pump water and sediment from the wells.

Appendix B – Wetland Soil Sampling Protocol

1.0 Introduction

This section provides the procedures to be followed for the collection of wetlands soil samples at the Syracuse China Landfill during the predesign sampling. A sample log will be completed for each sample collected which will describe the sample location, depth, collection method and other pertinent information.

2.0 Soil Sampling

2.1 Soil Sampling Procedure

Sample locations will be field-checked and staked prior to beginning sample collection. This will ensure that if resampling for further investigation is necessary, the sample locations can be identified at a later date. At each location, inconsequential surface debris (rocks, vegetation) will be cleared prior to sample collection. A new pair of disposable gloves will be used during sample collection at each location. Because the analyte of concern is lead, sampling equipment composed of plastic (polyethylene, lexan, polycarbonate) will be employed, although metallic equipment will be necessary to create the borehole.

Samples will be collected at 6-inch depth intervals; the surficial sample will be collected with a scoop or trowel. Subsequent samples will be collected with a scoop or trowel or by pressing plastic tubing (roughly 2-inch diameter) into the wetland soil, depending upon field conditions. Samples will be homogenized in a plastic bowl before transfer to the sample container. A new plastic sampling implement will be used for each sample, and other sample collection equipment will be decontaminated as described below between samples.

2.2 Field Identification of Soils

As soil samples are collected, they will be described by the on-site geologist as discussed in this section. The soil classification system outlined herein identifies granular soils on the basis of texture and cohesive soils on the basis of plasticity and incorporates the Unified Soil Classification System (USCS). This system is discussed below.

2.2.1 Description of Constituent Parts

The constituent parts of a given soil type are defined on the basis of texture, in accordance with the Grain Size Classification Chart of Soils. When describing soil samples, the following descriptive components should be used in the order shown:

1. Color
2. Grain size range (granular soils only)
3. Consistency (clay dominated soils only)
4. Dominant soil types with appropriate modifiers (e.g., clayey, silty, fine to coarse, etc.)
5. Other soil types, listed in the order of their predominance with each soil type portion and preceded by a modifier indicating the percent range (by weight) of that soil portion.
6. Structure
7. Type and condition of mineral/rock constituents
8. Moisture
9. Angularity; and
10. Geologic origin, if known

2.3 Decontamination Procedures

Sampling equipment will be decontaminated between samples and between sample locations to prevent cross-contamination. Equipment will be first be cleaned of visible contamination by scrubbing and rinsing with potable water. Equipment will then be rinsed with a laboratory-grade detergent (e.g.- Alconox, Micro, etc.) and scrubbed. Finally, the equipment will be rinsed with copious amounts of distilled water and allowed to air dry (weather permitting). As plastic sampling equipment becomes excessively scratched during the sample collection process, it will be replaced.

TITLE: SPECTRACE 6000 TRANSPORTABLE X-RAY FLUORESCENCE ANALYZER

1.0 SCOPE AND APPLICATION-This document addresses the application of Energy Dispersive X-Ray Fluorescence spectrometry (EDXRF) to the determination of contaminant metals in soil and sediments. The EDXRF technique is capable of both qualitative and quantitative analysis of elements with atomic numbers 11 (sodium) through 92 (uranium). This operating procedure discusses the determination of the elements listed in Table 1.

Table 1. Elements and their atomic symbols analyzed by this EDXRF method.

Arsenic (As)	Manganese (Mn)
Barium (Ba)	Mercury (Hg)
Cadmium (Cd)	Nickel (Ni)
Calcium (Ca)	Potassium (K)
Chromium (Cr)	Silver (Ag)
Copper (Cu)	Titanium (Ti)
Iron (Fe)	Zinc (Zn)
Lead (Pb)	

1.1 Principles of Operation-The Spectrace 6000 is a transportable laboratory grade EDXRF instrument. It is equipped with a single sample position.

1.1.1 Fundamentals of the X-ray spectrometric measurements- The basis of X-ray fluorescence spectrometry is the interaction of X-rays produced by the Spectrace 6000 X-ray tube with the constituents of the soil or sediment sample. When atoms in a soil sample absorb the tube x-ray, the energy causes the ejection of an electron from the atomic cloud. Next, electronic transitions occur to return the excited atom to a ground energy state. These transitions result in emission of a characteristic X-ray. The energy of the characteristic X-ray indicates the atomic number of the emitting atom and the specific electronic transition that occurred. (Reference 1,2) The Lithium drifted silicon(Si(Li))detector converts the characteristic X-ray energy into an electronic signal. The electronics in the Spectrace 6000 further processes the signal and displays the X-ray spectrum on a personal computer.

1.1.2 Generation of spectral background- When the X-ray tube shines on the soil sample some of the X-rays are scattered toward the detector rather than absorbed by the soil. The X-ray spectrum then shows the scattered radiation as background under the elemental emission lines. The magnitude of the background limits the achievable minimum detectable limit for the target contaminant elements. The peak fitting and deconvolution software of the Spectrace 6000 filters background signal prior to quantitative analysis. Each soil spectrum then can be compared with another without regard to background variations.

2.0 OVERVIEW OF THE METHOD- Three spectra are acquired for each EDXRF measurement. Each spectrum optimizes one or more target elements or matrix constituents of the sample. Standardization of the EDXRF method relies on National Institutes of Standards and

Technology (NIST) certified soil standard materials. Elemental emission peak deconvolution is followed by quantitative analysis with a fundamental parameters method. The fundamental parameters method can accurately determine the composition of a sample even though the standards used do not cover the range of concentrations expected. Additionally, fundamental parameters can address matrix interactions from widely varying soil types. Calibration by fundamental parameters proceeds by completely defining for the program each standard sample's composition including the major components (ex. Fe, Ca). Many instances arise when a portion of the matrix may be better estimated by a difference component. For soil, the difference component is defined as SiO_x where X can be 2-5. When X = 5, a composition of 24% Si and 45% O results that approximates the concentrations found in most soil types.

3.0 SAMPLE CONTAINERS AND HANDLING

3.1 All samples collected by McLaren/Hart will be collected in accordance with the applicable McLaren/Hart QAM and or QAPjP. McLaren/Hart cannot control the collection procedures used by outside concerns.

3.2 After sample collection, samples should be stored in either metal free glass jars or polyethylene bags. In the lab, only disposable wooden or plastic spatulas, clean glassware and plastic or aluminum weighing/drying pans should contact the soil samples.

4.0 INTERFERENCES-The EDXRF method is a total elemental analysis technique. Errors can arise for the following sources:

4.1 Sample preparation error- The nature of soil samples require an approach to such variables as moisture, particle size, and heterogeneity and representativeness of the sample to the soil at the site. Sample preparation as outlined in this SOP minimizes or eliminates the effects of many of these variables on the EDXRF result.

4.2 Spectral interference- Emission line overlap can be severe depending on the spectral peak position and relative concentrations of the overlapping elements. The Spectrace software utilizes a multiple linear least squares deconvolution method which produces accurate analyte peak intensities for subsequent quantification.

4.3 Chemical matrix interferences- Quantitative X-ray fluorescence analysis is a comparative analytical method; EDXRF spectrometer response for an elemental emission line is evaluated with respect to the known concentration of the element in a standard material. Contaminated soils are complex samples in regard to their overall elemental composition. Matrix effects are defined as the impact that the concentration variations of major soil components (ex. Ca, Fe, Si) has on measured analyte X-ray emission intensity. The fundamental parameters method mathematically corrects analyte intensities with respect to concentration variations of sample matrix components.

5.0 EQUIPMENT AND APPARATUS

5.1 Description of the Spectrace 6000- The Spectrace 6000 is a transportable, laboratory grade, Energy Dispersive X-Ray Fluorescence (EDXRF) spectrometer. It has found wide application in the analysis of soils, sediments, hazardous waste, and waste oil materials. The instrument utilizes a high flux rhodium (Rh) anode X-ray tube which is positioned to direct X-rays onto the sample. Standard equipment includes an electronically cooled lithium drifted silicon (Si(Li)) solid state X-ray detector. Pulse processing electronics in the Spectrace 6000 card cage module communicate spectral data to a personal computer. The personal computer displays and processes spectral information, and outputs elemental concentration data.

5.2 Equipment and apparatus list

5.2.1 Spectrace 6000 Analyzer System

Spectrace 6000 spectrometer and card cage modules
Spectrace 6000 operators manual
Personal computer (a 486 is recommended) with SSXRF.EXE software and printer.
Spectrace 6000 technical manual

5.2.2 Sample preparation and presentation materials

Sample communition device- mechanical grinder or manual grinding device such as a mortar and pestle.
Drying oven - conventional (115 degrees Celsius) or microwave
Drying containers (glass, plastic or aluminum weighing/drying pans)
Disposable X-ray cups (32 mm diameter closed end)
Polypropylene or mylar window film (0.14 mil thickness)

5.3 Instrument maintenance

5.3.1 Detector cooling- Ensure the free flow of air around the Spectrace 6000 spectrometer cabinet (especially fan vents). Additionally, a supply of uninterruptable 110V AC power is recommended so that the electronically cooled detector is always at operational temperatures.

5.3.2 Sample chamber cleaning- Keep debris and dust wiped from the chamber. Do not use forced air to dust the chamber because the detector beryllium window is fragile.

6.0 REAGENTS

6.1 The following reagents for the acquisition of peak shape spectra:

Potassium carbonate	Strontium carbonate
Tungsten oxide	Iron oxide
Calcium carbonate	Zirconium oxide
Mercury oxide	Copper metal

Titanium dioxide	Silver metal
Lead oxide or metal	Cobalt oxide
Vanadium oxide	Cadmium metal
Arsenic oxide	Nickel metal or chloride
Chromium oxide	Tin metal
Rubidium carbonate	Zinc metal or oxide
Manganese oxide	Antimony oxide
Strontium carbonate	Barium carbonate

All compounds or metals should be Analyzed Reagent grade or better.

6.2 Interference sample- When lead (Pb) metal or oxide is used to produce the reference lead emission lines the L alpha and L beta ratio does not accurately reflect the ration found in soil spectra. For this reason, an interference sample is used to generate the lead reference spectrum.

6.2.1 Composition of interference sample

Boric acid [H_2BO_3) - 15.8%
Silicon dioxide (SiO_2) - 50%
Aluminum trioxide (Al_2O_3) - 20%
Calcium oxide (CaO) - 11%
Iron oxide (Fe_2O_3) - 1%
Iron metal (Fe) - 2%
Lead nitrate [$Pb(NO_3)_2$] - 0.2%

6.2.2 Formulation of the interference sample-The materials listed in section 6.2.1, weighed to proper proportions, are introduced into a mechanical grinding vessel and ground for 3 minutes. This material is available from the Spectrace Instruments Applications Department upon request.

7.0 PROCEDURES

7.1 Prerequisites

7.1.1 Site location- The instrument must be placed so that free air flow around the instrument is supplied. Operate at temperatures of 50-90 degrees Fahrenheit and relative humidity between 20-80% only. Power requirements are 115 V AC, 14 amps and a power conditioner/filter is recommended. Power both the Spectrace 6000 instrument and the personal computer from the same AC line.

7.1.2 Detector cooling- Electronically cooled Si(Li) detectors require AC power during operation, however, Spectrace Instruments recommends continuous power to the system so that the detector remains cool and electronics stabilized.

7.1.3 Energy calibration- Once every twenty four hours, the gain setting of the instrument must be checked using the copper calibration disk supplied by the manufacturer. Execute the

automated "ENRGY CALIB" function from the procedure menu. The computer automatically adjusts electronics gain to ensure proper calibration. This function normally takes between 8 and 10 minutes. Figure 1 shows the copper emission spectrum displayed during energy calibration.

7.1.4 Acquisition of reference peak shape spectra- The acquisition of reference spectra is only required once. As long as no pulse processing modules have changed, these peak shape references remain valid. Often, this procedure can be done at the manufacturers site. Place the materials listed in section 6.1 and the interference sample described in section 6.2 in individual X-ray cups with polymer window film seals. Then acquire the following spectra in a subdirectory labeled \REFS with the conditions listed below.

A- 12 kV, aluminum filter - for the elements potassium, calcium, titanium, vanadium, chromium, and iron. Save the spectra individually in the \REFS subdirectory with the spectrum number equal to the atomic number (i.e. potassium [K] - SPECTRUM.19). Place the cursor on the K alpha peak of each element emission and allow at least 30,000 counts to acquire in the channel.

B- 35 kV, thick palladium filter - for the elements cobalt [Co], nickel [Ni], zinc [Zn], bromine [Br], arsenic [As], rubidium [Rb], strontium [Sr], and zirconium [Zr]. Save the spectra individually in the \REFS subdirectory with the spectrum number equal to the atomic number (i.e. cobalt [Co] - SPECTRUM.27). Place the cursor on the K alpha peak of each element emission and allow at least 30,000 counts to acquire in the channel. For the L line emission of mercury [Hg], lead [Pb], and tungsten [W] allow at least 10,000 counts to acquire in the L alpha channel. Save the spectrum as 100 + the atomic number (mercury [Hg] - SPECTRUM.180). For the interference sample, use the same conditions as above but allow the spectrum to acquire for 1000 seconds livetime and save the spectrum as SPECTRUM.199.

C- 50 kV, copper filter - for the elements silver [Ag], cadmium [Cd], tin [Sn], antimony [Sb], barium [Ba]. Save the spectra individually in the \REFS subdirectory with the spectrum number equal to the atomic number (i.e. silver [Ag] - SPECTRUM.47). Place the cursor on the K alpha peak of each element's emission line and allow at least 30,000 counts to acquire in the channel.

7.2 Standardization of the Method- Standardization of the Spectrace 6000 uses a set of NIST certified reference materials and/or site specific calibration standards. See the discussion in Appendix A on the prerequisites of site specific standards. By using NIST certified materials, the EDXRF standardization then can be referenced to NIST certificates or an independent analysis referee method. Standardization adjustment can be affected by including or omitting a particular analyte element in a standard or addition or removal of a standard sample altogether.

7.2.1 Setting up the standards file- For the standards NIST 2709, 2710, 2711, 2704, 8407, 8408 type in the standards file as shown in Figure 1. Parentheses indicate that the concentration is to be used to define the matrix of the standard but <u>not</u> to be used for estimation of analyte sensitivity. Generally, those concentrations in the standard less than 50

ppm are defined in parentheses. A blank indicates that the component is either not present or is at a concentration near the minimum detectable limit of the method.

7.2.2 Analysis Technique Setup- Proceed using the Analysis Technique Menu as described in the Spectrace 6000 operator manual pages 4-17 through 4-20.

7.2.3 Aquisition Setup- Set up the acquisition conditions as follows:

A- Low Z procedure: 13 kV tube voltage, 0.30 mA tube current, aluminum (0.13 mm) filter, and 100 seconds analysis livetime.

B- Mid Z procedure: 35 kV tube voltage, 0.10 mA tube current, thick palladium [Pd] filter (0.13 mm), 200 seconds analysis livetime.

C- High Z procedure: 50 kV tube voltage, 0.35 mA tube current, copper filter (0.63 mm), 200 seconds analysis livetime.

7.2.4 Analyze the certified NIST standards. Analyze the certified NIST standards starting with section 9.5.

7.2.5 Evaluation of the standardization: Table 2 lists the pure element count rates for the standardization. The pure element count rates should be within 20% relative of these values.

Table 2. Pure element count rates for the elements analyzed.

ELEMENT	PURE ELEMENT COUNT RATE
Arsenic	40323
Manganese	36326
Barium	9560
Mercury	5949
Cadmium	25667
Nickel	9086
Calcium	9734
Potassium	5960
Chromium	31464
Silver	25341
Copper	20830
Titanium	18577
Iron	40761
Zinc	23541
Lead	10242

7.2.6 Set up three procedures for the analysis of unknowns, identical to steps 7.2.2 through

7.2.3 except indicate a combination procedure in the mode "Run unknowns" in the analysis technique menu.

7.3 General keys and menu software- The Spectrace Instruments Operators manual and Technical manual should be consulted for operation and flow of analysis of the Spectrace software.

7.4 Pre-operational checks

7.4.1 Control sample check- One of the six NIST soil standards or a well characterized sample from the site is analyzed as an unknown. Plot the concentration response for at least one element (preferably a target analyte) from each of the three acquisition conditions on a control chart. For those analytes with greater than 100 ppm concentration, the result should be within 20% of the known elemental concentration. If a result exceeds the 20% limit, restandardize the method as described in section 7.2. If more than one measurement of an element in a set of five exceeds the Upper or Lower control limit (+ or - 3 x standard deviation of the charted data) perform a resolution and stability check.

7.4.2 Resolution and stability check- A resolution and stability check should be performed if the test outlined in section 7.4.1 fails. See the sample output in Figure 6 or consult the Spectrace Instruments Model 6000 Technical manual for details. Contact a Spectrace service engineer if the instrument fails this test.

7.5 Analysis of unknown soil samples:

7.5.1 Prepare samples as indicated in Section 8.0

7.5.2 On the procedure menu, select the run unknowns combination procedure setup in Section 7.2.6.

7.5.3 Hit the F1 "RUN" key and enter the number of samples to analyze and the indentifying label for the first soil sample. Repeat for all individual samples in the set to be analyzed.

7.6 Minimum Detectable Limits (MDLs) of the method for the Spectrace 6000

7.6.1 Non-target elements method MDLs- Determination of the non-target elements' MDL's proceeds by averaging the counting statistic error from the "CONCENTRATION ERROR" printout header for the element in each of the six standards. This average, multiplied by 3 is the MDL reported for that element.

7.6.2 Target elements MDLs- For the target elements, select the NIST standard which comes closest to the action level concentration for the target. Then using the "PEAK BACKGROUND" printout format use the equation found in section 10.2 to determine MDL's.

7.6.3 Typical MDLs for the Spectrace 6000 for soils are listed in Table 3.

Table 3. Minimum detectable levels of EDXRF analyzed elements.

ELEMENT	MDL (mg/kg)
Arsenic	8
Manganese	12
Barium	35
Mercury	8
Cadmium	.2
Nickel	7
Calcium	90
Potassium	120
Chromium	16
Silver	2
Copper	4
Titanium	18
Iron	11
Zinc	4
Lead	4

8.0 SAFETY- Spectrace 6000 operators are protected from accidental exposure to X-rays by a lid lock and side panel interlocks. If any problems arise with the X-ray on indicator light located on the front panel or with the interlock system, work is to stop immediately and a Spectrace Instruments service engineer is to be contacted. Beryllium windows are present on the X-ray tube and detector. Do not allow any sample or debris to fall on the window to avoid puncturing it. If a window should break, note that beryllium metal is poisonous. Use extreme caution when collecting broken beryllium pieces. Consult your Spectrace Instruments service engineer for advice on cleanup of broken windows.

9.0 SAMPLE PREPARATION

9.1 First agitate the sample in its glass or bag container to mix the soil material.

9.2 Using a wooden spatula, transfer approximately 15 grams of sample material onto the plastic/glass/aluminum weighing dish drying container.

9.3 Place in the drying oven or microwave oven and drive off moisture.

9.4 Transfer the material to the grinding vessel and grind to assure -250 mesh material either by mechanical grinder or manual grinding device.

9.5 Transfer approximately 8 grams of the dried material into a labeled disposable X-ray cup and seal with one sheet of polypropylene or mylar window film.

9.6 Place sample with mylar window facing down into sample chamber and close sample chamber lid.

9.7 Record sample name, file ID and other appropriate information into the instrument logbook.

9.8 Press F1 on menu to start analysis.

10.0 CALCULATIONS

10.1 MDL calculation for non-target elements- Calculation of the MDL for the non-target elements is three times the average counting statistics error. Use the "CONCENTRATION ERROR" report format to obtain the data.

10.2 MDL calculation for target elements- Calculation of the MDL for the target elements uses Equation 9.1 below and requires peak and background counting data from NIST certified standard reference material containing a concentration of the target element closest to the predetermined action level. Use the report format "PEAK BACKGROUND" to obtain the data for this calculation.

$$MDL = \frac{3 \times \sqrt{B} \times conc.}{P} \qquad \text{Eq. 9.1}$$

Where the variables are defined as:

MDL = minimum detection level;
B = background counts under fitted analyte peak;
P-= fitted peak counts of analyte peak:
conc. = concentration of analyte from standard reference material certificate provided by NIST.

11.0 QUALITY ASSURANCE/QUALITY CONTROL

11.1 Precision-Precision data is accumulated in the pre-operational check listed section 7.4. Keep in mind that precision is a function of counting time and the number of peak counts and background counts collected for the analyte. Precision in EDXRF measurements is predicted by counting statistics as shown in the following equation:

$$\text{Rel. } o_{theo} = \frac{\sqrt{P + 2 \times B}}{P} \times 100\% \qquad \text{Eq. 10.1}$$

The Spectrace Instruments model 6000 typically provides measurement precision 1.2 - 1.8 times the o theoretical. Several acquisitions of the control sample are required prior to making this determination.

11.2 Accuracy- The accuracy of an EDXRF measurement can be verified in two ways. First, certified

soil reference materials (procured from the NIST or other standard generating entity) not utilized in the Spectrace 6000 standardization are analyzed as soil unknowns as outlined in Section 7.5. Verify that results for target elements near the predetermined action concentration level are within 20% of the certified concentration for the standard. Second, a subset of samples (10% at the minimum), preferably near the action concentration level, are submitted to a laboratory for acid digestion and ion-coupled plasma emission or atomic absorption spectrometric (ICP/AA) analysis. The split submitted should be taken of the prepared soil material subsequent to Section 8.5. Target elements exhibiting a regression analysis (EDXRF data versus ICP/AA data) r^2 value greater than 0.95 has been considered QA3 definitive level data. Regression analysis producing r^2 values of 0.7 or above can be considered QA1 level (field screening) data. To improve the r^2 value, ICP/AA analyzed soil materials maybe added to the standards file setup in 7.2.1. The utmost discretion should be used to alter the standardization method of section 7.2. Laboratory data should be provided for all the elements listed in the standards file (Figure 2). Short of that potassium, calcium and iron along with the target elements must be determined in the potential site specific standard soil samples.

11.2.1 Matrix considerations- Additional QA/QC verification may include analysis of soils with varying matrix composition. Of interest is the effect on EDXRF results when analyzing samples with high siliceous or calcareous soils or soils with high iron composition. Additionally, acid digestion and ICP/AA analyzed site specific standards can introduce error due to variable recoveries caused by soil matrix differences, of target elements (see Reference 7). When site specific standards are used, errors are propagated into the EDXRF standardization.

12.0 REFERENCES

(1) E.P. Bertin, "Principles and Practice of X-ray Spectrometric Analysis", 2nd ed., Chap. 2, Plenum Press, New York (1975).

(2) J.L. de Vries, B.A.R. Vrebos, "Handbook of X-ray Spectrometry", R.E. Van Grieken and A.A. Markowicz, eds., Chap. 1, Marcel Dekker (1993).

(3) J. Sherman, Spectrochimica Acta, 7, 283 (1955).

(4) G. R. Lachance, R.J. Traill, Canadian Spectroscopy, 11, 43 (1966).

(5) J.W. Criss, L.S. Birks, Analytical Chemistry, 40, 1080 (1963).

(6) J. Ashe,

(7) Addendum to NIST Montana soils Analysis Certificate

Appendix A:
INTRODUCTION

Government agencies as well as private industry are actively investigating and remediating soils at sites contaminated by heavy metals. Energy dispersive X-ray fluorescence analysis (EDXRF) is well suited to the determination of heavy metals in contaminated soils because it is a non-destructive and accurate elemental analysis technique. Energy dispersive X-ray fluorescence spectrometers are field portable or transportable in a van or trailer. Transportable EDXRF systems can provide minimum detectable levels (MDL) below 10 ppm for most metals. Field portable EDXRF instruments provide MDLs below 50 ppm for most metals. EDXRF results correlate well with other metal analysis methods (AA or ICP).

Quantitative X-ray fluorescence analysis is a comparison analytical method; EDXRF spectrometer response for an elemental emission line is evaluated with respect to the known concentration of the element in a standard material. Simple sample matrix types such as polymers or hydrocarbons, exhibit linear X-ray intensity response over limited metal concentration ranges. Contaminated soils, by comparison, are complex samples in regard to their overall elemental composition. Matrix effects are defined as the impact that the concentration variations of major soil components (ex. Ca, Fe, Si) has on measured analyte X-ray emission intensity.

Matrix effects produce a non-linear measured X-ray intensity versus metal concentration response when analyzing soils. A classical method that addresses matrix effects, called site specific standardization, relies on a suite of standards and regression mathematics. When this aspect of EDXRF is applied to contaminated soils analysis, several concerns arise as listed in Table 1. The standard materials selected for EDXRF calibration must contain metal analyte concentrations that bracket the range found at the contaminated site. In addition, the concentrations of iron, calcium, and silicon in the standard materials must bracket those found in the soil types at the site.

Table 1. Comparison of two standardization methods.

FP Standardization	Site Specific Standardization
No site sampling required prior to project initiation;	Soil samples to be used as standards must be collected well in advance of project initiation date;
Pure elements and/or readily available certified reference materials are used as standards;	High costs associated with lab analysis of soils and significant time required to receive data back;

Concentration levels of matrix and metals in the standards need not bracket the levels found at the site.	A large number of standards are required so that the matrix and metal concentrations bracket the entire range found at the site.

Soil samples selected as standards are designated "site specific" and hopefully bracket the concentration ranges required. Some reasons for omitting a soil sample from the suite of standards may include: (1) Having several other samples possessing the same general concentrations of metals and matrix, or (2) questionable independent analysis data for a metal or matrix component.

Generating site specific standards may be prohibitive for two reasons: (1) Cost considerations concerning expeditionary sampling and sufficient independent analysis to have confidence in the soil metal and matrix compositions, or (2) time constraints involving sampling and waiting for independent analysis results.

As a result of the constraints imposed by site specific standardization, a mathematical treatment of matrix effects designated "Fundamental Parameters" (FP) has been developed (see Table 1). The FP routines provide accurate metal concentration determinations in contaminated soil samples that have wide ranges of metal and matrix concentrations. Calibration of an FP method requires only a limited set of certified generic soil standards or pure elements.

Spectrace data analysis software uses one of two types of FP calibration methods. The Spectrace 9000, a HgI_2 detector based field portable EDXRF spectrometer uses radioisotope excitation that classifies the FP method as an effective energy computation. The Spectrace models 6000 and 5000 use X-ray tube excitation and the FP routine is classified as a tube modeling routine.

TUBE MODELING FP ROUTINES

Fundamental parameter routines based on tube modeling use equations describing X-ray tube intensity output distributions. Mathematical derivation of these algorithms occurred sometime ago; they have only recently been executed on personal computers.

Tube modeling routines can use pure elements or oxides of the pure elements as standards. Unfortunately, however, X-ray excitation conditions appropriate for analysis of a pure metal sample do not result in optimum sensitivities and minimum detectable metal levels in a soil matrix.

To achieve optimum X-ray analysis conditions for metals in soils, a limited set (typically four) of soil standard materials is selected. The National Institute of Standards and Technology (NIST) provides several certified reference materials satisfactory for standardization of the tube modeling FP routines.

Prior to FP standardization X-ray spectra of the standards are collected and analyzed for analyte and matrix element emission intensities. Calibration proceeds by completely defining for the program each standard sample's composition, including the major components (ex. Fe, Ca). Many instances arise when a portion of the matrix may be better estimated by a difference component. For soil, the difference component is defined as SiO_x where X can be 2-5. When X =5, a composition of 24% Si and 45% O results that approximates the concentrations found in most soil types.

The tube output distribution is calculated by the program followed by determination of the matrix independent pure element count rate (PECR) for each analyte. The routine then develops a set of theoretical standards. Next, the routine computes the theoretical X-ray intensity expected for each analyte. Combining the theoretical standard and intensity information, alpha influence coefficients are detennined by solving simultaneous equations. Alpha coefficients describe the quantitative effect of each matrix element on an analyte's measured X-ray intensity.

Unknowns are quantitated by estimating analyte concentration from the measured intensity and the alpha coefficients. Next, theoretical intensities are calculated and then the computed intensities are compared with the measured intensities. If the intensities are more than 1% different, a new estimate of concentration is made and the theoretical intensity computation is repeated. The iteration continues until the theoretical and measured intensities converge. Figure 2 illustrates correlation between a tube modeling FP routine for 150 soil samples analyzed by EDXRF for Pb and Cd and inductively coupled plasma analysis (ICP) data.

CONCLUSION

The incorporation of fundamental parameter routines for EDXRF analysis of soils provides accurate estimates of metal contaminant concentration with a minimum number of standard materials. FP standardization offers several advantages when compared with site specific standardization. Fundamental parameters standardization relies on pure element standards or certified standard reference soil materials. These materials are readily available, unlike site specific standards. Universal application to all soil matrix types is another merit of FP standardization. When analyzing soil samples collected from a site, EDXRF results correlate well with AA and ICP methods. Fundamental parameters analysis methods provide rapid and cost effective EDXRF measurement data in contrast to site specific standardization that requires an initial sampling trip and the time interim waiting for laboratory results.